

United States Department of Agriculture
Agricultural Research Administration.

Report of the Administrator
of
Agricultural Research
1944.

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of
Agricultural Research
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**UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION**

LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF AGRICULTURE,
AGRICULTURAL RESEARCH ADMINISTRATION,
Washington, D C , October 20, 1944

HON CLAUDE R WICKARD,
Secretary of Agriculture

DEAR MR SECRETARY I submit herewith the report of the work of the Agricultural Research Administration for the fiscal year ended June 30, 1944, including reports of the following agencies of the Administration: The Bureaus of Agricultural and Industrial Chemistry, Animal Industry, Dairy Industry, Entomology and Plant Quarantine, Human Nutrition and Home Economics, Plant Industry, Soils, and Agricultural Engineering, and the Office of Experiment Stations

Sincerely yours,

EUGENE C AUCHTER, *Administrator*

REPORT OF THE ADMINISTRATOR OF AGRICULTURAL RESEARCH, 1944

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THE RESEARCH ADMINISTRATION

THE ADVANCES made in agricultural science in recent years are written in the production of our farms during this war.

The remarkable fact is that total annual production in 1942 and 1943 has been almost half again as much as it was in 1917-18, on about the same amount of land, and with some 4 million fewer people on our farms.

Previous production records for various major crops and products have been broken again and again. Hybrid corn enabled the Corn Belt in 1943 to equal its all-time production record, made in 1920—but with 6½ million fewer acres devoted to the crop. The release of 3 million acres from corn helped to make room for scientifically bred soybeans, and our production of this crop has increased so fast—from 77½ million bushels in 1940 to 195¾ millions in 1943—that it now rivals that of Manchuria, traditionally the Land of Beans. Cotton yields are at an all-time high—around 250 pounds per acre. The use of improved varieties of wheat and other small grains has enabled these crops to escape diseases that formerly decimated them whenever weather conditions were right for the rapid spread and growth of the deadly disease spores. We have jumped peanut production to amounts hitherto unheard of in this country. Egg production per hen has risen with great rapidity in recent years. Hog slaughter in 1943 was 42 percent greater than the 1937-41 average.

The net result of these and many other developments has been that our armed forces can feed millions of men and stock-pile great quantities of food while, at the same time, we are making large shipments to our allies and keeping our civilian population not less well—perhaps even a little better—nourished than it was in the years immediately before the war.

What makes these achievements possible?

Will, work, weather, planning, and prices each play an important part. But all of them together would not be enough. The final decisive factor is scientific knowledge.

Like American industrial workers, American farmers are technology-minded. During this war they have been especially alert to learn and use scientific practices, and agricultural science has made much progress since the last war. Better varieties of crops, better soil management, more and better fertilizers, better animals, improved methods of controlling diseases and insects, mechanization—these advances account for a considerable proportion of our increased production per man and per acre.

In this respect agriculture and industry are alike. If we want faster airplanes or more productive cows, we have to depend on research to find out how to get them.

Industry has its own research laboratories. The farmer's research agencies are, for the most part, the Department of Agriculture and the State experiment stations. He depends on them to anticipate and solve his scientific problems and to keep him up to date on scientific developments relating to his work. The countless experiments these agencies have conducted over many years have equipped him with materials and knowledge without which he could not have met the staggering demands of this greatest of all wars.

In addition to this accumulated knowledge, the Department and the State stations during the war have focused research efforts on solving a host of new and special problems arising from military needs, shortages of materials formerly obtained from abroad, and other conditions that accompany global conflict.

CLOSER COORDINATION OF RESEARCH ACHIEVED

In research for war it is vital to get results as quickly as possible, eliminate time-consuming delays and duplication, and make the available scientific personnel and equipment stretch as far as possible, all of which means close coordination and cooperation in a vast, complicated field of work. This close coordination and cooperation was assured when the Secretary of Agriculture in December 1941 brought seven of the Department's scientific bureaus together into one agency, the Agricultural Research Administration.

Thus, much of the research work of the Department and the accompanying measures for the control of diseases, parasites, and insects is now combined in a single organization, which also includes the administrative unit responsible for cooperative arrangements with the experiment stations in the States and Territories. This research work covers almost the entire range of agricultural production and the use of agricultural products in industry and in the home. The bureaus in the Agricultural Research Administration are those of Animal Industry, Agricultural and Industrial Chemistry, Dairy Industry, Entomology and Plant Quarantine, Human Nutrition and Home Economics, Plant Industry, Soils, and Agricultural Engineering, and the Office of Experiment Stations. The experiment station at Beltsville, Md., near Washington—known as the Beltsville Research Center—is operated as a service unit by the Agricultural Research Administration for the use of its bureaus and of other agencies in the Department.

The Agricultural Research Administration is not so much a new agency, in the usual sense, as a new arrangement of work that has

gone on continuously ever since the Department of Agriculture and the State experiment stations were founded. Research was their original function. In the course of decades, as the agricultural sciences have explored one new field after another, the work has become so extensive and so subdivided and separated that there has been a need to pull the parts more closely together. The war, which made it imperative to concentrate diverse research activities quickly and effectively on a common objective, has merely hastened this inevitable development. Fortunately, there is an underlying unity in all scientific research, no matter how varied its techniques and subject matter. It is all based on the same experimental approach, the same fundamental scientific viewpoint and method, and the same kinds of criteria for judging the validity of the results.

The following paragraphs summarize a few of the more outstanding results of the past year's work in the Agricultural Research Administration, with brief comments on their possible post-war significance. Further details of these and many other developments will be found in the reports of the bureaus, which are published in this volume and are also obtainable separately.

MILESTONES IN THE PROGRESS OF PLANT BREEDING

During the war, hybrid corn, produced by the crossing of selected inbred lines, has displaced open-pollinated varieties in the Corn Belt as completely as the automobile displaced the horse for transportation. The result of this major achievement of modern plant breeding is that a Corn Belt farmer can now grow 20 per cent more corn on the same acreage than he could a few years ago (and feed a correspondingly larger number of pigs), or alternatively, he can keep his production the same but use less land for corn and more for other crops. The big development of the near future is the spread of hybrid corn to other areas, especially the South. This is already on the way, breeders have developed hybrids that are in commercial production in Tennessee, Louisiana, Florida, Texas, and North Carolina. The indications are that hybrid corn will increase production per acre proportionally more in the South than in the North. Meanwhile, practically all canned sweet corn now consists of hybrid varieties, and better popcorn is a vigorous offshoot of the corn breeder's skill.

Onions are the next crop to feel the effects of hybrid vigor. Onion growing requires a great deal of labor, and a big advantage of the new development will be reduced labor requirements. Hybrid onions make it possible to increase production by as much as 20 to 50 per cent per unit of land, which means that less land, and consequently less labor, will be needed for a given quantity of product. (Incidentally, some of the hybrid onions are of mammoth size, the biggest so far weighing 4 pounds apiece.) Large-scale production of hybrid seed was made possible by several years of breeding to produce onions which cannot pollinate themselves because their pollen is sterile. Thus all that is necessary to insure hybrid seed is to plant alternate rows of a normal onion, which will produce pollen and be the male parent, and a male sterile onion, which can only receive pollen and will be the female parent. Seed is collected only from the male sterile plants. The first hybrid onion, released for production in 1944, is adapted

only to the Southwest Hybrids of all types for all areas will follow as fast as they can be produced

Rich possibilities for the breeding of better alfalfa are being opened up by the development of a somewhat similar technique for this crop. Hitherto, mass cross-pollination to produce hybrid seed has been rather hit-or-miss in results, since many plants pollinate themselves. Certain plants within a variety, however, are sterile to their own pollen. The new technique consists in selecting self-sterile plants of two varieties, dividing the clones until there are enough to plant a considerable area, and growing the plants of the two varieties close together so that they will cross with each other. Both single and double crosses can be produced by this method. Higher forage yields, resistance to bacterial wilt and to alfalfa leaf hopper (which causes yellows), and a 100 percent increase in carotene content are outstanding characteristics of some of the single crosses developed so far. In a 3-year test, the first wilt-resistant alfalfas, Ranger and Buffalo, have yielded 69 percent more forage than the older susceptible varieties, Grimm and Kansas Common.

That many plants in the future will be resistant to insects as well as to diseases seems assured, judging from the progress made so far. Plant breeders and entomologists have joined forces to produce wheat varieties resistant to theessian fly. Big Club 43 and Pawnee have now been released, and many other selections are either being tested or soon will be. Hitherto, growers of winter wheat have had a difficult choice—either plant at the normal time and risk the ravages of theessian fly, or plant at the wrong time in order to escape theessian fly, but risk winter-killing. Needless to say, disease resistance is also incorporated in the insect-resistant varieties. Meanwhile, progress is reported in developing corn resistant to euworm, corn resistant to the European corn borer, sugarcane resistant to the sugarcane borer, alfalfa resistant to the pea aphid, and sorghum resistant to chinch bugs.

Modern farming conditions permit no let-up in the drive for improved varieties of crop plants. Scores of notable contributions have been made during the war, mostly as a result of breeding projects started 10 or more years ago. Similarly, the new projects of today will produce the plants that will be grown a decade or so hence. A wholly new field, just at its beginning, is the breeding of plants with extra-high vitamin content in addition to the other qualities needed. Two new cabbages released this year, for example, are unusually rich in vitamin C.

NEW WEAPONS FOR WAR AGAINST INSECTS

Because diseases and insects are among the most insidious enemies an army has to face, the battle of men against insects is intensified in war. It is safe to say that in the past 4 or 5 years more progress has been made in protecting masses of men against the insect menace than in any like period in history.

Agricultural entomologists, working in close cooperation with the Army and Navy medical services, the United States Public Health Service, the Office of Scientific Research and Development, and other agencies, have been called on to make major contributions to this

progress. Out of the research have come some extraordinarily effective new insecticides and new methods of applying them.

So far it has of course been necessary to confine these new developments almost entirely to military use, since manufacturing could not be built up fast enough to meet other needs as well. But the weapons that now protect soldiers against insects will protect civilians after the war, and there are promising leads for many additional peacetime uses, particularly in the control of agricultural pests, as soon as the necessary research can be completed.

Among many important recent developments in entomology, the most outstanding can be summed up briefly as follows:

Aerosols—This means the dispersal of a liquid insecticide in such finely divided droplets that it becomes a mist, like the moisture in a man's breath on a cold morning, and finds its way into tiny crevices.

The mist or aerosol can be created by the use of a liquefied gas (such as Freon), by employing heat, or by mechanical devices. The so-called aerosol bomb, now standard equipment in the armed services, is an example of the first method. The insecticide in solution is mixed with a material which is liquid when kept at a low temperature or under pressure. This combination is introduced at low temperature or under pressure into a small stout hand container with a slender outlet tube. When the tube is opened the liquefied gas expels the material as a fine mist. Several means of utilizing heat to produce aerosols are being tested. By this method, part of the material is volatilized and given off in the form of vapor or smoke, which aids in carrying the droplets of insecticide.

Aerosols can be dispersed from aircraft, a development that opens new possibilities in treating large areas quickly and effectively—even areas such as forests and swamps that are inaccessible to ground equipment. Tests over forests during the past year indicate that work can be done in a few hours with aircraft which would take days or in some circumstances even weeks by ordinary methods.

After the war there should be an enormous field of usefulness for insecticide aerosols in agriculture, in industry, and in homes.

Synergists—It has been found that some substances which are not themselves deadly to insects will greatly increase the killing power of certain insecticides with which they can be mixed. Sesame oil, for instance, multiplies the effectiveness of pyrethrum many times. This discovery makes it possible to use smaller quantities of an insecticide with a synergist than could be used without it.

DDT—DDT was discovered as an insecticide by a Swiss chemist in 1939-40. Entomologists in the United States Department of Agriculture proved its extraordinary value in investigations begun in 1942.

DDT has been found to be even more practical than methyl bromide, the substance first used, in making possible complete control of lice on human beings and in clothing. It has also superseded the MYL louse powder developed by the Department, in which pyrethrum is used as the killing agent. Thereby typhus has been largely eliminated as a threat to our armed forces, and presumably it can be similarly eliminated in civilian populations after the war. DDT is equally deadly to mosquitoes—with all this means to the health and comfort of soldiers and, later, of civilian populations. Filth flies, those universal carriers of disease, also are readily killed by DDT.

Field tests so far have given good results in the control of 26 or more insect enemies of farm production, including such major pests as the codling moth, gipsy moth, Japanese beetle, white-winged beetle, European corn borer, chinch bug, tomato fruitworm (which is also the boll worm and the corn earworm), pink bollworm, hornfly, and lice of cattle and goats. DDT has given only fair results with several other insects, including ticks and grasshoppers, and poor results with a few others, including the Mexican bean beetle, boll weevil, red spider, and cattle grub.

Besides the wide range of insects it will kill, the most remarkable characteristic of DDT is its sticking power. It will adhere to a surface for weeks and remain poisonous to insects that touch it throughout that time. But the same characteristics that make it so effective may also limit its usefulness. It kills beneficial insects, including honeybees and ladybirds, as well as harmful ones, while leaving some insects unaffected. In certain circumstances its use may prove to be somewhat like turning a machine gun on a crowded city street to bring down a couple of bandits.

In other words, considerably more research needs to be done before we shall know fully how to use and how not to use this remarkable new insecticide.

DD (dichloropropane-dichloropropylene)—This byproduct of the manufacture of certain pharmaceuticals and plastics was found by a Hawaiian investigator to be very effective as a soil fumigant for killing root-knot nematodes, which attack a considerable number of different kinds of plants and are a serious menace to crop production particularly in the South Atlantic and Gulf States. Tests made last year show that it is also effective against wireworms in the soil. Investigations during the year have been directed toward determining the proper dosages and methods of application.

OTHER AIDS TO MEDICAL SCIENCE

The development of penicillin within 3 years from a laboratory dream to a commercial product that is saving many lives and untold suffering is a striking example of international cooperation among scientists in different fields.

The British physicians who first discovered its remarkable power to kill certain bacteria could find no way to produce enough of it to treat more than a few patients.

They brought the baffling problem to the United States, where one of the largest collections of molds and other micro-organisms in the world is housed in the Northern Regional Research Laboratory.

The scientists who work with this big collection of microscopic organisms are interested primarily in using them to produce industrial products out of agricultural raw materials. For it is microscopic organisms that convert sugar to alcohol and do a thousand other jobs useful or indispensable to man.

These scientists know the ways of the micro organisms much as a farmer knows the ways of his livestock or a zoo keeper the ways of his caged animals.

Penicillin is produced by *Penicillium notatum*, a common mold which is found, for example, on bread (a grain product) and cheese (a milk product). It would be expensive and impractical to feed a

mold bread and cheese. The agricultural-industrial scientists found that the mold would thrive and multiply on corn-steeping liquor, a grain byproduct, and lactose, a milk byproduct.

They studied different strains of the mold and found that some would produce a great deal more penicillin than others, much as a Holstein cow produces more milk than a Jersey. (The newest high-producing strain, not yet in commercial use, was found on a moldy cantaloupe.)

Working together, the experts in microscopic life, the chemists, and the engineers studied how best to produce the mold in large quantities. The first way worked out was to grow it on the surface of the feeding liquid, in bottles. The next was to grow it in big vats, stirred into the liquid. The latter was more difficult but cheaper, and it is the method now used in most commercial plants.

They worked out methods of separating the penicillin from the mold and purifying it so it could be used safely for injection into human beings.

As fast as these things were found out, the information was passed along to the manufacturers, who worked with the Government scientists and physicians in a coordinated program. Industrial production grew with the progress of the research. By mid-1944 a thousand times more penicillin was being produced than early in 1943.

Meanwhile, in 1944, dairy scientists of the Department published the results of investigations designed to develop methods of producing lactose from cheese whey. Six different methods were developed. Hitherto lactose has been a byproduct of commercial casein production. Now it can be made as a byproduct of cheese manufacture. Large quantities of lactose are needed to feed the hungry *Penicillium* molds.

Medical men and agricultural scientists feel that the startling success of penicillin opens up possibilities for the discovery and production of other useful bacteria-killers, or antibiotics, from microorganisms. Several such substances are already known. One, tyrothricin or gramicidin, produced by a soil organism, was found by the Western Regional Laboratory last year to grow better on waste asparagus liquor than on any other medium tried so far. Tyrothricin is being used experimentally in the treatment of mastitis of cattle.

The breaking of fragile capillaries in cases of high blood pressure sometimes causes apoplexy. In that connection, a discovery of interest to medical science was made by agricultural research workers in 1944. Studying industrial uses of tobacco, the Eastern Laboratory succeeded in isolating from bright flue-cured leaf substantial quantities of the yellow pigment called rutin. This was turned over to a medical school, which used it for experiments on persons with high blood pressure and confirmed the fact that rutin is a valuable remedy for capillary fragility.

ADVANCES IN LIVESTOCK RESEARCH

Further work with phenothiazine confirms the fact that it is the most valuable remedy for internal worm parasites of livestock discovered so far. Indeed its discovery ranks as one of the major developments of agricultural science in recent years. Conservative estimates indicate that this drug is already saving livestock producers in the United States at least \$10,000,000 a year.

Investigations in 1944 show that not only is continuous dosing with phenothiazine in salt not harmful to sheep; they thrive on it, as might be expected from the fact that they are kept relatively free of worm parasites that would otherwise be a drag on their vitality. It was also found during the year that phenothiazine in standard doses is a safe worm medicine for calves, and that it can be safely given to horses in small daily doses, mixed with salt, to inhibit the development of bloodworm larvae.

In some areas, particularly in low, wet pastures and irrigated land in parts of the West, Southwest, and Southeast, liver flukes are a menace to cattle production. Hitherto there has been no effective method of control except the use of chemicals to kill snails, in which the flukes pass part of their life cycle. During the past year it was found that hexachlorethane used in a mixture with bentonite is an effective internal remedy for infested cattle. This discovery was immediately put to use by producers.

Among the laboratory findings of the year, not yet confirmed on a large scale, are that borax in small quantities is useful in preventing coccidiosis in poultry; that sodium fluoride is an effective remedy for ascarids and stomach worms in swine; and that crude penicillin prepared by filtering the *Penicillium* culture is promising as a treatment for bovine mastitis caused by either streptococci or staphylococci.

During the year, important improvements were made in two widely used disease-control agents. Practical methods were worked out for increasing the yield of the bacteria used in preparing stained antigens for detecting pullorum disease in chickens; and it was found that troublesome contaminations of crystal violet hog cholera vaccine can be prevented by using glycerol in addition to the crystal violet in preparing the vaccine.

The extraordinary success of hybrid corn inevitably raised the question whether similar results could be obtained with animals, and some of the most significant livestock breeding research today is concerned with this question. The work is both difficult and slow, since it involves developing inbred lines to fix desirable characteristics and then crossing selected lines to see whether it is possible to produce controlled hybrid vigor. The long-time project of this type with swine being carried on at the Regional Swine Breeding Laboratory already shows some promising results. It has been found, for example, that if lines within pure breeds are inbred 30 to 40 percent, crossing the inbred lines can be expected to result in hybrid vigor as measured by size of litter and vitality, growth, and economy of gain of the pigs. A valuable earlier result of this work was the development of simple objective standards for selecting sows to be retained as breeders.

Feeding is about half the cost of milk production. Analyses of dairy herd improvement association records were completed during the year which showed that the cost of feed per pound of milk is 25 percent less for cows producing around 8,000 pounds a year than for those producing 4,000 to 5,000 pounds. How to foretell the production of a cow while she is still a calf is a matter of considerable importance to dairymen. A long-time study of this question has resulted in the development of useful criteria based on examination of the calf's udder. By this method, which involves the development of some ex-

pertness in judging the "feel" of the udder, calves can be divided into several grades from the standpoint of their future productive capacity.

NEW FOODS AND BETTER NUTRITION

Whether or not dehydrated foods will be as important in peacetime as they have been in war will depend on their quality, economy, and usefulness in comparison with fresh, canned, and frozen products. Dried milk and dried eggs will undoubtedly continue to have an assured place for certain uses. The place of dehydrated vegetables and dehydrated meats will depend on the individual merits of the different products within those groups. At any rate, the development and improvement of dehydration processes has been a major wartime task of Government laboratories and pilot plants, and they have successfully met the urgent war need. Improvements and refinements in methods and equipment have been made during the past year, and a detailed manual on vegetable and fruit dehydration was published for the use of operators of commercial plants.

Among new food products announced during the year is Velva Fruit, a frozen dessert of excellent quality and full fruit flavor. This product will furnish a new outlet for fully ripe tree fruits, berries, and cantaloups which in many cases could not otherwise be marketed. The ripe fruit can be stored in the form of a frozen puree, which can then be used to make Velva Fruit at any time. The product is made by mixing the puree with sugar and a small quantity of gelatine—a little lemon juice may be added to the less acid fruits—and beating the mixture in commercial ice-cream freezing equipment until it has a smooth, light consistency.

An apple sirup which at present is used mainly as a humectant or moisture-retainer for cigarette tobacco has been announced previously. During the past year a similar sirup for table use, sweet but without an apple flavor, has been developed. A new apple-juice concentrate with a rich apple flavor has also been produced on a pilot-plant scale. This product was made possible by the development of a method for removing and condensing the volatile flavoring matter of apples, which can then be added to concentrated juice. When mixed with about six parts of water, the concentrate makes a full-flavored sweet cider.

One of the most promising new fields of research in foods and nutrition is concerned with amino acids. These are the building blocks that make up the proteins in foods. Each protein has its own peculiar combination of amino acids, but determining the kinds and amounts of the different amino acids in any particular food is a laborious job. During the year methods were announced for readily and directly determining the content of two amino acids, tryptophane and cystine, in foods. Both are among the eight amino acids which, it is now known, human beings must get from food. Methods for determining two other amino acids, threonine and serine, in purified proteins have also been developed. These findings will help to make possible further progress in determining the requirements of human beings for the individual amino acids and their complex and important functions in the body. Work in this field is only at its beginning, but it is likely to have great significance in advancing nutritional knowledge.

The advances made in nutritional research during the past few years have resulted during the war in a greater certainty of knowledge regarding the nutritional needs of soldiers and civilians, and how to meet these needs, than has ever before been possible. The practical value of this knowledge has been evident in Britain and the United States especially. In both countries, nutritional science has been used effectively, though in different degrees and different ways, to guide food management policies.

In the United States, studies and analyses by nutritionists of the Department of Agriculture show that in 1943 the civilian food supply of the American people was sufficient in kind and amount to furnish each individual with more of every nutrient than the average available in 1935-39, the 5 pre-war years; and there is every indication that the same thing will be true in 1944. This is not to say, of course, that each individual obtained his full share, but the record of nutritional progress in spite of war conditions is nevertheless a remarkable one. Much greater progress should be possible after the war, not only in this country but all over the world.

INDUSTRIAL USES OF AGRICULTURAL MATERIALS

In the development of industrial uses for agricultural materials there are three steps of equal importance: (1) A capable laboratory job; (2) testing of the laboratory findings on a fairly large scale, in a pilot plant which duplicates, in a small way, the conditions in a commercial plant; and (3) cooperation and exchange of information with interested industries. One of the major contributions of the four regional research laboratories has been that a great deal of attention has been paid to the two latter steps, without which laboratory developments may never reach the stage of practical use.

During the war, of course, the research work in these laboratories has been concentrated on products and processes needed in wartime. Penicillin and dehydrated foods have already been mentioned. Considerable attention has been given to rubber. During the past year, for example, experimental work was practically completed on the process for producing butylene glycol from grain and converting the butylene glycol to butadiene; and a design for an industrial plant to use the process was prepared by a manufacturing firm. Processes have also been worked out for the recovery of rubber from kok-saghyz, guayule, and goldenrod.

A current research project is concerned with the improvement of tire cords made from cotton—one of the large outlets for this fiber before the war. In this work, considerable progress has been made in improving cotton cords for low-gage (small-diameter) tires by (1) the use of specially selected varieties of cotton, and (2) new and improved chemical and mechanical treatments. A new cotton bandage fabric of special texture and stretching properties has also been developed and is being tested by the military forces with promising results.

Noreseal, a new substitute for cork, made of ground peanut hulls or other agricultural byproducts, has been perfected to the point where it is being tried out under practical operating conditions in two pilot plants. Norelac resin, a new thermoplastic material made from

soybean oil, is also being evaluated in a pilot plant by a commercial concern. Promising fundamental research in modifying the character of oils so that they will have greater flexibility for different specialized uses has resulted so far in the laboratory conversion of cottonseed oil into a cocoa-butter substitute and of peanut oil into an olive oil substitute for industrial use. In the field of starch chemistry, a new process has been developed and is in commercial use for separating wheat flour into starch and gluten; the starch can in turn be converted into sugar sirups, as in the case of cornstarch, and the gluten can be used to produce monosodium glutamate. In connection with sweetpotato starch, the outstanding recent development is the building of a commercial manufacturing plant costing several million dollars by a large sugar company to use a process which was worked out by Department scientists.

These are only a few of the new developments in agricultural-industrial research, some of which are likely to have considerable post-war significance in meeting the problem of how to use our large production of certain agricultural commodities.

WORK OF THE ADMINISTRATOR'S OFFICE

The work of the Administrator's office of the Agricultural Research Administration has included such activities as these:

One of its first tasks was to review the then-existing research program and direct the changes necessitated by war.

It reviews all new projects, especially from the standpoint of eliminating avoidable duplication and assuring a simultaneous cooperative attack on each problem by all the sciences that can contribute to its solution.

It has served in general as the primary contact between the bureaus and such agencies as the War and Navy Departments, the War Production Board, the Rubber Director's Office, and the War Food Administration, planning, assigning, and coordinating research work to be done by the bureaus for these agencies.

It has brought the chiefs of all bureaus together regularly to work out common problems, and it has arranged meetings with groups of nationally known experts from outside the Department to consult on various research programs.

It coordinates the information and publication work of the bureaus with a view to improving and expediting the reporting of research results for farmers, scientists, and the public. This includes arranging for joint preparation of material involving two or more bureaus.

It has administered certain confidential wartime projects.

It directly administers the Plant, Soils, and Nutrition Laboratory—one of the 9 Bankhead-Jones laboratories—at Ithaca, N. Y., the work of which is broader in scope than that of any one bureau.

It directly administered the emergency meat-dehydration project, which began early in 1942 and was closed June 30, 1943, when its objectives were attained.

It has done a limited amount of reorganizing where it was evident that a regrouping of certain activities was desirable from a research standpoint.

It has acted as coordinator on major budgetary and personnel matters, especially where uniform procedures and common action were advisable.

It is working out a simplified project-reporting system for administrative use. This is a major problem, since thousands of projects are involved on which progress must be reported adequately yet without taking up too much of the scientists' time in paper work.

These activities are only the necessary top layer of the work of the Agricultural Research Administration. The mass of the work consists of the detailed research carried on all over the country by its scientists and those cooperating with them in the State experiment stations and other agencies.

MANY WARTIME DEVELOPMENTS HAVE PEACETIME SIGNIFICANCE

The war inevitably stimulated research in some fields and held it back in others. On the whole, the period has been rich in technical developments, some of which will continue to be of immense value after the war. Some, indeed, will only then reach their full usefulness, as in the case of new methods of fighting insects, now confined almost entirely to military needs. On the other hand, some of the new developments may have only a limited value in peace, as compared with their importance under the abnormal conditions of war.

In any event, the end of the war, like its beginning, will bring new and urgent problems for agriculture, and agricultural science will face as great a challenge in helping to solve them as it faced in meeting the problems of war. Just as factory production has been geared to special wartime needs, so has farm production. Both have been built to unprecedented capacity. The reconversion to peace will call for all the scientific knowledge we can muster if this productive capacity is to be a blessing instead of a curse—if it is to mean, not disastrous surpluses and unemployment, but abundance and well-being.

REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL AND INDUSTRIAL CHEMISTRY, AGRICULTURAL RESEARCH ADMINISTRATION, 1944

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 29, 1944.

DR. E. C. AUCHTER,
Administrator of Agricultural Research.

DEAR DR. AUCHTER: I present herewith the report of the Bureau of Agricultural and Industrial Chemistry for the fiscal year ended June 30, 1944.

Sincerely,

ORVILLE E. MAY, *Chief.*

INTRODUCTION

The Bureau of Agricultural and Industrial Chemistry attempts through research to benefit agriculture and at the same time to make major contributions to the welfare of the Nation as a whole. To achieve this goal the Bureau develops both food and nonfood uses for agricultural commodities and wastes by the application of chemistry and allied sciences. Established industrial uses of inedible products receive attention because it may be desirable to better adapt the products to these uses. New uses of primary or derived products are sought to provide adequate consuming markets. In cases where domestic agricultural products are lacking, or insufficient, or unsuitable for particular industrial uses, efforts are made to find domestic products that can serve directly, or be adapted to serve, the special purposes.

During the past year, as during 1943 and part of 1942, the work of the Bureau was concentrated on particular phases of its authorized fields of research that promised to yield information of value in furthering the Nation's war effort. Some of the work was suggested by and conducted in collaboration with the War or Navy Department or special war agencies. However, some time and thought were given by the administrative officers and division heads to the revision of current projects and preparation of new research line projects that can be put in effect promptly when it is possible again to emphasize peacetime objectives in the research program of the Department.

This Bureau collaborated with other units of the Department and with State agricultural agencies by preparing reports on the industrial alcohol and food processing industries to aid in post-war planning. As usual, conferences were held with representatives of the State agricultural experiment stations to consider the programs of the Bureau's four regional research laboratories.

In addition to the brief statements in this report on some of the important results of research during the past year, more detailed information on these and other research activities of the Bureau may be found in the 268 publications issued by it during the year and in the specifications of the 10 patents granted to employees. A list of publications and patents is available in mimeographed form.

The two most important industrial developments during the past year that resulted in large measure from the research work of this Bureau were the phenomenal growth of penicillin manufacture and the definite establishment of the sweetpotato starch industry by the construction of a privately owned and financed plant to process about 150 tons of sweetpotatoes per day. Although not yet in commercial use, the processes for making butadiene, the most important intermediate for synthetic rubber, from butylene glycol and for making the latter by fermentation of grain have been brought through laboratory and pilot-plant experiments to the stage where they can be applied commercially.

The research on food dehydration resulted in the publication of a manual for plant operators containing explicit instructions for dehydrating particular vegetables and fruits.

For the first time, the possibility of complete factory conversion of raw starch to sugars by mixed enzymes, as occurs in the digestive tracts of some animals, was demonstrated. An improved process for separating starch from wheat flour and recovering the protein unchanged in physical and chemical properties was developed. A new polymerizable starch derivative, allyl starch, which before polymerization is insoluble in water but soluble in organic solvents, was prepared and shown to be useful for protective coatings and laminated plastics.

Adhesives were made from peanut protein and found to be useful without heat for gumming paper, for bookbinding, and for making paper boxes. A waterproof glue for plywood was made from soybean meal and phenolic resin.

Fractions of ground corncobs and other crop residues were proven to be among the best materials available for use as soft grit in cleaning airplane engines and other fine machine parts by air blast.

New oil-soluble and water-insoluble nicotine compounds, some having fungicidal properties, were developed for insecticidal use.

A new process of recovering tartaric acid and tartrates for food and industrial uses from the wastes of the domestic wine and brandy industries was proven to be commercially feasible.

Sweetpotato vines preserved as silage were found to be equal to corn silage in feeding value and eminently suitable for winter feeding of dairy cattle in the South.

Cotton tire cords were greatly improved in physical properties by a "dual-stretch" process developed at the Southern Regional Research Laboratory.

Sixty-five applications for patents were filed in the Patent Office and information for use in preparing 108 additional applications was sent to the Office of the Solicitor. Ten patents were granted during the year and action on 147 patent applications was still pending on June 30, 1944.

The Nicholas Appert medal for outstanding work in food technology was awarded on May 30 to Dr. C. A. Browne, formerly Chief of the

Bureau of Chemistry, and since his retirement from the position of Supervisor of Chemical Research in 1940 an unpaid collaborator in this Bureau.

Dr. William W. Skinner, who became Chief of the Bureau in November 1942 following the death of Dr. Henry G. Knight and who had previously been Assistant and Associate Chief of the Bureau for many years, retired on March 31, being succeeded by the present Chief, Edward M. Chace, who had been in charge of the Bureau's Fruit and Vegetable Chemistry Laboratory at Los Angeles for 32 years, retired on June 30. Charles A. Wolfe, formerly head of the Division of Administrative Services, retired from his position as administrative officer on December 31, 1943, because of disability. Up to the end of the fiscal year, 220 persons, about one-third of whom were professional employees, had been furloughed for military service. The total number of full-time employees on the pay roll of the Bureau on June 30, 1944, was 1,246, of whom 603 were professional employees. The administrative officers of the Bureau and heads of its research laboratories and divisions, as of June 30, 1944, are listed below.

BUREAU ORGANIZATION AT END OF FISCAL YEAR 1944

Chief of Bureau.....	Orville E. May.
Assistant Chief.....	Carl F. Speh.
Assistant Chief.....	Henry A. Donovan.
Agricultural Chemical Research Division.....	Harlow H. Hall, Acting Chief.
Allergens Research Division.....	Henry Stevens, Chief.
Enzyme and Phytochemistry Research Division.....	Arnold K. Balls, Chief.
Pharmacological Research Division.....	Floyd DeEds, Chief.
Microbiology Research Division.....	Vernon H. McFarlane, Acting Chief.
Naval Stores Research Division.....	Leo A. Goldblatt, Acting Chief.

NORTHERN REGIONAL RESEARCH LABORATORY, PEORIA, ILL.

Director.....	Horace T. Herrick.
Agricultural Motor Fuels Division.....	Cecil T. Langford, Acting Chief.
Agricultural Residues Division.....	Elbert C. Lathrop, Chief.
Analytical and Physical Chemical Division.....	Reid T. Milner, Chief.
Commodity Development Division.....	P. Burke Jacobs, Acting Chief.
Engineering and Development Division.....	Cecil T. Langford, Chief.
Fermentation Division.....	Robert D. Coghill, Chief.
Oil and Protein Division.....	John C. Cowan, Chief.
Starch and Dextrose Division.....	Guido E. Hilbert, Chief.

SOUTHERN REGIONAL RESEARCH LABORATORY, NEW ORLEANS, LA.

Director.....	Daniel F. J. Lynch.
Assistant Director.....	Howard S. Paine.
Analytical, Physical Chemical, and Physical Division.....	Turner H. Hopper, Chief.
Chemical Engineering and Development Division.....	Edward A. Gastrock, Chief.
Cotton Chemical Finishing Division.....	James D. Dean, Chief.
Cotton Processing Division.....	Robert J. Cheatham, Chief.
Cotton Fiber Research Division.....	W. Kyle Ward, Jr., Chief.
Oil, Fat, and Protein Division.....	Klare S. Markley, Chief.
Sweetpotato Products Division.....	Paul R. Dawson, Chief.

EASTERN REGIONAL RESEARCH LABORATORY, WYNDMOOR, PA.

Director.....	Percy A. Wells.
Assistant Director.....	Rex E. Lothrop.
Analytical and Physical Chemistry Division.....	Michael J. Copley, Chief.
Biochemical Division.....	John J. Willaman, Chief.
Carbohydrate Division.....	Lee T. Smith, Chief.
Chemical Engineering and Development Division.....	Roderick K. Eskew, Chief.
Hides, Tanning Materials, and Leather Division.....	Jerome S. Rogers, Acting Chief.
Oil and Fat Division.....	Waldo C. Ault, Chief.
Protein Division.....	Richard W. Jackson, Chief.

WESTERN REGIONAL RESEARCH LABORATORY, ALBANY, CALIF.

Director.....	Theodore L. Swenson.
Biochemical Division.....	Howard D. Lightbody, Chief.
Commodity Byproducts Division.....	Louis B. Howard, Chief.
Commodity Processing Division.....	Robert P. Straka, Acting Chief.
Engineering and Development Division.....	Wallace B. Van Arsdel, Chief.
Physicochemical and Analytical Division.....	Charles H. Kunsman, Chief.
Protein Division.....	George H. Brother, Acting Chief.

PENICILLIN PRODUCTION NOW AN ESTABLISHED INDUSTRY

Last year's report told how the research of the Northern Regional Research Laboratory on penicillin, discovered and proved by British scientists, had helped to get commercial production of this powerful mold-produced antibiotic started. With the improved fermentation process developed by the Northern Regional Laboratory as a basis, production had been undertaken during the year by 17 chemical and pharmaceutical manufacturers.

The growth of the penicillin industry during the past year and a half has been one of the most remarkable developments in the whole war-production program. From approximately 100,000,000 Oxford units per month early in 1943 (about enough to treat 100 serious cases) the production of this invaluable therapeutic agent had increased a thousand-fold to 100,000,000,000 units per month by the middle of 1944. The War Production Board's tentative goal of 200,000,000,000 units per month was expected to be reached by the end of 1944. At the present time penicillin is being used routinely in the front lines of the Allied Armies in Europe as a purely prophylactic agent, with the result that Army doctors are tremendously enthusiastic about the way wounds are healing without infection setting in.

To produce the required quantities of penicillin 21 industrial plants have been, or are being, erected in the United States and Canada, varying in capacity from 1,000,000,000 to 70,000,000,000 units per month. Approximately 80 percent of the total production will result from the application of the submerged or "deep" fermentation method, 15 to 18 percent from surface fermentation, and the remainder from the growth of the mold on bran. However, the trend is definitely toward the submerged-fermentation method, and probably all penicillin will be made by this method within a year or two.

The contributions of the Northern Regional Laboratory to the production of penicillin can be divided into three categories: (1) The development of new and better organisms; (2) the discovery of superior

media and operating conditions for the actual fermentation; and (3) improvement of methods for recovering the penicillin from the broth in a form suitable for clinical use.

All industrial penicillin plants in this country are using particular strains of mold developed in the Peoria Laboratory. For surface fermentations, *Penicillium notatum* NRRL 1249.B21 is used exclusively. This organism, although descended from the original Fleming strain, is about twice as good as that strain as ordinarily encountered. The improvement in its penicillin-producing ability was brought about by a process of single spore selection and cultivation, continued until low-yielding variants had been eliminated and the strain had become somewhat stabilized at the higher level. For the submerged or deep fermentation, *P. notatum* NRRL 832 is the strain used. It is not a descendant of the original Fleming strain, but is one of those found in the extensive culture collection of the Northern Regional Laboratory. It is much more stable than the strain used for surface fermentations and can be readily distinguished by microbiologists familiar with the two strains. Recently a strain of *Penicillium chrysogenum* that gives high yields of penicillin was isolated from a moldy cantaloup. This new organism, NRRL 1951.B25, is markedly superior to both of those now used, and it is predicted that eventually it will be adopted by most of the commercial penicillin producers.

The Bureau has made three reports on the improvement of culture media; one of these was confidential in nature. The most important development was the incorporation in the culture medium of corn-steep liquor, a byproduct of the cornstarch industry. The modified nutrient, which increased penicillin yields 30 to 40 times, is being used by all penicillin producers, with a resulting demand for 12,000,000 pounds of corn-steep liquor for the calendar year 1944. The Bureau also found that lactose (milk sugar) is decidedly superior to any other easily available sugar as an energy source for the mold—at least in so far as penicillin production is concerned. Most penicillin plants now use this sugar exclusively, and this use requires more lactose than do all other uses combined; probably 5,500,000 pounds will be used in 1944 and 7,000,000 pounds in 1945.

The Bureau's contribution to methods for isolating penicillin from the spent culture media was considered so important by the Patent Office that its publication was prohibited by a secrecy order. The improved method is being used in some of the industrial plants.

The processes used in the penicillin industry today are based largely upon the methods of producing this drug developed in the investigations begun by the Northern Regional Research Laboratory in July 1941. The results of this research have been made available in three ways. They have been written up in the form of reports that have been made available to the Committee on Medical Research of the Office of Scientific Research and Development, with which the Bureau has been closely cooperating. These reports, classified as "Restricted," have been distributed by the Committee on Medical Research to all the producers and a few others who had a legitimate interest in the problem. To further aid in making this information available to producers, members of the Northern Regional Laboratory's staff have served in the capacity of consultants, traveling from plant to plant and assisting in the application of the methods developed by

the laboratory. Finally, the penicillin industry has availed itself of the opportunity to send groups of its own research scientists to Peoria to learn the techniques being practiced there. This opportunity has been open to foreign as well as domestic groups, including representatives from various South American countries, England, and China.

To summarize, the Bureau's concentrated research on penicillin since July of 1941 has resulted in: (1) Increasing the yield of penicillin by surface cultures 150-fold—from 2 to 300 Oxford units per milliliter of medium; (2) demonstrating that penicillin can be produced by the more practical method of submerged culture in yields of 150 to 175 units per milliliter and supplying an organism especially adapted to this method; and (3) facilitating the establishment of the new \$20,000,000 penicillin industry in time to save the arms and legs and lives of thousands of soldiers and sailors of this and other countries of the Allied Nations in the present world conflict.

ANTIBACTERIAL SUBSTANCES PRODUCED BY BACTERIA GROWN ON ASPARAGUS WASTE

Certain chemical substances synthesized by animals, plants, and micro-organisms have the power to prevent or retard the growth of disease germs or actually to destroy them. They are known as antibiotics. Penicillin is an antibiotic that has attracted much attention within the past 2 years. There are other antibiotics, not so generally known, that are useful as surface applications in treating animal and human diseases caused by pathogenic microbes. Some, like citrinin, are produced by molds; others, like tyrothricin, are produced by bacteria; and still others, like lysozyme, exist naturally in animal and plant tissues or secretions.

The problem of producing antibiotics by culturing micro-organisms has received attention at the Western Regional Research Laboratory as a phase of its investigations on the utilization of vegetable and fruit wastes. The juice pressed from asparagus butts, available in large quantities at asparagus canning plants, has been found to have properties favorable to the propagation of certain micro-organisms, including some that produce antibiotics.

Research in cooperation with several industrial organizations has demonstrated that concentrated asparagus juice is useful as a culture medium for the bacteria that produce tyrothricin. Use of the asparagus-juice culture medium appears to make possible a fourfold to fivefold increase in yields of tyrothricin over those regularly obtained industrially.

An antibiotic that had not been previously isolated and described was prepared by growing another species of bacterium in an asparagus-juice medium. This new antibiotic, which has been named "subtilin" from the species producing it, seems to have several advantages over tyrothricin. Yields per unit of time are much larger, and the period of incubation required before the organism produces maximum yields is much shorter than in the case of the tyrothricin-producing organism. The antibiotic activity per unit weight of partially purified subtilin, as estimated by bioassay with *Staphylococcus aureus*, is considerably greater than that of tyrothricin. The pharmacological properties of subtilin, although not yet extensively investigated, ap-

pear to be such that the clinical use of the product may not be limited to surface applications.

A process has been developed for preparing from asparagus butts a juice concentrate that is suitable for use by the microbiological products industry because it can be stored for a reasonable time before use. It consists of disintegrating the butts in a hammer mill, pressing the mass with a screw press, digesting the juice with naturally occurring enzymes, filtering it through cloth prepared with carefully selected filter aid in a plate-and-frame filter press, and concentrating the filtrate in a vacuum of at least 28 inches to a solids content of 70 to 75 percent. An experimental pack of the concentrate, in metal containers, was prepared by an asparagus-canning plant, and the product was made available to the microbiological products industry for experimental use and further evaluation. Requests for many tons of the asparagus-juice concentrate have been sent to the packer by industrial firms engaged in manufacturing antibiotics.

ANTIBIOTICS TESTED FOR TOXICITY TO ANIMALS

Before antibiotic substances produced by micro-organisms or isolated from plants or animal tissues or secretions can be used safely against pathogenic organisms, their toxicity to animals and probable toxicity to human beings must be known. For this reason, the Pharmacological Research Division started investigations on the physiological effects of citrinin and other antibiotics on small animals. It was first necessary to purify available samples of material. A simple and rapid method was developed for purifying citrinin, after which the toxicity of the pure compound was determined for rats, rabbits, and guinea pigs. The tests showed the necessity of limiting the quantity administered to very small doses. Progress has been made in determining exactly the maximum dosage that can be tolerated and in learning the mechanism of the toxic reactions, rate of excretion, maintenance of the drug's concentration in the blood, and distribution in the tissues. This information is necessary to evaluate citrinin as a potential therapeutic agent.

ALLERGENIC COMPONENT OF CASTOR BEANS SURVIVES COOKING

Recent studies on allergens of agricultural products revealed the nature of hazards confronting those exposed to castor beans in milling operations and in utilizing the press cake from the recovery of castor bean oil. The toxic protein component, ricin, which has disqualified the press cake for edible products, can be rendered virtually harmless by thorough cooking. However, a treacherous hazard was recently identified in the form of another protein component, CB-1A, which survives the cooking and retains extraordinary capacity to first induce sensitiveness to this component and then to provoke severe allergic reactions upon subsequent exposure to it, as in dust from the dried bean or the press cake. Both domestic and imported varieties of castor bean are essentially alike in this respect.

Continued research in collaboration with the Office of the Surgeon General, on egg proteins as extraneous allergens of certain highly important vaccines, yielded information of value in maintaining the health and efficiency of this country's armed forces. At present this is restricted to official use.

RUTIN, NEW MEDICINAL AGENT, ISOLATED FROM TOBACCO

In its research on the industrial utilization of tobacco, the Eastern Regional Research Laboratory isolated from flue-cured bright tobacco a substantial quantity of the yellow plant pigment rutin, recently proved to have medicinal value. The method used comprised percolation of the coarsely ground leaf tobacco with ethyl alcohol at room temperature, removal of alcohol by evaporation, extraction of the residue with boiling water, filtration, cooling of filtrate, recovery of material deposited on cooling, and purification of this material by repeated crystallizations from solutions in hot dilute ethyl alcohol. The yields ranged from 0.008 to 0.61 percent, averaging about 0.4 percent for good-quality leaf. The best yields were obtained from leaf of high quality. No rutin was obtained from stems or midribs. Lower yields were obtained when methyl alcohol was used instead of ethyl alcohol for extraction and recrystallization.

Many samples of cured tobacco were examined at the Eastern Regional Laboratory, but no rutin was obtained from any air-cured type. This substantiates the results of previous investigators which indicated that any rutin in the green tobacco would be oxidized to brown pigments during the air-curing process. Flue curing evidently inactivates the enzymes that catalyze oxidation and is thus responsible for the persistence of rutin in the cured product. Moreover, the bright tobacco for which the flue-curing process is used probably contains more rutin originally than other tobaccos.

An unsuccessful attempt was made to extract rutin from green Pennsylvania cigar filler tobacco. If it were possible to extract rutin from green tobaccos, unsalable leaf could be harvested for use as a source of rutin. Whether the failure was due to faulty technique or to the fact that no rutin exists in green tobacco of this type is not yet known. Further investigations are contemplated.

The rutin prepared from flue-cured tobacco was supplied to the Medical School of the University of Pennsylvania for clinical testing. Its value in treating cases of increased fragility of blood capillaries, the breaking of which sometimes causes apoplexy in persons with high blood pressure, was confirmed by marked improvement in most of the patients treated. By combining rutin with remedies for high blood pressure, definite improvement can be effected in a shorter time. The chemical properties of rutin and results of the treatments with it were reported by two scientists from the University of Pennsylvania and one from the Eastern Regional Laboratory to the Pennsylvania State Medical Society, which awarded a prize certificate to the three scientists in appreciation of their work.

OIL-SOLUBLE NICOTINE COMPOUNDS DEVELOPED

Heretofore, the use of nicotine and nicotine compounds as insecticides has been somewhat limited since no suitable oil-soluble, water-insoluble derivative of the alkaloid was known. An oil-soluble, water-insoluble nicotine insecticide would have definite advantages including: (1) Increased efficiency in penetrating the waxy protective coatings of insects, (2) concentration in the oil phase of oil-in-water emulsions, and (3) longer serviceability resulting from decreased removal from plant surfaces by rains and heavy dews.

Continued research by the Eastern Regional Research Laboratory on the nicotinammino-salt type of nicotine compounds, previously reported, has resulted in the preparation of a unique series of compounds that are insoluble in water but soluble in hydrocarbon solvents such as are used in oil sprays. Each of these compounds is a double salt of nicotine and a bivalent metal with certain fatty acids. Since copper, a recognized fungicidal agent, is particularly well suited for the preparation of an oil-soluble nicotine compound, it is possible to prepare a product that possesses fungicidal as well as insecticidal activity. The compounds appear to be sufficiently stable to promise an increased residual toxicity over free nicotine or nicotine sulfate. Preliminary tests by the Bureau of Entomology and Plant Quarantine have shown that these compounds are as toxic as or slightly more toxic than nicotine itself on an equimolecular-weight basis. Several industrial companies have requested samples of these compounds for testing. Although these oil-soluble compounds would be classified under fixed-nicotine type on a chemical basis, they have been found to be effective against *Aphis rumicis*, for which the free-nicotine type of insecticide is commonly used. Commercial production of an oil-soluble copper-nicotine compound may result from the fact that it supplies an insecticide and a fungicide in one package and in one application.

FURTHER ADVANCES MADE IN FOOD DEHYDRATION

The results of the engineering and technological research and of incidental studies on dehydration of food that have a direct bearing on commercial production of dehydrated vegetables and fruits, were published by the Department as Miscellaneous Publication No. 540, entitled "Vegetable and Fruit Dehydration—A Manual for Plant Operators." This manual makes available to actual and prospective commercial plant operators useful information gained through research during the last 3 years at the Western Regional Research Laboratory, as well as the results of collateral investigations and previously existing information pertinent to the subject.

During the past year, the Bureau continued its research on dehydration and on dehydrated foods, in cooperation with the industry and with State and Federal Government agencies, the main purpose being to further improve the palatability and keeping quality of dehydrated vegetables, fruits, and eggs. This general objective involves improvements in processing equipment and technique, in packaging, in the selection and control of storage conditions, and in chemical-testing methods for controlling enzyme inactivation and for determining vitamin retention by dehydrated foods.

Research on procedures for compressing dehydrated foods in order to make the saving in bulk as great as the saving in weight, which had already received some attention in the Bureau's dehydration research program, was broadened and accelerated as the result of a special grant of supplementary funds by the Office of Production, Research, and Development of the War Production Board and carried out in cooperation with that agency. The experiments were confined to the seven most important dehydrated vegetables (potatoes, sweetpotatoes, onions, cabbage, carrots, beets, and rutabagas) and to spray-dried

whole eggs. All except potatoes and eggs could be easily compressed by a relatively simple procedure, which comprised prewarming the dry product, pressing it into 1-pound or 2-pound block with a hydraulic press, and immediately restraining and cooling the compressed block. A package made up of such blocks contained from 50 to 150 percent more net weight of food than one of the same size containing the un-compressed material in bulk. Dehydrated potatoes were compressed successfully in the laboratory by pressing them into blocks while slightly moist and then drying them to the required degree, but no practical means for carrying out this procedure on the commercial scale, without injuring the product, has yet been devised. A similar expedient was used for dehydrated eggs, but the difficulty of drying the compressed blocks is so great that a means of preparing satisfactory blocks directly from the low-moisture powder is still being sought.

Improvements in dehydrator design were made available to the industry. Not only the versatile and simple counterflow tunnel drier, but also the more efficient two-stage combination of tunnel and bin driers and a simple and efficient portable cabinet drier suitable for institutional use were analyzed in the light of operating experience and new experimentally acquired knowledge about the drying characteristics of the common vegetables. The resulting designs are more solidly based on exact information than has ever before been possible.

Further improvements in the auxiliary equipment used by the dehydration industry were also devised during the year. A radically new way of constructing and operating steam blanchers was demonstrated on a pilot-plant scale. While development work has not been completed, the indications were that the new blancher offers a possibility of major savings in space requirement, equipment cost, maintenance cost, and steam consumption in blanching vegetables before drying them, which is an essential step in most cases.

The application of sulfur dioxide gas or sulfite solution to cabbage before dehydration, previously practiced by food packers in Canada and England, became common in the United States during the past year. Investigations at the Western Regional Laboratory confirmed the claims that this practice is advantageous. Higher drying temperatures can be used, and retention of color and vitamin C is more satisfactory, when sulfite is used. Because of these advantages, Government purchasing agencies adopted specifications that required the application of sulfite to cabbage in proportions of 750 to 1,500 parts per million of dehydrated cabbage. In order to learn how to meet this requirement, intensive studies were made in the Bureau's dehydration pilot plant and in commercial plants. A practical and effective method of applying sulfite solution during the blanching operation was devised. It entails a minimum of disturbance in the regular plant operations. This method has been used in the commercial production of several million pounds of improved dehydrated cabbage.

Since no easy method for determining the sulfite content of treated cabbage was available, either for plant control or for inspection, a simplified analytical procedure for sulfur dioxide in dehydrated foods was developed. It is being used as the official method by Government inspectors.

The sulfiting studies were extended to determine if there is any advantage in applying sulfur dioxide gas or sulfite solution to other

vegetables, such as potatoes, sweetpotatoes, carrots, onions, and tomatoes. Experiments are in progress to determine the optimum concentration of sulfur dioxide in the dried vegetable, and the best method of application.

The results of storage tests on vegetables, dried under similar conditions to different moisture levels and stored at different temperatures in air, in oxygen-free nitrogen, and in nitrogen containing low proportions of oxygen, threw light on the question as to what factors are responsible for deterioration during processing and storage. It was clearly demonstrated that the keeping quality of carrots and cabbage can be greatly improved by further reduction of moisture content, and that this factor outweighs the influence of the surrounding atmosphere. On the basis of information gained from these tests, a procedure was devised for learning in a relatively short time the probable shelf life of vegetables dehydrated to definite moisture levels and stored at definite temperatures.

The conditions under which potatoes and onions have been stored prior to dehydration were found to influence the drying characteristics of these vegetables and the quality of the dried products. Much of the discoloration and low quality of some dehydrated potatoes was traced to an increase in sugar content of the raw potatoes caused by low-temperature storage. It was shown that the bad effects of cold storage can be overcome in some measure by holding the potatoes at or above room temperature for about two weeks before processing.

Excessive blanching was found to be responsible for the poor quality of some of the dehydrated potatoes produced last year. The dried potato strips showed a marked tendency to lose shape and become mushy during rehydration and cooking if the raw potatoes had been blanched long enough to completely inactivate the peroxidase enzyme, as specified for Government purchases. Storage tests proved that blanching for a shorter time, which permitted some residual peroxidase, did not adversely affect keeping quality. To allow for such conditions, an entirely new peroxidase test was developed; it permits the application of a tolerance and overcomes much of the subjective character of the old test.

A number of reasonably good fruit powders were prepared in spray-drying experiments on a laboratory scale. The successful production of whole-orange powder was the most significant achievement. The juices of some fruits were spray dried, after addition of sugar and pectin, to produce jelly powders. These can be converted to jelly by heating for a short time in water. Several substances were found to be effective as drying aids for facilitating the desiccation of fruit juices to free-flowing powders. A large pilot-plant spray drier of unique construction was designed and installed at the Western Regional Laboratory for spray-drying experiments on a larger scale.

Pilot-plant experiments yielded further information regarding the best conditions (temperature, humidity, tray loading, etc.) for use in the dehydration of different vegetables, different varieties of the same vegetable, and particular vegetables subjected to different preparatory treatments or different conditions of storage in the raw condition. This information made it possible to suggest ways of overcoming some shortcomings in raw material and producing wholly acceptable products from types of raw material previously thought to be unusable.

QUALITY OF DRIED EGGS IMPROVED THROUGH MICROBIOLOGICAL STUDIES

A 30-fold increase in production of dried whole-egg powder occurred between 1939 and 1943 in order to supply increased quantities of eggs in a convenient form for packaging and transportation under lend-lease arrangements and also, since early in 1942, for American armed forces abroad. By the end of 1942 more than 100 plants were drying eggs; and, as might be expected, some of the operators did not fully realize that high quality depends upon strict sanitation in handling and processing, refrigeration of shell eggs and liquid-egg mix while being held for drying, and use of only clean, high-grade, strictly fresh eggs. Many complaints were made that the egg powder did not keep well, that it had an unpleasant odor or flavor, and that it sometimes contained food-poisoning bacteria.

The Bureau of Agricultural and Industrial Chemistry was asked by food-control and food-purchasing agencies of the Government to make microbiological studies on commercial dried eggs to determine their quality before purchase and exportation and to learn where improvements might be made in the product.

Thus far, nearly 3,000 samples of commercial egg powder have been obtained from egg driers throughout the United States and examined for different kinds of micro-organisms by the Microbiology Research Division. The Division wanted to learn how the proportions of microbial species in dried eggs are affected by geographic and seasonal conditions, handling practices, type of drier, and drying and storage conditions. The Government, through the Office of Distribution of the War Food Administration and the Foreign Economic Administration, has made immediate use of the data in several ways. For example, these data helped in evaluating the quality of the egg powder offered, in judging the quality of the shell eggs used, and in determining sanitary conditions in different plants and which plants should receive official approval as sources of dried eggs. They helped also in establishing tentative microbiological standards and in assuring foreign food missions that every effort is being made to improve the quality of dried eggs being produced in the United States.

The results of the microbiological studies were of service to the industry too, particularly as a basis for and guide in continued endeavors to improve the quality of dried eggs, and as an inspiration to compete in the production of egg powder having the highest possible quality. They have convinced the industry that in order to produce an egg powder of low microbial count, high palatability, and ready solubility—one that will more nearly resemble fresh egg—it is necessary to use for drying only clean, high-quality shell eggs and to apply strict sanitary principles in all stages of handling, processing, storing, and distributing.

"VELVA FRUIT" OFFERS COMMERCIAL OUTLET FOR SURPLUS CANTALOUPS AND OTHER FRUITS

"Velva Fruit" is the name of new high-quality frozen-fruit dessert developed by the Western Regional Research Laboratory. It has been recorded in the U. S. Patent Office as a generic name that may be used by any manufacturer for frozen desserts of a particular type

to distinguish them from other frozen desserts. Usually Velva Fruit contains only pure fresh-fruit puree, sugar (enough sugar being added to bring the soluble-solids up to 33 to 37 percent by weight), and 0.6 to 1 percent of gelatin in the form of a 10-percent sol. The milder-flavored fruits require addition of a little citric acid, not over 0.25 percent, to give tartness. One of the specifications in the official record of the name is that Velva Fruit shall not contain artificial flavor or color.

Velva Fruit has the natural flavor and color of the fresh fruit from which it is made, along with a pleasingly soft, smooth texture, essentially the same as that of ice cream. This texture is obtained by freezing the prepared mix in an ice-cream freezer, which incorporates sufficient air into the mass to give an "overrun," or increase in volume, of up to 100 percent. When the desired overrun has been obtained, the temperature of the product is adjusted to between 18° and 25° F. to facilitate drawing.

This new dessert differs from fruit ices and sherbets in having a much higher content of fruit puree and a much greater overrun. Ices and sherbets usually contain not more than 20 percent of fruit puree or juice by weight, whereas Velva Fruit contains over 50 percent. Sherbets have 25 to 40 percent overrun, while Velva Fruit has 80 to 100 percent. All of the nutritional qualities of the fresh fruit are well preserved in this new food, including a very large proportion of the fugitive vitamin C, which is more abundant in fresh than in cooked fruits.

Superior quality in Velva Fruit depends to a large extent on the selection of fully plant-ripened fruit that will produce a puree having a pronounced, characteristic flavor. The kinds and varieties of fruits found thus far to be most suitable are strawberries, raspberries, dewberries and their hybrids, blackberries, red-fleshed plums, cantaloups, apricots, peaches, and blends of berries with apples or pears.

Cantaloup Velva Fruit is one of the most promising of the many kinds tried, and one of the most interesting because it provides a means of utilizing a large proportion of the surplus cantaloups that are left in the field each year, either because the fruit matures too rapidly to be absorbed by the fresh-fruit market or because it is blemished, misshapen, or off-grade in size. It is estimated that around 20,000 tons of cantaloups have been wasted each year in only one of the growing areas in California because heretofore no use could be made of the melons unsuited for the fresh-fruit market.

In preparing the fruit puree a substantial proportion of finely divided fruit solids should be included. A clear juice or thin puree lacks the "body" provided by fruit solids, which are essential to good quality. However, the fruit solids must be finely divided to provide a smooth texture in the dessert. If air is incorporated while the puree is being prepared the vitamin content, and in many kinds of fruit the flavor and color, will be adversely affected.

In preparing purees to be quick-frozen for subsequent use in Velva Fruit manufacture, the flavor is best retained, as a rule, if heat treatment of the fruit or puree is avoided. It is desirable therefore to quick-freeze the puree promptly and, at the time it is to be made into Velva Fruit, to defrost it by placing the closed container in a cool

place, so as to prevent deterioration from oxidative changes and microbial growth. Apricots and plums are exceptions to the rule, in that the flavor of apricots is improved, and the quality of plums is stabilized without impairing their fresh flavor, by flash-heating to 190° to 200° F., followed immediately by rapid cooling. Some fruit, like peaches and light-colored sweet cherries, having flesh that turns brown when exposed to air, are put in boiling sugar sirup for 2 to 5 minutes before being reduced to puree.

CITRUS JUICE CONCENTRATES UNDER INVESTIGATION

Citrus fruit juices provide an excellent natural source of vitamin C and are in great demand in Great Britain and other Allied Nations where people normally consume fresh fruit as the source of this vitamin. Because of limited shipping space for fresh fruit and the shortage of tin cans and storage facilities for canned juices, orange juice is concentrated by the vacuum method to one-seventh of its original volume. Approximately 2 million gallons of concentrated orange juice were produced in Florida last year for lend-lease shipment, mainly to Great Britain for nursing and expectant mothers and children under 5 years of age.

At ordinary temperatures the constituents of concentrated orange juice react with each other, causing darkening, loss of flavor, and evolution of carbon dioxide gas, frequently accompanied by bursting of the containers. This reaction, as well as fermentation by yeast in unsterilized concentrate, can be prevented by storage and shipment under refrigeration, but refrigeration is not always available. Other means of prevention, therefore, are being sought.

Through a series of studies at the United States Citrus Products Laboratory in Winter Haven, Fla., on the changes that occur in concentrated orange juice at increasingly high temperatures, it was determined that gas production by enzymic action is improbable. The rate of gas evolution was found to increase at higher temperatures, which indicates ready decomposition of certain juice constituents with loss of carbon dioxide. Analysis of reacting concentrated juice showed almost complete loss of ascorbic acid (vitamin C). Measurable changes were not detected in other constituents of reacting concentrated juice. Reactions occurred, however, with the evolution of carbon dioxide when combinations of juice constituents were brought together in water solution and heated, indicating the possibility that more than one constituent serves as the source of carbon dioxide gas.

Concentrated orange juice is fermented by yeast at ordinary temperatures, and such fermentation also results in the evolution of carbon dioxide gas. Several different kinds of yeast have been isolated from cans of fermenting juice, and their physiological, morphological, and cultural characteristics are being studied. The amount of time required for heat at different temperatures to kill the cells of representative cultures was determined in single-strength and concentrated juices. These results may be used in establishing pasteurization temperatures for concentrated orange juice.

GRAPEFRUIT PECTIN-POMACE COMMERCIALIZED

The rapid expansion of the marmalade, jam, and jelly industry in the United States and other Allied Nations and the use of pectin

in pharmaceutical products as an emulsifying agent have resulted in domestic and export demands for powdered pectin in excess of the capacity of the pectin industry. The manufacture of powdered pectin requires elaborate and specialized equipment. To help relieve the shortage of pectin, a process was developed at the United States Citrus Products Laboratory, Winter Haven, Fla., for the production of grapefruit pectin-pomace from waste grapefruit peel at canning plants. The process consists of washing and grinding the peel, leaching out the water-soluble constituents, pressing out excess liquid, and drying. Pectic enzymes are inactivated in the ground peel by using hot water for the first leaching. Cold water is used for subsequent leachings. A distinct advantage of this method is that critical materials are not required and that most of the necessary equipment is generally available in citrus-processing plants. Two grapefruit canners have utilized the process and produced grapefruit pectin-pomace commercially. With technical advice and assistance from the laboratory personnel, numerous improvements have been made in the original process; these have resulted in a higher quality of product, easier plant operation, and reduced labor requirements.

TABLE SIRUP PREPARED FROM APPLE JUICE

The Eastern Regional Research Laboratory has developed a very palatable sirup from apple juice for food uses, such as table sirup. This is a bland sirup; that is, it does not have the tartness and flavor of apples. It differs from sirup previously developed by the same laboratory in not having the slightly bitter aftertaste that results from the presence of calcium salts. The process of preparing this new type of sirup from apple juice comprises filtration of the juice, passage through a bed of anion-exchange material that absorbs the malic acid, liming, filtration to remove precipitated calcium pectate, acidification, and concentration under vacuum. Some arsenical spray residue is removed in this process, but if more than a trace of lead arsenate is in the juice successive treatments with cation- and anion-exchange materials are required.

A concentrated apple juice that retains the flavor of the fresh apples has been prepared on a pilot-plant scale. It is made by blending ordinary concentrated apple juice with the concentrated apple-flavoring substances obtained by condensing the more volatile portion of apple juice at a low temperature and fractionally distilling the condensate. A 100-fold concentration of the flavoring substances has been obtained in a continuous process. When the full-flavored, concentrated juice is diluted with about six parts of water it is practically indistinguishable from fresh sweet cider except for its lighter color.

The bland apple sirup previously developed by the Eastern Regional Laboratory has assumed commercial importance during the past 2 years and has been accepted as a humectant by the tobacco industry. At least four manufacturers used it in their formulas for cigarette tobacco, and several of the larger companies will be definitely interested in it as soon as the supply can be enlarged to meet their requirements. In addition to keeping tobacco moist, apple sirup helps to develop the aromatic fragrance of Burley pipe-smoking tobacco.

TARTRATES RECOVERED FROM GRAPE WASTES BY NEW PROCESS

Further studies on the recovery of tartaric acid salts from grape pomace and brandy distillery residue led to the development of a new process substantially simpler than the one described in last year's report. The new process eliminates the need for cation-exchange materials and thus requires only about half the plant equipment of the former process. Labor requirements are correspondingly reduced.

The salts of tartaric acid are recovered by passing the well settled or otherwise clarified solution of grape waste through beds of anion-exchange material previously loaded with chloride ions. Tartrate ions from the solution efficiently replace chloride ions in the exchanger. Later a strong solution of sodium chloride is used to remove the tartrate in a concentration of at least 10 times that of the grape-waste solution and at the same time to regenerate the exchanger for the succeeding cycle. The tartrate solution is decolorized and treated with calcium chloride under controlled conditions to precipitate calcium tartrate, from which tartaric acid may be recovered by treatment with an equivalent quantity of sulfuric acid.

Cooperative experiments on a pilot-plant scale, in which about 5 tons of calcium tartrate were produced, have demonstrated the advantages of the ion-exchange process as far as yield and quality of product are concerned. Chemicals required for regeneration of the exchanger and for precipitation of calcium tartrate are not costly. Labor costs vary with character of equipment and magnitude of the operation. Continued contact with the turbid grape-waste solutions results in deterioration of the exchange material through adsorption of substances not removed in the usual regeneration process. Means for removal of these have now been developed, and the estimated useful life of anion-exchange materials is 500 cycles. A total recovery of about 1,600 pounds of tartaric acid per cubic foot of anion exchanger would be expected on this basis.

The United States requires about 15,000,000 pounds of tartaric acid annually for making baking powder, pharmaceuticals, and beverages, and for important industrial uses. It is made principally from imported argols, tartar, and wine lees.

NIGHTSHADE BERRIES REMOVED FROM CANNING PEAS BY NOVEL PROCESS

Nightshade is a troublesome weed in the commercial pea-growing areas of Oregon and Washington, where about one-fourth of the Nation's supply of canned peas is packed. Its immature berries, which closely resemble peas, sometimes contaminate mechanically harvested and shelled peas because they are not removed by the usual cleaning equipment. Removal of the berries on inspection belts is so difficult as to be impractical at times, and it becomes necessary to reject heavily contaminated lots or to avoid cutting portions of fields badly infested with nightshade weeds. Some large canners in Washington estimated that rejections represented from 3 to 10 percent of their total pea crop in 1941. Applied to all the peas grown in Washington and Oregon that year this proportion would mean a waste of from 4 to 14 million pounds of shelled peas. In order to prevent this loss of food and profits, a flotation process for removing

nightshade berries and other foreign material from mechanically shelled green peas was worked out in the field laboratory at Pullman, Wash., in cooperation with the Washington Agricultural Experiment Station and pea canners. Successful pilot-plant trials of the process were made during 1943, and several canning plants expected to adapt the process to commercial use in 1944.

The new process, for which a patent application is pending, is based on the difference in the wettability of shelled peas and nightshade berries. This difference is enhanced by applying a very small quantity of mineral oil in a preliminary treatment, after which the peas are fed mechanically into the top of a tank containing a foaming emulsion. With properly adjusted conditions as regards quantity of oil and foaming agent used, the nightshade berries, other weed seeds, and debris float and flow out of the tank, while the peas sink and emerge from the bottom. Most of the oil is removed by rinsing, and all but a minute trace is removed in the usual blanching operation before canning.

LEAF MEALS FROM VEGETABLE WASTES VALUABLE AS FEED

During the past year the Eastern Regional Research Laboratory has gathered data on the quantities of waste from commercially grown fresh vegetables in the fields, at shipping points, and at various kinds of processing plants, especially those that are promising as sources of high-protein, high-vitamin feeds, and has prepared this and other pertinent information for publication. The wastes that accumulate at shipping points where the fresh vegetables are graded and packed for market and at vineries and processing plants, were considered to be available for processing into feedstuffs or other products. The estimate for total waste available annually from 9 vegetables was 2,626,000 tons. The largest waste item, 1,751,000 tons, represented pea vines and pods; the second largest, 413,000 tons, tomato culls and trimmings; the third largest, 268,000 tons, lima bean vines and pods. The estimates for annual wastes from other vegetables, in descending order, were: Carrot tops, 57,000 tons; beet tops, 42,000 tons; spinach trimmings, 34,000 tons; cabbage trimmings, 33,000 tons; broccoli trimmings, 11,000 tons; and cauliflower trimmings, 10,000 tons.

The Eastern Regional Laboratory prepared substantial quantities of leaf meals from certain vegetable wastes by drying and screening. Chopped pea vines were easily dehydrated in a rotary forage drier with air at a temperature of 500° F. Other vegetable wastes, with the possible exception of carrot tops, pack too closely to permit dehydration in the common type of forage drier. The process used comprised flash-drying with air at about 240° F., which caused the leaves to become dry and brittle while the stems still remained moist and tough, followed by tumbling the material with stones in a rotary screen to break up and sift out the dried leaves. The stems, which have very little feeding value, were rejected. The yields of leaf meal, as percent by weight on the fresh waste, were as follows: Beet, 6.8; broccoli, 7.0; lima bean, 23.0; turnip, 6.5; carrot, 11.0; and pea vine (from viner) 15 to 19.

The first group of cooperative feeding tests on vegetable leaf meals were completed by the Delaware Agricultural Experiment Station.

Fourteen hundred chicks, divided into 7 groups of 200 each, were fed for 14 weeks on a diet containing 8 percent of leaf meal made from a single plant (alfalfa, pea vine, lima bean, broccoli, turnip, or carrot) and a diet that was similar except that it lacked leaf meal and contained proportionately more ground yellow corn and meat scrap. Addition of leaf meal to the diet was beneficial in all cases. Judged by relative rates of growth, the chicks thrived as well on carrot, lima bean, and turnip leaf meals as on alfalfa meal; they thrived even better on broccoli leaf meal because of its higher carotene content; but they did not grow as rapidly on pea vine meal as on alfalfa meal. Detailed results of the tests are reported in Delaware Agricultural Experiment Station Bulletin No. 247.

SWEETPOTATO SILAGE GOOD WINTER FEED IN SOUTH

Investigations of the Agricultural Chemical Research Division in cooperation with the North Carolina Agricultural Experiment Station have shown that excellent silage can be made from sweetpotato vines, or a mixture of vines and cull or surplus tubers. Conservation of this material by ensiling is of particular importance in meeting increased meat and dairy quotas for wartime needs, since thousands of tons of sweetpotato vines are wasted yearly in southern growing areas, where supplies of locally grown winter feed are inadequate to meet even the normal need for livestock.

Feeding tests with dairy cattle, covering a 3-year period and using silage put up in lots of 8 to 14 tons, have shown that silage made from sweetpotato vines or from a mixture of vines and tubers, is equivalent to corn silage in feeding value in a hay-and-grain ration. The maintenance of body weight and milk and fat production of the animals while fed sweetpotato silage was equal to that observed when they were fed corn silage. Also, the sweetpotato-vine silage was rich in carotene (pro-vitamin A), appeared to be highly palatable, and was eaten with practically no waste.

Bacteriological examinations of barreled lots of silage during the curing period showed that the predominating micro-organisms were the *Aerobacter* group of bacteria, the acid-forming bacteria, and the yeasts, which occurred successively during the silage fermentation in the order named. The acid-forming bacteria represented by far the greatest proportion of the total numbers of organisms found. Their activity produced from 1.4 to 1.8 percent of acid, calculated as lactic acid, which gave the ensiled material a pH range of about 3.8 to 3.5. The major portion of the acid fermentation took place within about 2 to 3 weeks after ensiling.

SYNTHETIC RUBBER PROGRAM HELPED BY IMPROVEMENT OF TALLOW EMULSIFIERS

The kind of synthetic rubber being produced in greatest volume (GR-S) results from the copolymerization of butadiene and styrene while they are suspended as minute globules in an emulsion. Since soap is used in preparing the emulsion it is an essential part of the synthetic rubber program. Synthetic rubber plants have obtained inconsistent results in the polymerization process and have suspected that some lots of soap contain substances that retard polymerization.

About 90 million pounds of tallow per year is needed for such soap, and present specifications require that a large proportion be edible tallow, which is ordinarily used in the manufacture of food products.

Since the Eastern Regional Research Laboratory conducts research on animal fats, it undertook an investigation of tallow and tallow soaps as a part of the comprehensive research program of the Rubber Reserve Company, in which a number of universities and several rubber companies and soap manufacturers also participated. It prepared pure samples of the saturated, unsaturated, and modified fat acids and the naturally occurring antioxidants that are present in tallow and tallow soap and sent them to various industrial collaborators for testing individually as to their effect on the polymerization process. It also determined the minor constituents of various tallows and tallow soaps after improving available methods and adapting them to the purpose. Small amounts of linoleic, linolenic, arachidonic, and diene conjugated acids and traces of triene and tetraene conjugated acids were found to comprise the polyunsaturated constituents of tallows and tallow soaps.

Comparison of the analytical data for soaps made from commercial tallows, purified fat acids, and hydrogenated tallow with factory results of polymerization when these same soaps were used as emulsifiers led to the conclusion that the presence of polyunsaturated compounds in the soap is largely responsible for retarded polymerization of GR-S synthetic rubber. It appeared that the more highly unsaturated the fat acid, the greater was its retarding effect. Linolenic acid had about three times the retarding effect of linoleic acid. Oleic acid had no adverse effect; on the contrary, it gave the soaps desirable properties.

Mild selective hydrogenation of tallows before they are used for the preparation of soap was suggested as the best remedy for the difficulties experienced with tallow soap as an emulsifying agent in the polymerization step of synthetic rubber manufacture. If this practice is followed, it is expected, from laboratory results, to lead to improved control of the polymerization step in the manufacture of synthetic rubber, elimination of the present necessity for using edible tallow in soap manufacture, and a 10- to 20-percent increase in the rate of polymerization. It is highly essential to the production of tires that the synthetic rubber used be of the highest possible uniformity. The use of hydrogenated tallow soaps will greatly aid in obtaining the desired uniformity.

MORE LEARNED ABOUT RECOVERY OF RUBBER FROM DOMESTIC PLANTS

During the past fiscal year the Eastern and Southern Regional Research Laboratories, cooperating with other bureaus of the Department in the Emergency Rubber Project, continued their investigations on the recovery of rubber from kok-saghyz, cryptostegia, guayule, and goldenrod. Experimental work to obtain pilot-plant data on the design of factories for the recovery of rubber from guayule was transferred to the new research laboratory and pilot plant erected at Salinas, Calif.

Kok-saghyz.—A simple, practical process was developed for recovering rubber in good quality and good yield from either fresh or dried kok-saghyz roots. A pilot plant for carrying out this process

was designed and built, and about 4,000 pounds of kok-saghyz rubber was produced.

Standard physical tests in the Eastern Regional Laboratory and in the laboratory of a large rubber company showed kok-saghyz rubber to be of very good quality—intermediate between guayule and hevea. About 3,000 pounds of the pilot-plant rubber were to be fabricated into all-kok-saghyz tires by two large rubber companies. These tires, ranging in size from 9.00-20, 10-ply truck tires to 6.00-16, 4-ply, passenger-car tires, were to be subjected to exhaustive laboratory and road tests.

On the basis of pilot-plant operations, it is estimated that a factory costing \$1,880,000 and operating 300 days per year would extract an average of 10 long tons of kok-saghyz rubber per day, and would serve a planting area of 39,800 acres net. The cost of extracting the rubber, without credit for byproduct and including amortization and everything except the cost of growing, harvesting, and transporting the roots, would be 11.7 cents per pound. Such a factory could turn out annually a quantity of byproduct sirup, suitable for fermentation to alcohol, containing 6,850,000 pounds of sugars; the value of this byproduct would represent a credit of 2.5 cents per pound of rubber, which would make the net cost of extracting the rubber 9.2 cents per pound.

Assuming a yield of 400 pounds of commercial rubber per acre, which probably could be attained by several years of additional research on breeding and cultivation of high rubber-bearing strains, it is estimated that a smaller factory costing approximately \$1,360,000 could turn out 10 tons of rubber per day at a net cost of about 7.4 cents per pound instead of 9.2 cents. The planting area required would be only 16,800 acres net. About 4,000,000 pounds of sugars per year would be produced, and the average credit would be 1.5 cents per pound of rubber.

Since the harvesting seasons cover only one month in the spring and one month in the fall, the necessary root-storage facilities to permit operation of the factory throughout the year are included in all the above figures.

Information accumulated in the course of pilot-plant experiments suggests that further experimentation would make possible material reductions in the estimated costs. Lower cost might result from destruction of the carbohydrates and some other plant constituents by retting the roots. This procedure would cut the cost of the factory in half by eliminating root driers, storage facilities for baled roots, and leaching batteries. The practicability of such a process would have to be established by further pilot-plant experiments.

Cryptostegia.—Because of the extensive plantings of cryptostegia vines in Haiti, where it was planned to recover the high-quality rubber latex by tapping the stems, it was expected that large quantities of leaves from pruning procedures would be available. The research work at the Eastern Regional Laboratory on cryptostegia was therefore directed toward the determination of the nature and distribution of the rubber in the leaves and the development of methods for its isolation.

Microscopic and microanalytical studies showed that about 90 percent of the rubber of mature cryptostegia leaves occurs in globules in

the chlorenchyma. The remainder is in the form of latex contained in the laticiferous ducts which extend into the leaf and follow the veins as they branch into the blade.

It was found that retting with an anaerobic organism, *Clostridium roseum*, would destroy the chlorenchyma cell walls, after which the coagulated protoplasts could be released by mild agitation. The cell rubber could then be recovered by boiling the protoplasts in dilute caustic followed by a creaming operation or by solvent extraction. The latter process is the more feasible. The product is a low-molecular weight rubber. It improves compounding characteristics and building tack when blended with GR-S. When used alone it has relatively low tensile strength.

The recovery of rubber from the leaves of *Cryptostegia grandiflora*, by any means yet devised, does not appear justifiable unless the leaves are available as a waste product from latex-tapping operations and unless there is an acute shortage of rubber, and a sufficient quantity of other natural rubber such as hevea, kok-saghyz, or guayule is not available.

Guayule.—The Eastern Regional Laboratory, in collaboration with the Guayule Rubber Extraction Research Unit at Salinas, Calif., established by the Department under the Emergency Rubber Project, submitted to the Forest Service recommendations of this Bureau for a process of recovering rubber from young guayule plants in January and March of 1944. These recommendations were based upon work done at the Eastern Regional Laboratory between September 1942 and September 1943 and subsequent larger-scale operations at Salinas, Calif., and were intended to serve as a guide in construction of proposed new factories for processing young guayule. The more important features of this process were described in the report for 1943.

As the result of extensive practical tests on the storage of young guayule shrub, carried out cooperatively by the Forest Service at Salinas, Calif., and analytical and technological work by the Eastern Regional Laboratory, it was found that the mechanically defoliated shrub can be baled and kept for 6 or 7 months without significant change in yield or quality of rubber, provided that a moisture content of not less than 20 percent is maintained. This requires storage in a space that can be sealed against the entrance or egress of air. Successful storage for 6 months would permit a guayule rubber recovery plant to operate throughout the year instead of only half of the year.

Forced aeration was found to be essential to successful retting of guayule shrub in bulk. This is an improvement over existing retting processes for guayule, which depend upon natural aeration. The rubber obtained from guayule shrub retted for 21 days under the conditions used by this Bureau had a resin content about 40 percent lower and a tensile strength about 1,200 pounds per square inch higher than had the crude resiniferous rubber obtained from unretted shrub. However, some loss of rubber resulted from the retting process. Retting seems to be advisable only if a sufficiently higher price can be obtained for the higher quality rubber obtained to offset the loss in quantity of rubber from its use.

It was shown that the rubber-hydrocarbon content of guayule worms can be increased by a short pebble-mill scrubbing treatment in dilute ammonia water followed by washing and a similar pebble-mill scrubbing in a dilute solution of ammonium stearate and ammonia.

The physical properties of the rubber were likewise improved by this simple treatment.

Investigations on the drying of guayule rubber with an experimental drier, in which hot air was blown downward through a bed of the rubber worms at high velocity, indicated that an air temperature as high as 200° F. could be used safely. It is believed that this method of drying can be applied in a continuous type of drier, with great saving in labor over the customary method of vacuum drying in batches and with a marked improvement in quality.

Goldenrod.—Investigations at the Southern Regional Research Laboratory on the recovery of rubber from goldenrod were completed with the processing of a substantial part of the crop produced at Waynesboro, Ga., during the 1943 season. The dried plant material was screened, and only the leaf fraction was used. The high resin content of the rubber extract was reduced by a purification step involving precipitation with acetone. More than 800 pounds of rubber was produced, most of which had a resin content below 5 percent; it was converted into usable material by partially compounding in solution and by precuring.

The method of compounding goldenrod rubber in solution consisted of adding part of the sulfur and vulcanizing chemicals to the rubber in benzol solution, thereby obtaining excellent and uniform dispersion. Special equipment was used for removing benzol from the partly compounded mixture by vacuum distillation and for uniformly working and heating the mixture to partially cure the rubber. The precured material was of satisfactory consistency for further compounding and processing on standard rubber mills.

In compounding experiments vulcanizates of both gum and tread stocks were obtained that had tensile strengths up to 3,600 pounds per square inch, and the range for precured batches routinely produced in the pilot plant was from 2,500 to 2,800 pounds per square inch. The tread vulcanizates had a high ultimate elongation and good rebound and resilience, with a fair tensile modulus. Their abrasion resistance was excellent, and their age resistance was good. Goldenrod rubber was comparable to hevea in low hysteresis (heat build-up); indications were that addition of goldenrod rubber to GR-S (up to 30 percent of the mixture) would reduce the excessive hysteresis of the synthetic rubber. In tear resistance and permanent set, goldenrod vulcanizates were inferior to similar hevea vulcanizates.

One of the larger rubber manufacturing companies undertook a factory processing test, based on the encouraging results of laboratory milling and vulcanizing experiments. This comprised the production of plied-fabric bicycle tires, 26 by 2.125 inches in size, by regular manufacturing operations. Over 40 tires were manufactured. A wheel test on 3 of these goldenrod-rubber tires averaged 1,362 miles, as compared to approximately 700 miles for a prewar hevea-and-reclaim tire of similar construction, and approximately 450 miles for current all-reclaim wartime tires.

The critical situation in regard to rubber supplies at the time this project was begun required speedy development of every possible source of natural rubber. The low content of rubber in goldenrod, and the large amount of accompanying resin, made this plant a particularly difficult material to process, but methods were developed for obtaining

high extraction efficiency and for purifying the rubber hydrocarbon to a high degree by simple, practical operations which were carried out successfully on a pilot-plant scale. Despite the unmanageability of the extremely sticky pure rubber initially obtained, practical methods were developed for handling goldenrod rubber and converting it by precurcure to an intermediate product suitable for further processing and manufacture into useful rubber articles by the usual rubber-working operations.

COTTON TIRE CORDS IMPROVED BY 'DUAL-STRETCH' PROCESS

The work of the Southern Regional Research Laboratory on cotton tire cord, begun in November 1942, has been intensified and broadened in scope during the past fiscal year. The object of this research, namely, the development of improved cotton tire cords, is being approached from two directions; one is experimental selection of the commercially available variety or varieties of cotton most suitable for this use, and the other is the improvement of available cotton through chemical and mechanical treatments.

The initial lot (three groups) of experimental 7.50-20 S-4 military truck tires, mentioned in last year's report, were tested by the United States Army at Camp Normoyle, Tex., and Camp Seeley, Calif. The cords in these tires were of the low-gage (small-diameter) type made from yarns, representing three selected varieties of commercially available cotton, spun by the Southern Regional Laboratory and processed into cord by a commercial tire-cord manufacturer. Detailed results of these tests have not been released by the Army for publication, but it can be stated that the tires made from two of the cotton varieties gave much better performance than any other low-gage cotton-cord tires so far tested by the Army, and that all three groups of tires performed better than the control tires made from standard cotton-cord fabric.

A second lot of 7.50-20 S-4 military truck tires, comprising three groups made from medium-gage cotton cords, were undergoing test by the Army at Camp Normoyle when this report was written. The cords for these tires were also made from yarns spun at the Southern Regional Laboratory.

Cord has been manufactured commercially from the variety of cotton that gave the best results at Camp Normoyle for use in experimental 7.00-20 S-4 truck tires and 6.00-16 S-3 passenger-car tires for testing by the Government Test Fleet. These tires were to be tested against similar tires in both sizes made from standard commercial cotton cords, and against a group of 7.00-20 rayon-cord tires.

Swelling and stretching treatments for cotton tire cords, and for other cotton yarns and cords, have been used in industry. The low-gage cords prepared for tests by the Army were subjected to a wet-stretching treatment. Several treatments of this type have been investigated, and cords showing exceptionally high count-strength products have been produced. As a general rule, an increase in strength obtained in this way is accompanied by a decrease in elongation. This decrease in elongation can become so great that the resulting cord becomes less satisfactory for use in tires. A secondary treatment for stretched cords of this type has been developed to overcome

this difficulty. It makes possible the production of a cord of given elongation while most of the increased strength of highly stretched cords is maintained. The two treatments together constitute a new process which is called the "dual-stretch" process.

In the dual-stretch process for improving tire cord, the original cord, after soaking, is subjected to a tension just short of the breaking point while being dried in hot air. This insures the maximum tensile strength obtainable. The second stage consists of a similar stretching treatment at room temperature in which the tension is carefully adjusted to produce just the desired degree of elongation. In most cases there is a slight loss of tensile strength at this stage, but the final strength is still far above that of the original cord, even in cases where such loss occurs. The influence of this treatment on other characteristics, such as flexing durability and hot breaking strength, is being investigated. Preliminary results indicate that the hot strength is improved. Adhesion of the cord to natural and synthetic rubber does not seem to be affected appreciably by the treatments.

The permanent effect of repeated cycles of temperature changes upon cotton and rayon tire cords has also been investigated. Repeated exposures at low temperatures (-40° F.) showed no significant changes, but very interesting results were obtained after exposure to high temperatures. In the latter case the cords were exposed for 16-hour periods at 265° F. with 8 hours' exposure to standard conditions (a relative humidity of 65 percent and a temperature of 70° F.) between high-temperature exposures and 24 hours' exposure to standard conditions before testing. Both rayon and cotton cords suffered a loss of strength and an increase in elongation under this treatment. After a more severe treatment, heating for 24-hour periods at 265° F., the rayon cord showed a greater decrease in strength and a greater increase in elongation than did the cotton cord. When, however, the cords were tested at this elevated temperature, instead of first being cooled and conditioned, their relative positions were reversed.

In another test, it was found that a single exposure for 16 hours at 280° F. did not produce any great change in the tensile strength and elongation of cotton cord. A separate investigation showed, however, that a significant change in the structure of the cotton, as manifested by viscosity in cuprammonium solution, occurred under these conditions. This is in line with well known observations on other types of cellulosic material that incipient breakdown is evident from the viscosity determination before any change in strength is measurable. Viscosity determinations were made on most of the experimental cords to find out if the cord had been damaged by the treatments.

An investigation was made of the relative adhesion of cotton and rayon tire cords to natural and synthetic rubber both at room temperature and at higher temperatures. In the case of untreated cords, cotton had much better adhesion than rayon. It was found that with proper treatment the adhesion of either type of cord could be greatly improved. Promising results were obtained with several new types of adhesives.

At the close of the year investigations on plastic properties of dual-stretched cotton cords were in progress. These included: (1) A study of the behavior of the cords during long-continued uniform loading; (2) measurement of cord relaxation as a result of long-continued,

uniform stretching; and (3) a study of cord behavior under cyclic variable loading. The plastic behavior of cotton cords when subjected to strain at various temperatures is similar to that shown by rubber and other elastic substances. Rayon and mercerized cotton cords have a considerably greater initial plastic flow than wet-stretched cotton cord, but after the initial flow all cords show about the same relaxation rate.

NEW COTTON BANDAGE FABRIC WELCOMED BY HOSPITALS

Large-scale laboratory production and clinical trials of the new elastic and adherent bandage fabric mentioned in last year's report have been continued. Close to 6,000 yards of open-weave cotton cloth (40 inches wide) have been processed and cut into the new bandages. Bandage fabrics have been produced from several different commercially available types of cloth to learn which weave or construction is best suited to the purpose. The texture and elastic properties of the fabrics so produced have been given a laboratory evaluation and one of the fabrics has been given extensive hospital service trials. This particular fabric has all the desirable characteristics of and greater commercial possibilities than any other investigated thus far.

Samples of these new conforming-bandages, which stay in place on extremities and permit movement of bandaged joints, have been used in six hospitals, from which uniformly favorable reports have come. They are giving unusual and very satisfactory results, particularly in bone surgery where they have been proven superior to regular gauze. Thirty dozen bandages have been furnished to the War Department, Office of the Surgeon General, for testing. The United States Naval Hospital at New Orleans has reported:

It is our opinion after using this product for 6 months that it is superior to regular gauze bandages for special work. It may be sterilized without affecting its elasticity, and has been found particularly desirable in head, knee, arm, or elbow dressing. The greatest amount of these bandages has been used in the orthopedic department. We feel there is a definite need for this product and would encourage the continuance of its development.

Information on the properties and processing of elastic fabrics has been furnished to the leading manufacturers of gauze bandages. A fundamental study of industrial methods used for preparing bandage fabric, particularly kier boiling and bleaching, is in progress. The investigation includes tests on the effects of boiling in different alkalies and of using different bleaching agents. The information will be helpful in adapting the new bandage-making process to commercial use.

WEATHER-RESISTANT FLAMEPROOFING TREATMENTS DEVELOPED FOR COTTON FABRICS

As the result of continued efforts to develop a more effective permanent flameproofing treatment for cotton fabrics, the Southern Regional Research Laboratory has perfected a treatment with antimony oxide, chlorinated hydrocarbons, and a synthetic resin applied as an emulsion. The treated fabric differs only slightly from untreated fabric in appearance, feel, and flexibility and can be subjected to a dozen or more standard launderings without becoming inflammable.

The treatment, which is believed to be commercially feasible, does not weaken the fabric. It definitely increases resistance to the deteriorating effects of outdoor exposure. Test samples, after 6-months' weathering, showed no loss in strength as compared to a normal loss of about 50 percent for the untreated material. Cotton fabric processed by this method is flameproof, but not entirely glowproof. Sometimes, especially when tested after repeated launderings, the charred area glows for several minutes after the flame is removed. Although this fault is minor in some uses, efforts are being made to develop improved fireproofing treatments better suited for garment fabrics. In cooperation with the Office of the Quartermaster General, considerable work has been done in the testing, theoretical elucidation, and improvement of a new commercial flameproofing process, the details of which may not be revealed at this time. This latter treatment has been combined with the former one to give results that are better in some ways than those obtained with either treatment alone.

A method of flameproofing cotton fabrics, involving the use of halogenated organic derivatives of cellulose, has been discovered and is being evaluated. During the past year six applications were prepared for patents covering various flameproofing processes.

INDUSTRIAL UTILIZATION OF SWEETPOTATOES MOVES FORWARD

Establishment of a permanent sweetpotato starch industry, based on the research of this Bureau, seemed to be assured when the United States Sugar Corporation was authorized by the War Production Board to erect a multimillion-dollar sweetpotato starch plant at Clewiston, Fla. Construction was rushed and initial operations were scheduled for the fall of 1944. The plant will have a daily capacity of about 240,000 pounds of finished starch, and an estimated annual production of 50 to 75 million pounds. This development represents a translation to large-volume, streamlined operation of the sweetpotato-starch manufacturing process originally developed in the laboratory, applied on a small commercial scale in the Laurel Starch Factory, and progressively improved through the technical assistance of the Southern Regional Research Laboratory. Plant design, equipment, and the proposed process of the Clewiston plant are based largely on technical data and information obtained in large-scale cooperative tests of improved processing equipment at Laurel in 1941 and subsequently. In maintaining technical control of processing in the new plant, application will undoubtedly be made of the latest findings from continued investigations in the regional laboratory at New Orleans and in the starch factory at Laurel, Miss.

With technical assistance and advice from the Southern Regional Laboratory, the sweetpotato starch plant of the cooperative organization, Sweetpotato Growers, Inc., at Laurel, Miss., continued production of high-quality starch for special wartime requirements. The new L-4-5 high-starch sweetpotato variety developed cooperatively by the Louisiana Agricultural Experiment Station and the Department, which comprised a considerable proportion of the raw material processed in 1943, demonstrated its superior processing quality with high recovery and high quality of starch. It was found feasible to manufacture starch from sweetpotatoes containing a high proportion of Porto Rico sweetpotato culls from an associated plant

dehydrating sweetpotatoes for food use. The improved methods of factory control developed or adapted by the Southern Regional Laboratory greatly facilitated adjustment of processing conditions to the different grades of new material.

Continued investigations on starch byproducts opened up a definite prospect of raising the byproduct credit in sweetpotato-starch manufacture by recovery of 60 percent or more of the sweetpotato protein now wasted in starch factory "fruit water" and by production of feed yeast, *Torula utilis*, from the sugars in the same waste. Use of the protein-recovery process in the small factory at Laurel, Miss., would save daily about a ton of crude protein now wasted and would raise the protein content of sweetpotato pulp, the byproduct feed, from the present 2 to 4 percent to perhaps 16 percent. Similar application of the yeast-production process would yield a ton or more of high-protein, vitamin-rich feed supplement per day. Nearly another ton of yeast per day could be produced from the wasted starch tailings after concentration and conversion of the starch to sugars.

A process was developed on a laboratory scale for the extraction and recovery of high-grade pectin from unlimed sweetpotato pulp in yields as high as 32 pounds per ton of fresh sweetpotatoes. However, integration of this process with other processes providing outlets for the starch and sugars, without requiring lime treatment of the pulp, would be necessary for its economical exploitation.

WHEAT STARCH OBTAINED FROM FLOUR BY NEW PROCESS

The Northern Regional Research Laboratory has developed a new (third) process for separating wheat flour into starch and gluten. It is called the "batter process" because it involves the conversion of flour into an elastic but free-flowing batter by appropriate mixing of a critical amount of water with flour. By tearing apart this batter mechanically in the presence of water, the starch is quickly and almost completely washed out, leaving the gluten suspended in the starch milk in the form of small lumps or curds. The two are separated by flowing the suspension over a vibrating screen; the gluten curds remain on the screen until shaken off, while the starch milk passes through. The starch milk may be used directly for fermentation or for conversion to sirup or crystalline dextrose. However, for the production of prime-quality starch, which is required for making the best grades of sirup and sugar in addition to having important uses requiring no chemical conversion, the starch milk must be subjected to the well-known industrial tabling procedure. The crude gluten passing over the end of the screen contains about 75 percent protein, on the dry basis. A higher grade of gluten, containing up to 95 percent protein, can be prepared by comminuting the wet crude gluten in water to remove most of the residual starch and screening again. Dried at a low temperature the screened material gives an "undevitalized" or natural gum gluten, which is suitable for fortifying low-protein flour for bread making or use in other food products. Drying at higher temperatures, as on a drum drier, yields a product suitable for certain food products, stock feed, and industrial uses.

The batter process has been found applicable to all types of wheat flours or ground wheat except those having a protein content of less than 8 percent. The advantages of the process lie in the speed and

simplicity of operation, the fact that there is no need for chemicals, and the practically complete recovery of the wheat gluten in an undeveloped state. Advantageous use of the batter process can be made in beet-sugar factories and sugar refineries for the production of starch for conversion into sweetening agents. Comparatively little new equipment would need to be installed, because these plants already contain nearly all the equipment necessary for the preparation of sirups from the converted starch liquors. Since beet sugar factories operate seasonally, the production of sirups from starch could be carried out during the off-season; this would keep the plants busy throughout the year. It is for such application that the process is most feasible. Many commercial organizations are testing the process on a pilot-plant scale and, within the past year, a number have used it, with some modifications, on an industrial scale. A beet sugar refinery in the off-season is producing 10 million pounds of wheat sirup monthly from the starch liquors, the byproduct gluten being diverted to another industrial organization for the production of monosodium glutamate, used extensively as a condiment because of its meat-like flavor.

During the past decade soft wheat has been a burdensome surplus crop in the Pacific Northwest; its price has approximated, and, in some years, has even been less than, the Chicago market price of corn. In that region, the production of starch and sirups from wheat appears to be particularly attractive as a permanent industry.

MEANS FOUND FOR CHANGING UNCOOKED STARCHES TO SUGARS

Although raw starches are hydrolyzed to sugars in the digestive processes of many animals, it has not been possible to bring this change about in the laboratory until recently. During the past year the Enzyme Research Laboratory discovered that uncooked wheat flour is readily and almost completely digested by a mixture of enzymic extracts from hog pancreas and the mold *Aspergillus oryzae* grown on bran. There was more than chemical evidence of the change; the gradual break-down of the starch granules was actually observed under the microscope.

The enzymes of *Aspergillus oryzae* in the form of moldy bran, as well as those of malt, are used commercially for hydrolyzing the starch of grains to sugars preparatory to fermentation, but the starchy material must be cooked to get quick results and even then it is unusual for more than 90 percent of the starch to be changed to fermentable sugars. All published data show that the hydrolysis of raw starches to sugars by enzymes is very slow and incomplete.

The discovery that raw starch can be converted to fermentable sugars by enzymes outside of living organisms constitutes an important scientific contribution to the chemistry of starch. Its practical application in fermentation and possibly other industries remains to be developed by further research.

The explanation of the fact that wheat flour is digested readily and almost completely by the mixture of enzymes from hog pancreas and moldy bran is believed to be, in part, that the pancreas and mold extracts contain enzymes that supplement each other, some being able to digest the amylose, and others being able to digest the amylopectin, of the starch. But this is not the complete explanation. An inor-

ganic substance that exists in wheat and can be extracted from the ash of wheat flour also was found to be necessary for rapid hydrolysis. This is calcium chloride. Both calcium and chlorine ions were previously known to have a favorable effect on the enzymic hydrolysis of starch. The complete digestion of pure raw starches requires the addition of traces of calcium chloride along with the mixture of pancreas and moldy bran enzymes, but milled grains probably contain enough calcium and chlorine to make this addition unnecessary.

The conversion of starches to sugars by this method is more complete and many times faster than by the usual enzymic methods. The products of the digestion are glucose and maltose, the former sugar predominating. A small proportion of maltase is present in the extract of moldy bran and is assumed to be responsible for the formation of glucose from maltose. Maltose is the principal product of starch hydrolysis by malt enzymes.

Different starches vary in their susceptibility to hydrolysis by this method. Potato starch is relatively resistant compared to wheat starch or cornstarch, but the size of the starch granules does not seem to be a determining factor in this resistance. A moderately acid reaction, pH 5.2, is best for the digestion of raw starch by the mixed-enzymes method. Temperatures up to 55° C. (131° F.) are permissible when relatively large quantities of enzymes are employed.

GRAIN-TO-GLYCOL-TO-BUTADIENE PROCESS READY FOR INDUSTRIAL USE

The process of making butadiene, the principal intermediate for synthetic rubber manufacture, from butylene glycol obtained by fermentation of dry-milling products of corn or wheat is ready for commercial application.

Last year's report told of the progress that had been made by the Northern Regional Research Laboratory in its special wartime research on fermenting grain mash to butylene glycol, recovering pure butylene glycol from the fermented liquor, and converting butylene glycol to butadiene. Sufficient work had been done on the three steps of the process to indicate that they could be carried out successfully and that more butadiene could be obtained from a bushel of corn by way of butylene glycol than by way of ethyl alcohol. A system of recovering the glycol from fermented grain mash had been devised which was expected to overcome the difficulty caused by the high proportion of suspended solids, but this remained to be tried out on a large scale.

The experimental work on this method of making butadiene has been practically completed, and, at the request of the Office of Rubber Director, a manufacturing firm that has supplied much of the distillery equipment used in the United States has prepared a comprehensive report on the equipment that would be required for industrializing this process and has submitted a preliminary design and estimates of construction and operation costs for a plant that could produce 10,000 tons of butadiene per year. As usual, in order to design such a plant, many physical and chemical data based on actual experiments were required. These were available as the result of the laboratory and pilot-plant experiments that had been carried out.

Pilot-plant experiments were made independently by the Northern Regional Research Laboratory and by a large distilling company. While both agencies carried out all steps of the development through the pilot plant, the 1-ton pilot plant of the industrial firm was larger in most respects than that of the Northern Regional Laboratory and this was a distinct advantage in proving the process. Since the conception of the process was entirely a wartime development and there was little background of information upon which to base one of the steps and practically none for the other two, many perplexing problems had to be solved. Those of a fundamental or purely scientific character received special attention from the Northern Regional Laboratory, while those of an engineering and practical nature received attention from both the Northern Regional Laboratory and the industrial firm.

A summarized report on each of the three steps of the process follows:

(1) *Fermentation*.—The demonstration by the Northern Regional Laboratory in 1940 of the possibility of industrializing the fermentation of carbohydrates to 2,3-butylene glycol by the organism *Aerobacter aerogenes* is the basis of the present process. The perfection of the butylene glycol fermentation, which is comparable in its sensitiveness to the butanol process, has been worked out in a period of less than 3 years. Starting with yields of about 10 pounds of butylene glycol per bushel of corn in 1940, yields of 14.5 pounds per bushel have been obtained in the pilot plant and in fermenters having up to 8,000 gallons capacity. Although 14 pounds per bushel is the figure accepted for plant design, continuous operation of a full-scale plant should result in consistently higher yields, since the present fermentation efficiency does not approach theory as closely as is the case with ethyl alcohol or butanol fermentation.

(2) *Glycol recovery*.—Distillation was used by the Northern Regional Laboratory in its first work on the recovery of butylene glycol from dextrose beers, and the concept that some type of distillation technique could be developed as an industrial operating procedure has been generally advanced by this Laboratory. The recovery of butylene glycol has proved to be an exceedingly difficult problem. The following methods have been studied on a pilot-plant scale: Solvent extraction, vaporization by spray drying, atmospheric drying or vacuum-drum drying of fermented mash, distillation of kerosene extract, and steam stripping. Recovery of the residue in a form suitable for use as feed is also involved in each one of these methods. The steam stripping method, developed through pilot-plant scale at the Northern Regional Laboratory, proved entirely practical for continuous operation and was the one considered in the plant design. The cost of steam is low, since the steam can be recycled; glycol recovery is 95 to 97 percent. The steam stripping method has also been investigated on a pilot-plant scale by the distilling company. Examination of the byproduct feed for vitamin content showed that it was equal to high-priced poultry feed supplements in this respect.

(3) *Conversion of glycol to butadiene*.—Experiments on the conversion of butylene glycol to butadiene by esterification and pyrolysis in a 100-pounds-per-day butadiene pilot plant were carried out by the Northern Regional Laboratory. First a continuous esterification proc-

ess was developed on a large laboratory scale; it yielded butylene diacetate (of 99- to 100-percent purity) equivalent to 97 percent of the glycol used; the remaining 3 percent of glycol was represented by a byproduct, methyl ethyl ketone. When this process was tried in the pilot plant of the distilling company, the expectations from laboratory experiments were fulfilled in every respect. The laboratory work indicated an 88-percent conversion of the diacetate to butadiene (of 99-percent purity) and a loss of acetic acid in the recovery process not to exceed 1 percent. These results were realized in the operation of the 100-pounds-per-day butadiene pilot plant at the Northern Regional Laboratory and also in the pilot plant of the distilling company. It is rather unusual in development work for small-scale laboratory results to be so completely substantiated. Equal or better results, therefore, can be expected from full-scale operation.

For the production of butadiene from grain, the butylene glycol process has two distinct advantages over the alcohol process: First, the very high purity of the butadiene made by pyrolysis of ethylene diacetate makes it possible to avoid costly and complicated purification steps; and second, fermentation to a 4-carbon glycol rather than to a 2-carbon alcohol results in a higher over-all yield than by the alcohol process. Assuming a yield of 14 pounds of glycol per bushel of corn, 95-percent glycol recovery, and an 85.4-percent conversion of glycol to butadiene (all of these figures have been consistently obtained in pilot-plant operations), the yield of butadiene per bushel of corn (containing 34 pounds of starch) would be 6.82 pounds. The present yields of butadiene from alcohol are equivalent to about 6.25 pounds of butadiene per bushel of corn.

NEW STARCH COMPOUND USEFUL IN COATINGS AND LAMINATING PLASTICS

The Eastern Regional Research Laboratory in its research on the utilization of carbohydrates has developed methods for the preparation of highly substituted allyl ethers of starch that may find important industrial uses. For the first time allyl starch soluble in organic solvents has been prepared. A direct method of preparation was developed. It comprises the treatment of starch with allyl chloride (made commercially from a byproduct of petroleum distillation) in the presence of concentrated sodium hydroxide and acetone. This method makes possible the commercial production of allyl starch at a relatively low cost.

The most promising use of allyl starch is as a coating material. When applied in solution to a surface of wood, paper, or metal it forms a smooth, glossy coating. When this coating is subjected to heat or long standing, it becomes very resistant to the agents that often damage varnished surfaces. It is no longer soluble in ordinary organic solvents; it is not affected by heat up to 200° C.; and it resists the action of hot oils and moderately concentrated acids and alkalis. A number of catalysts accelerate this polymerization or insolubilization of allyl starch.

Allyl starch compounded on a rubber-working mill with various ingredients used in rubber products, including sulfur and vulcanization accelerators, and subjected to long-continued heating, yields a

hard thermoplastic composition that is highly resistant to organic solvents, oils, acids, alkalis, and heat. Such a plastic can be used as an adhesive for the preparation of laminated materials of good strength and quality from paper, fabrics, and wood veneer.

In order to obtain a better understanding of the mechanism of the polymerization of allyl starch, allyl ethers of simpler carbohydrates and of polyhydroxy compounds have been prepared and used experimentally. These ethers are liquids that can be easily distilled and obtained in the pure state. Being compounds of low molecular weight, and therefore not viscous, they are better than allyl starch for impregnating wood, paper, and textiles and can be polymerized within these materials. Most of them seem to polymerize in the same manner as allyl starch, and some of them may prove to be of practical value. Among the simpler compounds prepared were allyl ethers of sucrose, methyl glucoside, mannitol, sorbitol, inositol, pentaerythritol, ethylene glycol, and glycerol.

CRUDE LACTIC ACID CONVERTED TO PURE DERIVATIVES

Lactic acid can be produced easily by the fermentation of milk sugar and other carbohydrates, but in order to be useful in chemical synthesis it must be purified or be converted into pure derivatives. One of its most important derivatives is methyl lactate, which can be readily transformed into pure lactic acid by treatment with water, into other esters by treatment with various alcohols, and into methyl acrylate (used for making acrylate resin) by acetylation and pyrolysis.

During the past year the Eastern Regional Research Laboratory developed a simple and satisfactory method for preparing pure methyl lactate from crude dilute lactic acid. This is advantageous to the chemical industry because it avoids the cost of first purifying and concentrating the lactic acid. The method comprises passing methanol vapor through an aqueous solution of crude lactic acid heated to about 90° C., condensing the vapors, and fractionally distilling the condensate to recover methyl lactate. It has been used successfully with acidified fermentation liquors and with the residue from the purification of lactic acid by solvent extraction.

Purified lactic acid instead of methyl lactate can be produced by the same method through a slight change in procedure. If the condensate is heated before distillation, the methyl lactate is decomposed into lactic acid and methanol, after which the methanol and water can be removed from the lactic acid by distillation.

INDUSTRIES EAGER TO TRY COCOA-BUTTER AND OLIVE-OIL SUBSTITUTES MADE FROM COTTONSEED AND PEANUT OILS

Last year's report mentioned the successful preparation by the Southern Regional Research Laboratory of a substitute for cocoa butter from cottonseed oil and of a substitute for technical olive oil from peanut oil by processes involving controlled hydrogenation and low-temperature solvent fractionation. The first can replace cocoa butter in confectionery and pharmaceutical products, and the second can replace technical olive oil as a worsted spinning lubricant.

Requests were received from numerous domestic and foreign firms interested in the possible use of these substitutes for samples large enough to permit factory trial in particular products or processes.

Inquiries were also received from industrial firms that were interested in the possibility of producing these substitutes commercially and wanted information on processing details and production costs. To supply large samples and to answer the many requests for cost data and possible commercial yields, pilot-plant experiments will be required. Pilot-plant equipment was designed and ordered.

Pending the installation of the pilot-plant equipment for modifying cottonseed and peanut oils, attention was given to the development of a method for determining various degrees of plasticity in plastic fats, which was needed especially for comparing natural cocoa butter with the substitute therefor. Such a method is equally useful in the study and testing of butter, lard, and plastic shortenings made from oils. Research was also conducted to acquire needed fundamental knowledge on the thermal properties, and especially volume changes from physical or chemical action, of cottonseed and peanut oils, of solid and liquid derivatives of these oils, and of pure synthetic glycerides prepared from the component fatty acids of these oils. The results of this research are given in several papers that were prepared for publication.

GOOD COLD GLUE MADE FROM PEANUT PROTEIN

In order to relieve wartime shortages of gums and other adhesives that are suitable for use in bookbinding and for making gummed tape, gummed paper, and set-up paper boxes, the Southern Regional Research Laboratory undertook the development of such products from cottonseed and peanut meals. Work to date has shown that it is possible to prepare peanut-protein glues suitable for use in the manufacture of gummed tape having relatively good adhesive strength. The dried glue film has good appearance, is less hygroscopic than some gum adhesives, and becomes tacky and sticks tenaciously as soon as it is remoistened and applied to another surface. Unique characteristics of peanut-protein glues, particularly their tackiness and fluidity at room temperature, make them suitable for certain gluing operations for which vegetable proteins have heretofore been considered unsuitable. Since glues made of peanut protein become tacky as soon as moistened and require no heating, they could be used in the paper-box and book-binding trades with less difficulty than is encountered with certain other types of glue.

GLOBULAR PROTEINS CONVERTED TO FIBROUS FORM

As a result of recent work in the Eastern Regional Research Laboratory methods have been developed for converting so-called globular proteins to the fibrous form in which the polypeptide chains of the protein molecules have substantially the same parallel arrangement as those of the naturally fibrous protein, keratin (found in wool, hair and feathers). This rearrangement in molecular structure yields artificial fibers that are stronger than fibers made from globular proteins. One method, applicable to extruded filaments, comprises heating the globular protein in the presence of water, and stretching it. Alternatively, the conversion is induced without heat through use of certain chemical agents and stretching. Among the globular proteins thus converted, and for which X-ray diffraction patterns characteristic of natural protein fibers have been obtained, are casein, gliadin, zein, soybean protein, peanut protein, hemoglobin, serum albumin, lacto-

globulin, tobacco-seed globulin, ovalbumin, pumpkin-seed globulin, and edestin. The methods used have thus far proved most readily applicable to the simple globulins and albumins, whose physical properties are easily changed by heat or certain chemical reagents. Measurements on casein, lactoglobulin, and ovalbumin filaments have shown that the wet and dry tensile strengths are increased by conversion of the protein to the oriented, fibrous form.

Hardening of artificial protein fibers with quinone and by acetylation has been extensively investigated. The water absorption of casein fibers treated with quinone is about two-thirds as high as that of similar fibers treated with formaldehyde. The protein-quinone complex is quite stable, whereas the reaction of formaldehyde with protein is reversible. In the studies of acetylation it was found that 6 percent of acetyl by weight can be introduced into formaldehyde-hardened fiber without causing deterioration. Fibers of such acetyl content are much superior to the comparable nonacetylated fiber. Water absorption is definitely lowered by acetylation but even more notable is the development of resistance to boiling water solutions. Other hardening treatments more effective than those employing formaldehyde, quinone, or acetylation are being sought.

WATERPROOF GLUE FOR PLYWOOD MADE FROM SOYBEAN MEAL AND PHENOLIC RESIN

As a result of efforts by the Northern Regional Research Laboratory to develop new adhesives from soybeans, the details of a method for preparing a new soybean-modified phenol-formaldehyde adhesive for plywood have been worked out. The glue is prepared by mixing the protein meal with a commercially available or freshly prepared phenolic resin in the intermediate or "A" stage. A high-protein meal is needed, and it can be obtained by removal of the water solubles from extracted soybean meal. One commercial trial has demonstrated that excellent birch and birch-basswood plywood can be fabricated with this glue.

Soybean meal has been used for many years in making adhesives for gluing softwood veneers, but in recent months its use has declined. This decline appears to be due to an emphasis on the production of moistureproof and highly moisture-resistant plywoods. The older soybean adhesives were not highly moisture-resistant; the new adhesive can be made either moistureproof or moisture-resistant by controlling the amount of phenol-formaldehyde used.

The present demand for moistureproof plywood is very high because of the Navy's need for special types of marine construction, and the post-war demand for moisture-resistant plywood is expected to be almost as great. In particular, the fabrication of plywood for outdoor construction where moisture resistance is necessary, such as barns, silos, cement forms, storage bins, and houses, will receive much attention from the industry. Since the new adhesive gives excellent moisture-resistant bonds with both soft and hard woods and its cost is estimated to be much lower than that of other waterproof adhesives, it will probably be accepted by the plywood industry as soon as sufficient plant trials demonstrate its feasibility.

NORELAC, RESIN FROM SOYBEAN OIL, PROGRESSING TOWARD INDUSTRIAL USE

The development by the Northern Regional Research Laboratory of a feasible method for the production of Norelac, a thermoplastic resin, from soybean oil and the demonstration of a number of possible uses for this product have led to its production on a semicommercial basis. In 1943 an industrial firm became sufficiently interested in Norelac to build a pilot plant having a capacity of 1,000 pounds a week. This plant was placed in operation early in 1944, and approximately 15,000 to 20,000 pounds of the resin have been prepared. This small-scale production of Norelac assures thorough evaluation of the material by a large number of industries for many possible uses to an extent that would not be possible at the Laboratory.

Previous work showed that Norelac is useful as a protective coating for wood and steel and as a moistureproof, self-sealing, thermoplastic coating for paper, cellophane, glassine, and other wrapping materials. Preliminary experiments made recently by the Quartermaster Corps have indicated that a Norelac lacquer gives tin cans excellent resistance to corrosion by salt spray. Additional commercial tests are now in progress.

Although the resin is not yet established as a commercial product, two of the steps leading toward its acceptance have been completed; these are laboratory research and pilot-plant development. Its future will depend on careful control of the manufacturing process to obtain the desired properties, additional technical development of uses, and reasonable cost in comparison with competing products.

SOLVENTS STUDIED FOR TUNG OIL EXTRACTION

Further investigations by the Agricultural Chemical Research Division on the possibility of increasing the recovery of oil from domestic tung fruit by the application of solvent extraction showed that the moisture content of tung kernels and of dehulled tung fruits very materially influences ease of preparation and efficiency of the subsequent extraction by solvents. In laboratory extraction tests, maximum efficiencies were obtained with tung kernels containing between 6 and 9 percent of moisture; in pilot-plant studies, in which a continuous counter-current extractor was used, maximum extraction efficiency (99.9 percent) was obtained with dehulled tung fruit containing 7 percent of moisture. Further pilot-plant tests indicated that a clear, liquid tung oil of good quality can be obtained by the use of heptane as the solvent. The relatively high temperature of ground waters in the South would make advantageous the use of heptane instead of hexane, as the solvent, since solvent losses would be materially lower. Varnishes made from the heptane- and hexane-extracted oils, as well as that made from expressed tung oil, appeared to be of high quality; they are being tested for durability near Gainesville, Fla.

GROUND CORNCOBS USED FOR CLEANING AIRPLANE ENGINES

Basing its action on the results of cooperative experimental work by the Northern Regional Research Laboratory, the United States Navy Department has standardized ground corncob (to pass 10-mesh

and be retained on 32-mesh screens, Tyler series) for use as soft-grit material in an air blast for removing carbon from airplane cylinders and pistons. The use of soft grit in an air blast of 80 to 90 pounds pressure is a wartime development; this cleaning method replaces the previously used chemical and mechanical methods of removing carbon and oil residue baked onto high compression-engine parts. Among the first materials employed with the air blast were cracked wheat, corn grits, and clover seeds. Because of the shortage of food materials, the Department of Agriculture, at the suggestion of the Navy, undertook to find suitable substitutes among nonfood materials. Samples of ground crop residues of various kinds were prepared and supplied by the Northern Regional Laboratory for comparative tests. The Navy selected ground corncobs as the most suitable for its purpose. The corncob meal is used repeatedly and lasts from 5 to 10 times as long as the corn grits formerly used; it also has the advantage of polishing the metal parts during the cleaning operation without causing any change in dimensions of the parts. The heavy fraction of ground peanut shells is also suitable for use in air-blast cleaning of metal surfaces. Ground rice hulls, because of their high silica content, are highly abrasive to steel, and cause dulling of polished surfaces. Ground nut shells are reported to be slightly abrasive. Cobs from hybrid seed corn represent the preferred raw material source, since these are dried in the seed houses.

NORESEAL MAY COMPETE SUCCESSFULLY WITH CORK

Publication by the Northern Regional Research Laboratory of technical details relating to the preparation and practical testing of Noreseal, the cork substitute developed from agricultural materials (peanut shells, proteins, and plasticizers) for use in the beverage industry, has aroused wide interest among both bottlers and cork manufacturers. It seems to be generally believed that Noreseal represents the best and most practical cork substitute offered thus far. At least three manufacturers are already contemplating the production of Noreseal; others have indicated their desire to manufacture it when the pilot-plant studies now under way have yielded additional information.

Two pilot-plant investigations are in progress. One pilot plant, having a capacity of 150,000 crown-seal discs per hour, has been built and operated by a trade association in Peoria for testing the method of producing sheet Noreseal. The other, operated by the Northern Regional Laboratory, is developing a method of dispensing Noreseal into individual crowns; this was made possible by the loan of an automatic dispensing machine by an industrial firm. The second investigation is nearing completion. This dispensing process eliminates many of the manufacturing operations required for the preparation of the cork-composition disc. It can be made entirely automatic and is capable of yielding a product of uniform quality. Preliminary cost estimates indicate that Noreseal dispensed directly into crowns may survive competitively as a post-war product.

TURPENTINE DERIVATIVES USEFUL FOR SYNTHETIC RUBBER

The report for 1943 stated that samples of myrcene made by pyrolysis of beta-pinene, isolated from turpentine, were supplied to sev-

eral commercial firms for use in experiments to determine its value for making synthetic rubber. One firm reported that myrcene proved to be a very useful addition to rubber-making materials because its polymerization product increased the tackiness or adhesive property of synthetic rubber in dry form, which is deficient in synthetic rubber of the usual type. This firm also expressed a belief that myrcene might be used as an intermediate for synthesizing other chemical products. It was producing myrcene on a small pilot-plant scale and expected to increase production later.

Improvements were made in laboratory methods of producing myrcene and isoprene from turpentine and in equipment for purifying these and similar products by fractional distillation under vacuum. A patent for a fractionating column and scrubbing tower was granted during the year. By a special pyrolytic method, yields of isoprene above 65 percent of theory were obtained from dipentene, which can be derived from turpentine. Improved techniques were developed for experimental polymerization of myrcene and isoprene to synthetic rubber. Small-scale pilot-plant equipment was being constructed at the Naval Stores Station for the production and purification of beta-pinene, myrcene, and dipentene from turpentine.

NAVAL STORES INDUSTRY USES BUREAU'S GUM-CLEANING PROCESS

During the naval stores season ending March 31, 1944, about 40,000,000 pounds of high-grade rosin and 1,500,000 gallons of turpentine were made from pine gum cleaned by a process developed by the Naval Stores Research Division and covered by U. S. Patent No. 2,254,785, the use of which has been granted to seven commercial firms by license from the Secretary of Agriculture. One commercial firm was licensed to use U. S. Patent No. 2,295,235 covering an improved process for producing rosin, which was also developed by the Naval Stores Research Division.

PINE GUM NOT DAMAGED BY CHEMICAL STIMULATION OF TREES

Tests on pine gum obtained by the United States Forest Service in experiments designed to increase the secretion of oleoresin or gum by the application of a chemical substance to the fresh-cut streaks on southern pine trees demonstrated that rosin and turpentine of good quality can be made from such gum by processes developed by the Naval Stores Research Division of this Bureau. This finding has helped to convince gum producers that it is safe to use chemical stimulants in efforts to attain the production goal for rosin and turpentine.

NEW DOMESTIC SOURCES OF TANNINS EVALUATED

Tannins from barks, woods, leaves, roots, and fruits are essential for making vegetable-tanned leathers. Heretofore, this country has depended on foreign sources for about two-thirds of its vegetable tanning materials. War has curtailed importation of foreign supplies and seriously reduced and threatened to practically stop heavy leather production. It is therefore highly important that the availability and relative value of new and undeveloped domestic tannins be determined.

Several materials have been under investigation at the Eastern Regional Research Laboratory to determine their suitability as sources of tannin.

Canaigre.—Field studies on canaigre (*Rumex hymenosepalus* Torr.) as a tannin crop were continued in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. From experimental plantings in Texas and New Mexico, and wild and cultivated stands in Arizona, nearly 16,000 pounds of roots were harvested in 1943. In field drying tests about 10,000 pounds of fresh roots, containing about 70 percent of moisture, were successfully shredded and air-dried on hard-surface asphalt, giving a product that could be shipped or stored without spoilage.

The tannin content of canaigre varies with strain of plant and with soil and climatic conditions. Wild canaigre roots secured near Las Cruces, N. Mex., and planted at Winter Haven and Lubbock, Tex., and at State College, N. Mex., have produced five generations of progeny. The average tannin contents of the progeny for the 5 years at the three locations were, respectively, 26.0, 21.8, and 21.2 percent, on a moisture-free basis. Selection and propagation of strains from individual hills of canaigre are worthwhile. One selection at Lubbock, Tex., over a period of 5 years gave a calculated average yield of 12.54 tons of fresh roots per acre, with an average tannin content of 23.3 percent (moisture-free basis). Two selections at Winter Haven, Tex., during the same period yielded an average of 12.33 tons and had an average tannin content of 24.1 percent (moisture-free basis). These experimental yields are higher than those obtained in run-of-field tests, but the tannin contents are about the same.

Canaigre roots contain, in addition to tannin, starch and sugars, both of which may be of economic value. The former interferes with the easy extraction of tannin, and the latter, when extracted with the tannin, are responsible for the production of low-purity tanning extracts. A bulk sample of canaigre roots has been found to contain, on a moisture-free basis, 2.98 percent of free reducing sugars calculated as dextrose, 15.69 percent of disaccharide identified as sucrose, and 25.19 percent starch.

Progress has been made in the laboratory processing of canaigre for the production of extracts suitable for tanning heavy leather. Methods for removal of starch and sugars and their conversion into valuable coproducts are being studied. Use of finely powdered roots has been found to facilitate hydrolysis of the starch. A bacterium has been isolated from canaigre roots which is effective in fermenting canaigre sugars in the presence of tannin without damage to the latter. A tanning extract has been prepared containing 51.9 percent tannin and having a purity (soluble-solids basis) of 65.6.

Scrub oak bark.—About 20 species of scrub oaks grow in Florida and neighboring States, and it is reported that there are about 5,000 square miles of scrub oak forest in Florida. The three most important of these oaks are Turkey oak (*Quercus laevis* Walt.), Bluejack oak (*Quercus cinerea* Michx.), and Blackjack oak (*Quercus marilandica* Muench.). The tannin content of scrub oak barks is reported as ranging from 9 to 12.5 percent, but some samples have been found to contain as much as 16 percent. From a sample of Turkey oak bark from Gainesville, Fla., which contained 10 percent tannin, a

powdered tanning extract has been made in the laboratory; it contained 61.2 percent tannin and had a purity of 63.7. A small-scale tanning test, using this extract for making heavy leather, gave good results. Cooperative tests on a pilot-plant scale are now being planned to determine the feasibility of using scrub oak bark for the manufacture of tanning extract and the extract for tanning heavy leather.

Sumac.—Studies conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering over a number of years have shown that the tannin content of cultivated sumac plants increases with age for the first 3 years of their life. Data for older plants have not yet been obtained. Tannin content was highest in midsummer; it decreased moderately during the fall months.

Young plants cannot be cut profitably more than once a year and should not be cut during the first year. Hereditary factors influence tannin content, indicating that it should be possible to locate desirable strains of sumac that are high in tannin and suitable for propagation.

White sumac (*Rhus glabra*) gathered in eastern Iowa was used in a commercial tanning test and, when dried and handled properly, produced excellent sheepskin leather. Two carloads of sumac were shipped from Iowa to tanning-extract manufacturers in 1943 and similar shipments were planned for 1944.

Western hemlock bark.—Studies on the utilization of Western hemlock bark from floated logs were continued by the Eastern and Western Regional Research Laboratories in cooperation with industrial firms. Laboratory-prepared powdered extracts were made from both fresh water- and salt water-floated barks. That made from fresh water-floated bark was the better of the two, but neither could be considered a high-quality extract. Small-scale tanning tests demonstrated that these extracts could be blended with standard tanning extracts, but their addition did not improve the blends or the leathers produced. The use of a commercial continuous hydraulic press for removing excessive water and some salt from salt water-floated bark was studied at the Western Regional Research Laboratory. After being crushed, the bark was leached rapidly, and the leach liquor was filtered, bisulfited, and evaporated to dryness. The dry powdered extract contained over 66 percent tannin. The leaching efficiency, however, was low, and the tanning properties of the extract were not equal to those of commercial tanning extracts. The economic aspects of the utilization of salt water-floated bark as a source of tannin are not favorable.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY, AGRICULTURAL RESEARCH ADMINISTRATION, 1944

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., October 14, 1944.

DR. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I present herewith the report of the Bureau of Animal Industry for the fiscal year ended June 30, 1944.

Sincerely,

A. W. MILLER, *Chief.*

GENERAL SCOPE OF ACTIVITIES

THE BUREAU OF ANIMAL INDUSTRY, during the year, made contributions of value to the war effort in the field of research and in the eradication of livestock diseases and parasites. In these activities, as well as in the enforcement of regulatory laws, it cooperated with other Federal units, States, and other agencies. The Bureau's work was carried on under the direction of A. W. Miller, who was appointed Chief in August 1943. It dealt with intensified production of livestock products through new means of processing meats and other commodities, improved methods of feeding and management, and the eradication and control of diseases of domestic animals.

RESEARCH PROJECTS COVER WIDE FIELD

Investigations of various methods of meat dehydration showed that the rate of drying can be increased when meat with a low fat content is ground to small particles after precooking. Air for drying gave best results when heated to 160° F. or 180° and blown through and not across the meat. Drying was found to kill any trichinae in the muscle tissue when the ground pork was dried to 3-percent moisture content at temperatures ranging from 102° to 120° F.

Studies of wartime feeds for swine and poultry showed that satisfactory diets containing no animal protein may be obtained by using available feedstuffs. In swine diets, wheat was found to be more satisfactory than corn in replacing animal protein, and in poultry diets soybean meal replaced animal protein supplements. Dried distillers' grains also were found to produce satisfactory gains in pigs when from 9 to 12 percent of these products was included in the ration.

Research on one of the most troublesome poultry diseases, fowl-paralysis, indicates that some strains of chickens have more resistance to the disease than others. Breeding from stock with the lowest incidence of the disease has resulted in several lines of White Leghorns

that are comparatively resistant and have longer life spans than the others.

LIVESTOCK-DISEASE CONTROL AIDS FOOD PRODUCTION

Many of the communicable livestock diseases are being controlled by means of quarantine measures, and campaigns for the eradication of other maladies are in progress. The Bureau's drive to eliminate bovine tuberculosis is in the clean-up stage, and the eradication of cattle ticks is 99 percent complete. At the end of the fiscal year, 591 counties in 22 States were designated as modified accredited Bang's-disease-free areas, indicating their practical freedom from the disease. In this project there has been an increased demand for calftlood vaccination.

Studies of hexachlorethane, by the Bureau, showed the product to be effective in removing liver flukes from cattle when administered as a suspension mixed with bentonite. The flukes were removed from affected, unthrifty cattle, and the animals showed a remarkable improvement. Fluky cattle that were in good or fair condition showed no unfavorable reaction when treated with 100 cubic centimeters of suspension, but weak and emaciated animals sometimes were seriously affected by such treatment.

In cooperation with the National Poultry Advisory Council, work on the program to reduce losses in poultry was continued up to and including January 7, 1944, at which time the project was transferred from the Bureau to the War Food Administration.

PERSONNEL

The Bureau had on its rolls at the end of the year 1,640 full-time classified employees (table 1), exclusive of 427 employees on furlough for military training and service. Veterinarians constituted about 90 percent of the 822 professional and scientific employees.

TABLE 1.—Classified employees at end of fiscal year

Service	Employees in—		Total employees
	Departmental service	Field service	
Professional and scientific.....	34	788	822
Subprofessional.....	12	424	436
Clerical, administrative, and fiscal.....	100	235	335
Crafts, protective, and custodial.....	10	37	47
Total.....	156	1,484	1,640

In addition to the employees shown in the table, there were in the field service 129 unclassified agents employed full time on animal-disease control work or research work in cooperation with the States; 46 full-time unclassified laborers; 197 veterinarians, and 35 others employed intermittently; and 110 collaborators serving without pay.

ANIMAL-HUSBANDRY RESEARCH

Animal-husbandry investigations conducted by the Animal Husbandry Division, under the direction of Hugh C. McPhee, head

animal husbandman in charge, included research on many emergency wartime problems as well as on fundamental and practical problems relating to more efficient breeding, feeding, and management of farm livestock and poultry, and research on their products for use under both wartime and peacetime conditions.

PREVENTING HERMAPHRODISM IN GOATS

A 20-year study of the occurrence of hermaphrodites (individuals with reproductive organs having both male and female characteristics) in the Beltsville, Md., herds of Saanen and Toggenberg goats was completed. Hermaphroditism and the polled, or hornless, character were found to be very highly correlated. Data from the Beltsville herd and from other investigators have failed to show an authentic case of a horned hermaphrodite. In the Beltsville herd all 79 hermaphrodites were produced by polled parents. The results suggest that hermaphrodites are always females genetically; bucks seem not to be affected. Results of this study indicate that hermaphroditism can be bred out of goat herds simply by using one horned parent in each mating.

TESTING THE FEEDING VALUE OF DEFLUORINATED PHOSPHATES

To supplement the inadequate supplies of bonemeal and other phosphates for livestock feeding, governmental agencies and private interests have done considerable work in the last year on the defluorination of rock phosphates and superphosphates, as well as on deposits of natural phosphates low in fluorine. To assist in this work, the Bureau tested the relative effectiveness of these products for bone and body growth with laboratory white rats. Samples varied considerably in these respects. Defluorinated rock phosphate produced experimentally by the Tennessee Valley Authority was almost as good as bonemeal, if not equal to it. Some of the defluorinated superphosphates, however, had to be fed at twice the level of bonemeal, and one sample was none too effective at three times this level.

These results raised a question as to the effect of temperature, in the heating of the superphosphate during the process of defluorination, on the availability of the calcium and phosphorus. Accordingly, the feeding value of samples of superphosphate heated at different temperatures in the laboratories of the Bureau of Plant Industry, Soils, and Agricultural Engineering was tested with rats. Material heated at 600° and 760° C., consisting chiefly of metaphosphates and pyrophosphates, gave poor results in the feeding tests, suggestive of those obtained with the poorer of the commercial products. On the other hand, the material heated at 1,010° gave a product, principally tricalcium phosphate, that compared very favorably with the better commercially defluorinated superphosphates and was almost as good as if not equal to bonemeal. Thus it appears that the degree of heat employed in defluorinating superphosphates materially affects the feeding value of the product.

IMPROVED METHODS IN MEAT DEHYDRATION

Further work on meat dehydration, as a wartime need, showed that in air drying the rate of dehydration was accelerated when fat content

was low, grinding was done after precooking, the size of the particle was small, and the air at a temperature of 160° to 180° F. was circulated through, instead of across, trays loaded with not more than 1.5 pounds of precooked meat per square foot of surface. Several satisfactory processes were developed for the dehydration of meat. Among them was the vacuum rotary, which seemed to combine more good points than any other method studied.

To develop methods for producing dehydrated meat that will more closely approach fresh meat in quality, raw pork was frozen at 0° F., ground, dried to about 5-percent moisture content in moving air at 120° F., and further dried to 2- to 3-percent moisture content in vacuum at temperatures that did not exceed 120°. The product had a desirable fresh-meat appearance, superior rehydration capacity, and a higher palatability rating than comparable samples of the precooked type. With a moisture content of 3 percent or less and properly vacuum-packed, it remained in good condition for at least 6 months at temperatures up to 70°. However, in 2 to 9 weeks of storage at 120°, the raw dehydrated meat acquired a dark color and burned flavor, with accompanying losses in rehydration capacity, soluble nitrogen and amino-acid content, and a rapid increase in the proportion of free fat acid, indicating development of rancidity. Samples of pork and beef representing proposed commercial processes for producing raw dehydrated meat of this general type gave similar results. It was concluded that any specifications drafted for raw dehydrated meat should provide for a moisture content of not more than 2 percent.

TRICHINAE IN PORK KILLED BY DEHYDRATION

Jointly with the Zoological Division, the Division began studies to determine the effect of dehydration on the viability of trichinae larvae when present in large numbers in fresh pork. The possible value of such a method for killing trichinae was suggested by previous knowledge that desiccation is often fatal to worm parasites. After heavily infected raw pork was frozen at 0° F., it was ground through a quarter-inch plate, spread on trays, and dried in moving air at 70°, 102°, and 120° to moisture contents of about 5 to 19 percent. Further dehydration was accomplished in vacuum at the same temperature in each instance. Incomplete results indicated that in the pork dried at 102° and 120° all the organisms were dead at the 3-percent moisture level. Since 102° is the normal body temperature of hogs and trichinae live in the muscle tissue of these animals, a marked effect from the dehydration factor itself is shown. However, that temperature of drying is also important was indicated by the fact that test rats fed pork dried at 70° to approximately 3-percent moisture content became heavily infected with trichinae.

CHANGES IN REFRIGERATED MEAT

Work was done to determine the temperature-time relationship necessary to inactivate the enzymes in fresh meat in an effort to develop improved methods for controlling changes in quality of meat in freezer storage. Catalase was the enzyme used as the index. When muscle tissue from pork loins was heated to an internal temperature of 155° F. for 15 minutes, 160° for 5 minutes, and 165° momentarily,

the catalase was completely destroyed. Heating momentarily at 160° inactivated the enzyme for a short time, but 2 days later a trace of catalase was present, indicating a recovery. On the basis of these results, an experiment was begun to determine what influence preheating at 165° would have on pork loin subsequently kept in freezer storage.

In an experiment to determine the effect of various freezing temperatures on the drip loss of beef during thawing, the loss was found to decrease with the reduction of freezing temperatures from +18° to 0°, -10°, -40°, and -114° F. An increase in the proportion of moisture frozen within the muscle fibers and in the rupturing of the fibers, permitting the proteins to reabsorb more of the water originally frozen in the meat, was believed to be the reason why meat kept at the lower temperatures lost less weight.

RATE OF FEEDING BEEF CATTLE AFFECTS MARKET GRADE

To obtain information on the most desirable level of feeding beef cattle, cooperative work was carried on with the North Carolina Agricultural Experiment Station. Steers of similar grade that weighed about 800 pounds each when placed on experiment were individually fed in sets of three as follows: One animal was full-fed barley with soybean meal, another was fed two-thirds as much, and the third animal was fed one-third as much as the first, all being fed for the same period of time. The animals were allowed to eat all the lespedeza hay they would consume.

A summary of 2 years' results shows that at the close of the feeding period, when the full-fed steers weighed approximately 1,000 pounds, those fed the intermediate ration weighed only about 30 pounds less on the average and those fed the least barley with soybean meal weighed approximately 130 pounds less, the average daily gains per head being 1.63, 1.37, and 0.88 pounds, respectively. The full-fed steers consumed an average ration of approximately 11 pounds of concentrates and 9.5 pounds of hay daily while those fed two-thirds as much concentrates consumed 36 percent more hay than those full-fed and only about 6 percent less than those fed the low-grain ration. The steers fed the highest proportion of concentrates to roughage, however, were not significantly greater in efficiency of feed utilization than those fed the two-thirds concentrate level. Moreover, there was little difference between the full-fed and intermediate-fed cattle in live-animal and carcass grade, fatness, proportion of edible meat, desirability of flavor of fat and lean, or richness of juice in the meat. In all these respects, however, the cattle fed the least concentrates were definitely inferior to the other two groups.

MEAT GRADES EVALUATED

In further work with the Office of Distribution, War Food Administration, means were developed for making better estimates than heretofore of the physical composition of the dressed lamb carcass and six primary cuts by grades. For example, average values for separable-fat content of carcasses of Prime, Choice, Good, Commercial, Utility, and Cull grades were calculated as follows: 33.5, 28.6, 23.6, 18.7, 13.7, and 8.7 percent, respectively. With fat decreasing and bone

content increasing as grade decreased from Prime to Cull, the Good grade was found to contain, on an average, almost equal proportions of these two components, the lean-meat content being about 53 percent.

Although factors other than composition enter into the determination of grade, close relationships were found between grade of dressed lamb carcass and the proportions of protein, fat, moisture, and mineral matter in the edible meat of the carcass and cuts. Highly useful average chemical-composition values were determined for the carcasses and cuts of the several grades. For example, the average percentages of protein in the edible meat of carcasses of the Prime, Choice, Good, Commercial, Utility, and Cull grades were found to be 13.2, 14.1, 15.0, 15.9, 16.8, and 17.7, respectively. Used in conjunction with physical-composition values mentioned above, these percentages of chemical constituents make possible the calculation of amounts of protein, fat, moisture, and mineral matter in the edible meat of any lamb carcass or primary cut of known weight and grade.

For estimating the grades of beef carcasses varying widely in weight, plumpness of round, and live weight divided by length from the first rib to aitchbone were found to be the most useful of the factors studied. Ratio of carcass length to width approached them closely in value for this purpose.

FATTENING CATTLE DEVELOP VITAMIN A DEFICIENCY ON YELLOW CORN

Yellow corn is generally considered to be an important source of vitamin A in farm-animal nutrition. The occurrence of vitamin A deficiency among cattle in the Corn Belt, however, has raised a question regarding the value of corn as a source of this factor for cattle. In preliminary studies with fattening steer calves at the Beltsville station, symptoms characteristic of vitamin A deficiency, such as blindness, convulsions, stiffness, edema or swelling of the legs (anasarca), and rapid breathing in hot weather, terminating in death, developed when the animals were consuming a balanced ration containing 11 to 14 pounds of yellow corn with oat straw as the roughage. Blood analyses indicated that the animals were deficient in carotene and vitamin A and revealed a marked increase in total plasma globulin, particularly fibrinogen and euglobulin fractions (plasma proteins), together with a decrease in plasma albumin. Since yellow corn cannot be depended upon to furnish fattening cattle with ample vitamin A, the value of well-cured, high-quality hay and silage for preventing this deficiency when yellow corn or cereal grains are fed cannot be overemphasized.

CHOPPED SUGARCANE A USEFUL ROUGHAGE FOR STEER FATTENING

To compare chopped sugarcane with cottonseed hulls and peanut hay as a source of roughage, steer-feeding experiments were carried on in cooperation with the Georgia Coastal Plain Experiment Station. The sugarcane was considerably superior to cottonseed hulls and approximately equal to good-quality peanut hay. In this test the concentrates—ground snapped corn and cottonseed meal—were kept constant in all groups and the animals were fed all the roughages they would eat. The average concentrate ration for the 112-day period was 11.4 pounds of corn and 2.25 pounds of cottonseed meal. The roughage rations averaged 19 pounds of chopped sugarcane, 11.9 pounds of

hulls, and 9.7 pounds of peanut hay. The steers fed the sugarcane consumed about 525 pounds more roughage per 100 pounds of gain than those fed peanut hay, but since the sugarcane contained 71.4 percent of water, the actual feed consumption on an air-dry basis was less than for the hay. The fact that sugarcane is highly adaptable to much of the coastal area in the South and Southeast and a great tonnage can be produced per acre makes the crop of value as a source of roughage for cattle feeding.

WINTERING BEEF BREEDING COWS ON FOREST PASTURE

A comparison of different planes of nutrition in wintering beef breeding cows on forest land, as well as a study of the effect of winter grazing on forage and tree production was made in cooperation with the North Carolina Experiment Station and State Department of Agriculture, the Forest Service, and the Bureau of Plant Industry, Soils, and Agricultural Engineering. Cottonseed meal was fed at the rate of 2, 4, and 6 pounds per head daily to three lots of breeding cows grazing forest pastures. All three groups wintered satisfactorily and calved normally, but the percentage calf crop increased in direct proportion to the increase in amount of cottonseed meal fed. From December to late in April the dry cows fed 6 pounds of supplement made slight gains, those fed 4 pounds maintained their weight, and those fed only 2 pounds lost nearly 50 pounds of weight per head. All cows that calved lost weight during the wintering period, but the losses were much less in the groups receiving the most supplement.

Even though the cows wintered on the least supplement were in nearly as good condition at the close of the summer grazing season as those in the other groups, because of greater subsequent summer gains, they apparently had been in too poor condition at breeding time for as high a percentage of conceptions to result. Wintering beef breeding cows in the forests on native forage and a moderate amount of protein concentrates appears to be practical and economical for this region.

DISTILLERY PRODUCTS USEFUL FOR BEEF PRODUCTION

The value of distillery slops and distillers' dried grains for beef production was studied near Louisville, Ky., in cooperation with the Kentucky Agricultural Experiment Station and a local distilling company, and at the Beltsville Research Center. A 224-day test showed that 700-pound Medium to Good grade feeder steers fed distillery slop made from whole-wheat mash gained, on the average, 1.70 pounds per day, similar steers fed granular-wheat slop gained 1.50 pounds, and steers fed a slop made from equal parts of corn and wheat gained 1.45 pounds. These slops were fed *ad libitum* and there was but little difference in the consumption, as shown by the average consumption per head daily of 21.9 gallons of the whole-wheat slop as compared with 20.4 gallons of the granular-wheat slop and 19.5 gallons of the corn-wheat slop. In addition to the slop, 5 pounds of hay per head was fed daily. This test clearly indicates the usefulness of these slops for beef production; they are particularly valuable in areas close to distilleries. In the past a very low grade of cattle has been used for slop feeding, but this experiment has shown that very satisfactory gains and high-quality beef can be produced by using a Medium to Good grade of feeder cattle.

SORGOS BETTER THAN SORGHUMS AS SOURCES OF CAROTENE

At Spur, Tex., in cooperation with the Texas Agricultural Experiment Station, steers were fed sorgo silage (sumac variety), made from the 1941 and 1943 crops, and sorghum silage (hegari), from the 1943 crop, to determine their value as sources of carotene. Also, these silages were compared with cottonseed hulls fed with ground threshed milo and cottonseed meal. The results indicated that the carotene content of both silages was not reduced because of the time in storage. The sumac silage averaged considerably higher in carotene than hegari silage throughout the test, even though it was considerably lower in dry matter. On the basis of a carotene requirement of approximately 2,500 micrograms daily per 100 pounds of live weight, it appears that fattening steers which receive as much as 1 pound of sumac silage or 2.75 pounds of hegari silage per 100 pounds of live weight will be protected against vitamin A deficiency for fattening periods of about 200 days. There was no evidence of night blindness among the steers fed silage, but in the steers fed cottonseed hulls there was considerable. The average carotene and vitamin A contents of the livers of the steers fed cottonseed hulls were lower than those of the steers fed the silage. Night blindness may persist in cattle which show a range of 0.73 to 1.51 parts per million of pure carotene in livers, as indicated by these studies. The steers fed cottonseed hulls made greater gains and attained a higher finish than those fed silage but required more dry matter to produce 100 pounds of gain.

TESTED BULLS IMPROVE BEEF PRODUCTION

The steer progeny of three generations of Shorthorn sires at the Beltsville Research Center have been tested in the record-of-performance feeding test at Beltsville. The steers sired by the grandson were superior to the steer progeny of the sire and grandsire in average daily gain and in efficiency of feed utilization. They also required 22 days' less time to reach a slaughter weight of 900 pounds than the steer progeny of the grandsire and 41 days less than those of the sire. The steers sired by the son dressed 61.6 percent as compared to 60.9 percent for the progeny of the grandson and 59.4 percent for the steer progeny of the sire. These results indicate that progress can be made in the efficient production of beef by the use of bulls proved for their ability to transmit such qualities as rapid rate of growth and gain, and capacity for economical use of feed.

Two sons of a proved Milking Shorthorn sire in the herd at Beltsville have been tested, through their progeny, for the production of both beef and milk. Seven daughters of one son in their first lactation, a period of 305 days, produced approximately 1,300 pounds more milk and 37 pounds more butterfat than their dams. The steers by this sire were slightly superior to those of his own sire in average daily gain and efficiency of gain during the fattening period. Two daughters of the other son have completed their first lactation, also 305 days in length, during which they produced 1,320 pounds more milk and 54 pounds more butterfat than their dams. The steer progeny of this sire were approximately equal to those of his half brother in efficiency of feed utilization and daily gain for the fattening period and were slightly superior in dressing percent.

CROSS-BREEDING INCREASES STEER GAINS AND CARCASS QUALITY

The results of cross-breeding studies at the U. S. Range Livestock Experiment Station, Miles City, Mont., showed that the first-cross Shorthorn × Hereford steers made 70 pounds more feed-lot gain than the Herefords. As the carcass grades were essentially the same for the two groups, the increased weight of the crossbreds resulted in greater financial returns. In both carcass grade and gains in the feed lot, the second-cross steers (Aberdeen Angus × Shorthorn-Hereford) were superior to either the first cross or the Hereford steers. One group of Herefords out of six, however, surpassed the crossbreds in feed-lot gains, but in gross returns the crossbreds exceeded the Herefords by 27 percent.

CALVES NURSING DAMS PRODUCE MORE BEEF THAN THOSE HAND-FED

In a comparison, at Beltsville, of results from hand-feeding milk to calves and from allowing one or more calves to nurse a cow, 9 Milking Shorthorn steers that nursed to a weaning weight of 500 pounds made an average gain of 2.03 pounds per day, as compared with an average of 1.77 pounds for 98 steers that were hand-fed. Furthermore, the calves that nursed required 35 days less time to reach a weight of 500 pounds than the hand-fed calves. These advantages were carried on through a fattening period, as the former gained 1.96 pounds per day, as compared with 1.58 pounds for the latter steers, and required 43 days less time on feed. The steers that nursed produced carcasses approximately two-thirds of a grade higher than the hand-fed steers and their dressing percentage was higher.

The carcasses of five of the nine steers were in the Good grade, as compared with average Medium for the hand-fed steers. The hand-fed steers dressed 57.70 percent of their liveweight, as compared with 61.88 percent for the steers that nursed. In heifers the advantage of nursing over hand-feeding was not so great as in the steers, but the trend was in the same direction.

RAMBOUILLET SHEEP BEING IMPROVED FOR WESTERN RANGES

At the Western Sheep Breeding Laboratory, Dubois, Idaho, an important phase of the research has been the breeding of Rambouillet sheep with open faces, free from wool blindness. Such sheep have produced 12 percent more pounds of lamb per ewe per year than wool-blind sheep.

Results also show that the Rambouillet flocks of the laboratory excel by 25 percent the wool production of commercial flocks under similar types of management. Research at the laboratory with Rambouillet sheep is furnishing commercial sheep and wool producers information of direct practical application in the improvement of their own flocks.

STABILIZING WOOL AND BODY TYPE IN WHITE-FACED CROSSBRED SHEEP

In recent years cross-breeding as practiced for the production of range sheep has resulted in a mixture of types that in many cases has proved to be undesirable. To assist in stabilizing the wool and body

types of these crossbred sheep, the Bureau has developed the Columbia and Targhee breeds.

Effort is being continued at the Dubois station to improve these breeds still further through the application of various principles of breeding and selection. For example, with Columbia the average increase in inbreeding for offspring over dams this year was 4.19 percent (actual, not relative, percentage). A program of crossing Columbia lines was initiated to explore the possibilities of improving these sheep by line crossing and to determine the crossing value of the lines. In these first tests the cross-line offspring exceeded the straight-line offspring by an average of 0.51 pound in birth weight per lamb. With the Targhee the average increase in inbreeding for the offspring over their dams last year was 7.2 percent. In Corriedale matings the average inbreeding in the offspring increased 5.3 percent over that of their dams. The average unscoured-fleece weights of yearling ewes, adjusted to 365 days' growth, were 10.07 pounds for Columbia, 9.28 pounds for Targhee, and 9.28 pounds for Corriedale. The average sheared-body weights per yearling ewe were 98.44 for Columbias, 89.33 for Targhees, and 84.85 for Corriedales.

From the results to date it is increasingly apparent that these three breeds are strong in the wool characteristics and body conformation desired in the primary types of western white-faced crossbred sheep, and this breeding research is blazing the trail in the efforts being made to standardize the wool and body types of range sheep.

IMPROVED SHEEP FOR NAVAJO INDIANS MEET WOOL REQUIREMENTS

At the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, N. Mex., studies showed that to meet the weaving requirements of Navajo Indians, wool should grade 48's and 50's in fineness, with a minimum staple length of 4 inches for 12 months' growth and that it should be lustrous and light-shrinking with a broad crimp or wave. The unscoured annual fleece weights of mature ewes should average 8 pounds, with a clean-wool yield of not less than 4 pounds. The fleeces should be as uniform as possible in fiber length and diameter and relatively free from kemp and commands a satisfactory price in comparison with improved wools on the commercial market.

Study also showed that the sheep which will produce such wool successfully under the environmental conditions on the Navajo Reservation must possess maximum hardiness and adaptability to the semiarid range conditions of the Southwest. Their body size should be about medium, mature ewes averaging about 110 pounds, and mature rams about 185 pounds when in breeding condition. The lambs should weigh about 50 to 60 pounds at weaning age and be of good feeder type.

Sheep of the desired type were developed through cross-breeding old-type Navajo ewes with purebred Romney and Corriedale rams, followed by selective matings of the first generation Romney \times Navajo and the first generation Corriedale \times Navajo crossbreds and selective linebreeding of the first and succeeding generations of the $\frac{1}{4}$ Romney- $\frac{1}{4}$ Corriedale- $\frac{1}{2}$ Navajo offspring. In fleece and body type, a fair percentage of the first and second generations of such offspring closely approach the desired objectives. Further breeding work will be required to develop uniformity of type and to fix important fleece

and body characteristics so that the sheep will breed relatively true for the desired characteristics.

BLOOD-PHOSPHORUS LEVELS VARY IN RANGE EWES

Results of a 4-year study of factors affecting the blood-phosphorus level of range ewes at the Western Sheep Breeding Laboratory, in cooperation with the Idaho Agricultural Experiment Station, show that blood-phosphorus levels in breeding ewes vary with the season of the year. The highest levels occurred in the winter, followed by a drop at lambing time, and an increase in May and June, when the range forage was succulent. In September the level was again about as low as at lambing time, and this low level continued into November and rose to the highest point in January.

WOOL PRODUCTION OF BUREAU SHEEP IMPROVED

At Dubois, Idaho, considerable improvement in wool production of range Rambouillet sheep in the experimental flocks has been made during recent years through the development of accurate laboratory measurements of length of staple and weights of clean wool per fleece and their application in the selection and matings of the breeding animals. During the last 4 years the weight of clean wool per fleece from yearling Rambouillet ewes has increased from 3.17 to 3.61 pounds, or 14 percent. The commercial yield of clean wool per 100 pounds of unscoured wool has increased from 35.50 to 45.31 pounds. The average staple length of these fleeces increased from 2.17 inches to 2.55 inches, or 17.5 percent.

One of the Rambouillet flocks at Dubois is being line-bred for the improvement of length of staple. In the last 4 years this has been increased from 2.56 to 2.98 inches, or 16.4 percent. Last year this long-staple line excelled the other Rambouillets at the laboratory by 16.9 percent in commercial weight of clean wool per fleece. Of the entire Rambouillet flock of mature ewes at Dubois, 57 percent had Strictly Combing wool last year, as compared with only 29 percent the previous year. As the older ewes with shorter staple are culled out and younger ewes with longer staple are added to the flock, there is a rapid increase in the proportion of Strictly Combing fleeces. In 1943 the commercial value of a Strictly Combing fleece was \$5.87, as compared with \$5.00 for a slightly shorter French Combing fleece. These results illustrate how rapidly wool improvement can be effected through the application of suitable breeding and selection methods to the financial advantage of the producer.

WOOL-SHRINKAGE STUDIES AID INDUSTRY

In shrinkage studies on wool conducted in cooperation with the Wool Division, Livestock and Meats Branch, War Food Administration, more accurate and exact methods of determining the clean wool content have been developed. These have not only involved the development of a practical procedure of determining the clean wool content of large quantities of wool from the scouring of small samples but also the development and perfection of a coring device for removing for shrinkage determination truly representative small samples of

wool from bags or bales. The application of these techniques this year on approximately 19 tons of wool produced at the Bureau's Dubois station indicated that the wool was actually yielding approximately 5 percent more clean wool than was formerly estimated for similar grade wools in the wool markets.

WET-PLUCKED CHICKEN FEATHERS PRESERVED BY SIMPLE PROCESS

In the Bureau's animal-fiber laboratory at the Beltsville Research Center a simple and effective process has been developed by which wet-plucked chicken feathers may be preserved for industrial use. The process involves the use of 15 pounds of common salt and a pint of commercial concentrated hydrochloric acid, dissolved in 30 gallons of water for each 15 pounds of wet feathers to be preserved. A tight 50-gallon wooden barrel makes a convenient container. Thorough mixing was found to be essential to make certain that all feathers are exposed to the preservative. The solution costs initially about 1¼ cents per pound of wet feathers treated. The expense is further reduced by the fact that several lots of feathers can be preserved in the same solution before its preservative value is spent. The use of this preservative makes possible industrial utilization of millions of pounds of chicken feathers formerly wasted or used for fertilizer.

SWINE RESEARCH IMPROVING BREEDING METHODS

In developing and testing effective methods of breeding and selection for the improvement of swine, research studies were continued at the U. S. Regional Swine Research Laboratory, Ames, Iowa, and co-operating State agricultural experiment stations. The four phases are studies of various systems of breeding, measures for appraising hogs and hog carcasses, heritability of various characters, and physiology of reproduction. In these studies, which are being conducted in cooperation with the State experiment stations of Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Oklahoma, Ohio, South Dakota, and Wisconsin, emphasis is being given to productiveness of sows, growth rate of pigs, economy of gains, vitality of pigs, and desirability of carcasses, all important production factors.

Results obtained during the past year tend to confirm tentative conclusions that the purebred hogs now available in the country can be inbred slowly, increasing the inbreeding 3 to 4 percent per generation until it reaches approximately 30 percent, without much loss in productive characters.

Results indicate also that hybrid vigor can be expected from crossing inbred lines, even within a breed of purebred hogs, if the lines are inbred 30 to 40 percent. Crossing of inbred lines within a breed has produced approximately one-third more pigs per litter at birth, 1¾ more pigs per litter at 5 months, and 30 pounds more weight per pig at 5 months than did the parent lines. When the lines are of different breeds the increase from crossing tends to be greater than if the lines are of the same breed. The results make clear that inbred lines should be produced from stock as nearly unrelated as can be found within a breed to obtain best results from crossing lines of the same breed.

Results so far indicate that if further progress is to be made through selection for productive characters, selections must be based largely on

performance rather than on eye judgment. They also show that use of selection indexes or performance scores in selecting for functional characters may speed improvement. Data obtained in the laboratory indicate that an index or performance score based on three to five traits would be sufficiently simple to make it practical. Traits showing the most promise for this purpose are: (1) Number of pigs farrowed, (2) weight and number of pigs at weaning, (3) rate of growth to 5 or 6 months or rate of gain from weaning to market weight, and (4) score for market desirability.

PERFORMANCE OF NEW SWINE STRAINS FROM CROSSBRED STOCK PROMISING

Experiments carried on at Beltsville, Md., since 1935 have now reached the stage where inbred lines are being developed within seven strains from crosses involving the Landrace and Chester White; Landrace and Duroc-Jersey; Landrace, Duroc-Jersey, and Hampshire; Landrace, Duroc-Jersey, Hampshire, and Yorkshire; Landrace and Large Black; Landrace and Poland China; and Yorkshire and Duroc-Jersey. The system of inbreeding as now practiced will permit more accurate selections for high-quality performance than would be possible under random breeding. In general, from three to four boars are used within the different strains, giving inbreeding rates of about 4 percent per generation. Some of the new lines are proving very promising and there are already indications that they are superior to the others.

At Miles City, Mont., in cooperation with the Montana Agricultural Experiment Station two inbred strains of Landrace \times Hampshire breeding are now in the process of being formed. The average inbreeding of the 39 litters farrowed during the year in the black strain was 18 percent, while that of the 10 litters in the red strain was 34 percent. Data bearing on the relative merits of the two strains showed an advantage for the black strain in each of the points compared. The respective averages were 10.5 and 7.4 pigs in size of litter, 7.9 and 6.7 pigs weaned per litter, 221.4 and 179.7 pounds weaning weight of litter, and 28.1 and 26.8 pounds weaning weight of pigs. Average daily gains to a final weight of about 225 pounds of 80 pigs in the black strain and of 16 pigs in the red strain were 1.42 and 1.32 pounds respectively, with average feed required per 100 pounds of gain of 362 and 395 pounds, respectively. While the performance of the red strain is still satisfactory, the relative performance of the two strains to date indicates that strains in which inbreeding progresses more slowly are likely to show a greater response to selection than strains in which the inbreeding increases rapidly.

DRIED DISTILLERS' GRAINS FOR SWINE

A national shortage of protein feeds for livestock feeding prompted a study at Beltsville of distillers' dried grains with solubles made from different grains and grain mixtures in the production of alcohol for war purposes to determine their place in the swine ration. Besides the high protein content, these products contain fairly generous levels of the vitamins in the B complex. Eight lots of 10 pigs each were fed to market weight on different kinds of dried distillery grains with solubles made from corn and wheat. The dried distillers' grains

were fed as protein supplements to replace either 3.6 or 7.2 percent of the protein in the diet, with a basic ration of corn, tankage, soybean meal, alfalfa meal, and minerals.

Results of the tests showed that under the experimental conditions, rations containing 3.6 percent of protein derived from dried distillers' grains with solubles, or actually 9.4 to 12 percent of the distillery product, produced average daily gains varying from 1.17 to 1.26 pounds daily, with feed consumption per 100 pounds' gain varying from 392 to 425 pounds. When distillery products were fed at the higher protein level so that they amounted to 18 to 26 percent of the ration, the average daily gains varied from 0.81 to 0.85 pound daily and the feed required per 100 pounds gain varied from an average of 508 to 567 pounds. The average daily gain of the check lot fed a standard ration, without distillers' dried grains and solubles, was 1.27 pounds daily on a feed requirement of 393 pounds of feed per 100 pounds' gain. No significant differences were observed between distillers' grains with solubles made from a wheat mash, a corn mash, or a combination of the two grains. The reason for the wide difference between the two levels of feeding of the products is being further investigated.

ANIMAL PROTEIN MAY BE OMITTED FROM WARTIME SWINE RATIONS

A study has been made at Beltsville, Md., of diets with and without animal protein for reproduction and growth in swine. Four groups of sows and gilts were fed throughout the gestation period for spring and fall litters on diets of (1) corn and trinity protein supplement ($\frac{1}{2}$ animal- and $\frac{1}{2}$ vegetable-protein mixture); (2) corn and all-vegetable protein mixture; (3) wheat and all-vegetable protein mixture; and (4) corn and low animal-high vegetable protein mixture. Legume hay was fed in racks during the winter gestation period and pasture was available during the summer gestation. No marked differences attributable to diet were observed in the number of pigs farrowed per litter and the number weaned at 56 days of age. During the growing and fattening periods hogs receiving some animal protein in the supplement gained at a faster rate than those on the all-vegetable supplement, although wheat proved to be more satisfactory than corn with the all-vegetable-protein supplement used. The results indicate that a good all-vegetable source diet can be used during the gestation period but is less satisfactory for the rapid growth and development of growing pigs than a diet containing some animal protein.

PREVENTION OF LOCOMOTOR INCOORDINATION

A type of locomotor incoordination in pigs that has appeared in the feed lot in various sections of the country results from a characteristic form of nerve degeneration. Earlier work had shown that this condition could be produced experimentally on a normal diet of corn, tankage, alfalfa meal, linseed meal, and mineral mixture, which had been subjected to a heat treatment. Recently, it was found that calcium pantothenate added to this heated basal diet greatly reduced the incidence and severity of the disorder but that the addition of pyridoxine appears to be necessary for full prevention. The quantity of

calcium pantothenate effective for protection was 0.5 milligram, and of pyridoxine 0.15 milligram, per kilogram of body weight.

EFFECT OF ROUGHAGE LEVEL ON UTILIZATION OF RATIONS BY HORSES

Further studies of the effect of the roughage level on the utilization of rations by horses have demonstrated a high correlation between decreasing fiber content and increasing digestibility of the ration. These changes in digestibility have been marked not so much by increases in digestibility of the fiber as in that of the other nutrients. Furthermore, chopping of the hay has not affected the digestibility. Rations with a high crude-fiber content providing 10 pounds of hay per 1,000 pounds live weight gave a protein digestibility coefficient of 62 percent, while a medium-fiber ration derived from 4 pounds of hay with an increased proportion of concentrate gave 72 percent, and a low-fiber ration from a concentrate mixture without added hay gave 80 percent. Corresponding coefficients for the nitrogen-free extract in these rations were 66, 79, and 88 percent, respectively. The conventional coefficients of digestibility of protein, fat, and nitrogen-free extract in hay are of course lower than those for the same nutrients in, oats and corn, so that a part of these increases in digestibility may be accounted for by the increases in the proportion of grain in the rations. Allowing for these differences, however, the results obtained in these studies indicate that in the case of the horse, the coefficients of digestibility for protein, fat, and nitrogen-free extract in the concentrate feeds varies with the amount of roughage and hence of crude fiber in the ration.

Obviously these increases in digestibility coefficients produced a marked increase in the total digestible nutrients per unit of ration. Thus a horse requiring 10 pounds of total digestible nutrients will have this requirement met by the use of 14.6 pounds of a ration with a 4-pound hay allowance as compared to 18.7 pounds of one with a 1-pound hay allowance. Besides the reduction in weight of the ration a marked reduction in volume is also achieved, especially if the mixture is chopped and pelleted or otherwise compressed, thus facilitating the transportation of Army horse rations under field conditions.

CERTIFICATION OF ANIMALS IMPORTED FOR BREEDING

As provided for by the Tariff Act of 1930, certificates of pure breeding were issued for 24,339 animals imported during the year. This is an increase of 1,909 animals over importations for the previous year. Importations by species of animals were: Cattle, 20,697; horses, 88; sheep, 2,736; swine, 350; goats, 13; and dogs, 455. Because of war conditions almost all the importations were from Canada and Mexico.

BREEDING CHICKENS FOR INCREASED RESISTANCE TO LYMPHOMATOSIS

In the research program directed toward reducing the mortality of chickens at the U. S. Regional Poultry Research Laboratory, East Lansing, Mich., marked progress has been made in breeding lines of chickens increasingly resistant to lymphomatosis, or fowl paralysis, a disease responsible for large annual financial loss to poultrymen. Results of these studies indicate that resistance to the disease has been

increased materially in certain lines of closely related birds over that in other lines in the experiment. The practice of breeding year after year from stock whose brothers and sisters and whose progeny show the lowest incidence of lymphomatosis, when all are equally exposed to the infection, has resulted in the development of lines of White Leghorns which are more resistant to the disease as demonstrated by fewer cases and a longer average life span. This resistance is measured by comparing the incidence of the disease and viability of the birds with other lines selected and bred for susceptibility, the progeny of which are maintained under similar conditions with reference to exposure to the causative agent. For example, one susceptible line has shown an average mortality from lymphomatosis to 300 days of age of 47.2 percent, whereas a line bred for resistance to the disease has suffered a mortality of but 11.1 percent.

The principle of breeding chickens for resistance to lymphomatosis as demonstrated at this and other experiment stations is being used extensively and effectively by some poultry breeders in reducing their losses from this disease. Its direct use is limited to those who pedigree their birds and keep accurate viability records, using only those individuals for breeding purposes whose progeny have a high percentage viability and consequently a relatively low mortality from lymphomatosis. However, the rate of progress is slow, as is the case with other characters of a complex nature.

CROSSING INBRED CHICKENS INCREASES EGG PRODUCTION OF PROGENY

Pullets produced during the year from certain matings among unrelated inbred lines of the same and different varieties are laying at a rate considerably in excess of that shown by line-bred strains of the same varieties at Beltsville. The pullets from these crossed inbred lines also show viability considerably superior to the line-bred strains under the same environmental conditions.

DETERIORATION RATE IN EGG WHITE AFFECTED BY BREEDING

In an attempt to establish divergent lines of chickens producing nondeteriorating and deteriorating thick white in stored eggs, selection studies were carried on at Beltsville for the last 4 years. Individual and family differences in the shrinkage of thick white indicated that this characteristic is probably inherited. The nondeterioration line has shown high variability. In 1943, eggs from this line averaged about 33 percent in shrink of thick white. The deterioration line averaged about 62 percent. Eggs from the progeny of the two lines averaged about 50 percent and 62 percent, respectively. The difference between these two progenies is highly significant statistically. It is, therefore, probable that further selection may lead to greater divergence of the two lines and reduction in variability of the nondeterioration line.

SHELL QUALITY IMPROVED THROUGH FAMILY SELECTION

Selective breeding studies have resulted in the development of two divergent lines of chickens, one of which shows about 60 percent more shrinkage in egg weight than the other. Amount of shrinkage under standard conditions is an indication of shell quality. These

two lines appear to be approaching stabilization because the average performance of their progenies have shown practically the same amount of difference for the past two years. The results indicate that the shell quality of eggs can be materially improved through family selection of breeding birds for high shell quality, as evidenced by relatively low shrinkage in the egg when stored.

ANIMAL PROTEIN NOT ESSENTIAL FOR GROWING POULTRY

Among the changes forced upon poultry feeders by the war none has caused more concern than the decreased use of meat and fish meals and dried-milk products and their replacement with vegetable-protein supplements. Results of poultry-feeding investigations at Beltsville indicate that this concern does not appear to be justified, as diets which produced very good growth of chicks and poults were compounded from soybean meal, grains, alfalfa meal, and small quantities of mineral and vitamin supplements. The studies showed that particular attention must be given to the mineral and vitamin supplements in such diets, as soybean meal supplies much less calcium, phosphorus, riboflavin, and probably certain other water-soluble vitamins than do the animal-protein supplements. In these tests the diets for chickens contained 35 percent of soybean meal; those for turkeys, 40 percent. Although chickens grew very well when fed diets containing soybean meal but no animal protein supplements, their growth was somewhat better when the diet included 2 percent of sardine meal, a very small quantity in comparison with prewar feeding practice.

EGG PRODUCTION NOT AFFECTED BY DIETARY LEVELS OF FAT

Because of the great need for fats in wartime there has been some tendency to decrease the fat content of poultry feeds below the customary 4 or 5 percent, and questions regarding the possible effects of this change are frequently asked. On the basis of experiments with laying pullets at the Beltsville Research Center the change toward lower fat levels is justified. In two experiments, each of 36 weeks' duration, no significant differences in egg production occurred as a result of varying the fat content of the diet from less than 1 percent to slightly more than 8 percent.

PHOSPHORUS REQUIREMENT OF TURKEY POULTS

In another investigation of poultry diets, the phosphorus requirement of turkey poults was found to be about 0.6 percent of a diet containing 80 Association of Official Agriculture Chemists units of vitamin D per 100 grams and as little as 0.48 percent of a diet containing 160 A. O. A. C. units of vitamin D per 100 grams. This relationship is of practical importance because supplies of phosphorus supplements are restricted, whereas supplies of vitamin D are not.

STUDIES OF FACTORS THAT AFFECT EGG PRODUCTION

Poultry-physiology studies were conducted at Beltsville in an attempt to influence favorably the production of eggs through environmental or physical means. In these studies the condition under which ovulation can be induced experimentally has been determined. The

differentials underlying the constitution of clutch sequence also have been discovered and analyzed, the hormonal function of the ruptured follicle of the hen in controlling the time of lay of at least the last egg of each clutch has been established, and the determination made of hormonal and other factors which cause break-down of the ovarian follicle before it completes its growth and ovulates. An outstanding accomplishment of these experiments last year was the discovery that the ruptured follicle which previously contained a given yolk regulates the subsequent stay of that yolk in the oviduct whenever ovulations do not follow each other by about 25 to 27 hours. All ruptured follicles are equally capable of regulating the time of lay in the absence of closely associated ovulation. An attempt is being made to determine the effects of controlled lighting on reproductive processes in the hen, with particular reference to the manner in which such effects are mediated through the anterior pituitary gland. Determination of this mechanism, however, will require further study.

HOT-WATER TREATMENT OF EGGS HELPS PRESERVE QUALITY

Investigations on the keeping quality of fresh eggs indicated that dipping commercial fresh eggs in hot water for a limited time stops embryonic growth, stabilizes the quality of egg white, and destroys many bacteria which cause spoilage in untreated eggs. The value of this method, first reported by the University of Missouri, was confirmed in further tests at Beltsville. Additional work was done to determine the range of time and temperature that can be used without producing coagulation of the white of the eggs so treated. It was found, for example, that eggs, initially at room temperature (70°-75° F.) could be treated for 4 minutes at 144° F. or for 44 minutes at 124° F. with practically the same results. The initial temperature of the eggs must be considered in determining the time length of the treatment and proper temperature of the water. The fertility of the eggs was destroyed when the temperature produced incipient cloudiness of the white. Fresh eggs—those less than 24 hours old—and eggs that were treated with oil while fresh, coagulated in less time than did other eggs at temperatures above 134° F.

FEEDING FISH PRODUCTS IMPAIRS FLAVOR OF TURKEY MEAT

A study was completed of the effect of feeding certain fish products on the odor and flavor of roasted turkey, in cooperation with the Bureau of Home Economics and Human Nutrition. From the results obtained it was determined that fish oils of all kinds should be omitted from the diet of turkeys from 8 weeks of age until marketing. However, if it is necessary to feed fish oils the quantity should be restricted to one-eighth percent or less of the total diet. Only good-quality sardine and tuna fish meals should be fed to market turkeys beyond the age of 8 weeks. When one or both of these meals are fed, the quantity should be limited to 5 percent or less of all-mash growing diets, to 8 percent or less of growing mashers that contain 20 to 22 percent protein, and to 12 percent or less of the mashers that contain 32 percent protein.

NATIONAL POULTRY IMPROVEMENT PLAN IMPROVING QUALITY OF CHICKS

Participation in the work of the National Poultry Improvement Plan, designed to improve the production and breeding qualities

of poultry and to reduce mortality from pullorum disease in the United States, has continued to grow during the last year. The entrance of Pennsylvania during the year has increased the number of actively cooperating States to 45. Furthermore, there has been a substantial increase in the number of breeders, hatcherymen, and hatching-egg flock owners voluntarily participating in the plan, as shown in table 2. The scope of the plan is evidenced by the fact that about 40 percent of all chicks hatched in the United States during the year were produced by cooperating hatcheries.

Emphasis is placed on careful selection of the females in hatchery-supply flocks and the use of production-bred cockerels from farms doing trap-nesting, pedigree breeding, and family selection, to head such flocks. Reports indicate that about 27 percent of the participating hatchery-supply flocks were mated to males of this quality during the year, as compared to 19 percent the previous year. The records of all the pedigreed U. S. R. O. P. candidates for which complete egg-production records were obtained in 1942-43 showed a hen-housed¹ average egg production of 167 eggs as compared with an average farm production of 112 eggs per layer for the year. The daughters of U. S. R. O. M. sires averaged 199 eggs per bird, and the daughters of U. S. R. O. M. dams 207 eggs per bird in 1941-42.

Pullorum disease is being effectively controlled and the losses of chicks from this disease are being reduced through the operation of the plan. More than 20 million birds were officially tested this year, with an average of 2.4 percent reactors. Surveys in several States indicate that chick losses have been reduced proportionately as percentage of infection in breeding flocks has been reduced.

A turkey-improvement program, including both breeding and pullorum disease eradication, was made a part of the National Poultry Improvement Plan during the year. The program has already been officially adopted in 12 States. Official pullorum testing was conducted in 334 flocks, consisting of 52,178 birds, of which 688 or 1.32 percent were found to be positive reactors to the test.

TABLE 2.—Participation in the National Poultry Improvement Plan, 1939-44¹

Item	Extent of participation during year ended June 30—					
	1939	1940	1941	1942	1943	1944
States.....	44	44	44	44	44	45
Hatcheries.....	2,033	2,192	2,465	2,667	2,729	3,080
Egg capacity of hatcheries.....	76,782,922	60,578,718	117,915,752	135,742,179	149,426,834	189,756,009
Breeding flocks.....	42,591	50,559	59,136	69,681	69,569	81,894
Breeding birds.....	8,653,568	10,714,238	12,010,766	15,518,967	16,534,458	20,332,048
Breeding birds tested for pullorum disease.....	6,772,031	8,900,869	10,527,946	14,906,649	15,900,011	20,332,048
United States Record of Performance flock owners.....	317	335	335	317	326	320
United States Record of Performance flocks.....	396	429	445	425	435	447
Birds entered in trap-nest flocks.....	124,937	144,447	154,969	160,022	151,685	158,290
United States Record of Performance breeding pens.....	2,206	2,429	2,749	2,999	3,261	3,618
Females in United States Record of Performance pens.....	30,081	32,949	38,957	42,841	45,964	49,280

¹ See previous Annual Reports of Chief of Bureau for earlier data; plan was established July 1, 1935.

¹ The number of eggs laid during the year divided by the number of hens entered.

RESEARCH IN ANIMAL DISEASES

On November 1, 1943, the work of the Animal Disease Station at the Beltsville Research Center was consolidated with that of the Pathological Division, with Harry W. Schoening, principal veterinarian, in charge of the combined activities. The new arrangement was designed to bring about closer coordination of the Bureau's disease-control investigations. During the year the following work was continued: Investigations of the diseases of domestic animals and birds and the poisoning of livestock by plants, and the examination of viruses, serums, and other biological products used in diagnosing, preventing, and treating diseases of domestic animals.

VESICULAR DISEASES

OUTBREAK AMONG SWINE IN SERUM PLANT IN MIDDLE WEST

Vesicular stomatitis, vesicular exanthema, and foot-and-mouth disease are three vesicular diseases of animals which resemble each other clinically. For a definite diagnosis, they require animal inoculations and a study of the disease so produced.

In August 1943 a vesicular disease of swine appeared at a hog cholera serum plant in the Middle West. A large number of animals were involved and the symptoms and lesions were indistinguishable from those of foot-and-mouth disease. After quarantining the establishment and all biological products, the Bureau carried out extensive tests to identify the disease. Inoculations of horses, cattle, swine, goats, and guinea pigs and filtration tests were made, and the results definitely showed that the disease was vesicular stomatitis and that the virus was of the New Jersey type.

Although swine were known to be susceptible to vesicular stomatitis by artificial inoculation, the disease had not previously been reported as occurring naturally in these animals. Extended investigations failed to reveal definitely the source of the infection in this outbreak. After a period of quarantine all affected animals were killed. Extensive tests were made to insure the safety of all biological products at the establishment before they were released.

Studies of the virus from the 1943 outbreak in swine and of other strains being maintained gave the following results: The virus readily produced typical vesicular stomatitis in horses, cattle, swine, and guinea pigs. The disease was found to be highly contagious among swine under certain conditions. Three weeks after the first signs of the disease convalescent swine or the pens that had been occupied by them failed to infect contact animals. Under some conditions, however, hidden infections and immunity resulted from contact with infected animals. The disease was reproduced readily in swine by intravenous inoculation of stomatitis virus together with hog cholera virus or when used alone. The artificial disease was indistinguishable from that which occurred originally in the animals at the biological establishment. However, a large, hyperimmunizing dose of hog cholera virus apparently retarded the development of vesicular stomatitis in some instances.

DIFFERENTIATING VESICULAR STOMATITIS FROM FOOT-AND-MOUTH DISEASE

Foot-and-mouth disease virus is known to produce typical vesicle formation in the mouth and on the feet of cattle when it is inoculated intramuscularly. In order to obtain more definite information as to the intramuscular infectivity of vesicular stomatitis virus, 64 cattle, mostly adults, were injected intramuscularly or, in a few instances, subcutaneously at various times, with one or both types of the virus. None of the cattle developed vesicular disease, and all but 2 were found to be immune when inoculated on the tongue with virus of the same type as had been inoculated previously. The results of these tests on a significantly large number of animals, different virus preparations being used at various times, establish intramuscular inoculation as a useful means of differentiating the viruses of foot-and-mouth disease and stomatitis.

Inoculation of sheep on the tongue was found to be another aid in differentiating the two diseases. Reports of inoculations of the virus of foot-and-mouth disease indicate that sheep may be readily infected. Apparently little work has been done with vesicular stomatitis in sheep. Accordingly 16 adult sheep were inoculated on the tongue with the 1943 swine virus, which, as already stated, was of the New Jersey type. Eight of these animals were inoculated about 6 months later with Indiana virus. Finally, 22 other sheep, including a few lambs 1 to 11 months of age, were inoculated with the New Jersey virus and 5 days later with the same Indiana virus used above. No lesions occurred in any of the 38 sheep inoculated. In every instance the virus used produced typical vesicular stomatitis in horses, cattle, or guinea pigs.

VESICULAR EXANTHEMA BEING STUDIED

During the year the Bureau began cooperative research on vesicular exanthema with the California Agricultural Experiment Station. At the California station the blood of swine with vesicular exanthema was found to be infectious during the early stages of the disease. The particle size of the virus was determined through ultra-filtration tests. Hamsters (gopherlike rodents) were infected by intradermic inoculation of the abdominal skin. The virus was isolated from the muscles of the ham of a hog slaughtered in the acute stages of the disease. It was found that inactive exanthema virus could, like some other viruses, be reactivated by the addition of cystein.

INFECTIOUS EQUINE ENCEPHALOMYELITIS BEING CONTROLLED

During the calendar year 1943, the Bureau received reports of 4,768 cases of infectious equine encephalomyelitis (sleeping sickness) in 34 States. This number is slightly less than that for the preceding year.

During the summer of 1943 the George Williams Hooper Foundation for Medical Research, at San Francisco, isolated three strains of virus from mosquitoes collected in California, Nebraska, and Washington at the time of equine encephalomyelitis outbreaks. By immunity tests in laboratory animals these strains were confirmed in Bureau laboratories as being of the western type of equine encephalomyelitis virus.

Eastern virus was identified from two equine cases in Maryland. Representative strains of eastern and western virus were supplied to a number of domestic and foreign applicants. Rabies virus was isolated from an Arizona horse in which a clinical diagnosis of encephalomyelitis had been made.

HOG CHOLERA

DEVELOPING MORE DEPENDABLE CRYSTAL VIOLET VACCINE

Crystal violet vaccine produced by the regular method—treating hog cholera virus with a mixture of crystal violet and disodium phosphate—is sometimes contaminated. Previous work has shown the superiority of a mixture of crystal violet and glycerol in preventing contamination. Therefore, comparison of vaccine prepared with these two mixtures for sterility, potency, and duration of immunity was continued. All crystal violet vaccines containing glycerol so far produced (48 lots) have been sterile, whereas about 15 percent of the control vaccines containing phosphate instead of glycerol, have been contaminated. Including tests made last year, 32 lots of vaccines containing glycerol and their control lots (containing phosphate) have now been tested for potency. The vaccines containing glycerol were at least as potent as their controls.

A patent on the crystal violet-glycerol vaccines was applied for, and the formula was released for experimental use.

The Bureau conducted a number of other studies relating to the preparation of the vaccine and its mode of action. Among the findings the studies showed that hog cholera virus, injected into pigs vaccinated with crystal violet, survived in the vaccinated pigs at least 4 days and perhaps 6 days. However, virulence was usually lost by the eighth day, whereas virus injected into pigs that had been treated some weeks previously with serum and virus could not be detected 2 days after its injection.

Studies were also conducted to determine the resistance of vaccinated pigs to viruses from different sources. Pigs vaccinated with crystal violet were exposed to 6 different commercial viruses of varying degrees of virulence. Altogether 42 vaccinated pigs were used. They were divided into 7 groups of 6 each. Each of the 6 groups was exposed to one of the selected viruses and the seventh group to the same strain of virus used to produce the vaccine. In each group 2 untreated susceptible pigs were exposed as controls. All vaccinated pigs were protected; only 2 showed slight reaction, and the others remained well. All controls developed acute hog cholera and died or were killed for virus.

EQUINE INFECTIOUS ANEMIA

In studies of transmission of equine infectious anemia, it was found that colts ranging from suckling age to 2 years old were as susceptible to the infection by subcutaneous inoculation as were adult horses. Milk from infected mares contained the virus of the disease, and, when injected into susceptible horses, regularly produced infectious anemia. However, subcutaneous injection of large amounts of urine or saliva from an acute case failed to establish the disease in sus-

ceptible horses. The persistence and insidious nature of the disease is shown by the fact that blood of a symptomless carrier horse originally infected in April 1935 was still infective in December 1943, a period of 8 years 8 months.

Studies also showed that infected pregnant mares may abort during or following the febrile attacks characteristic of the disease and the colts foaled may be infected at birth and are usually very weak and die in a short time. Mares that were infected after foaling failed to transmit the disease to their colts through their infected milk or by contact.

In studies on improved methods for preserving virus, it was shown that virus in desiccated spleen tissue, which was fully active after storage at 5° C. for 9 months 10 days, was inactive after storage at the same temperature for 5 years. Virus in defibrinated blood containing 20-percent buffered glycerin solution retained its activity for 15 months at 5° C. but was inactive after storage for 7 years at the same temperature. Dehydration under high vacuum while in the frozen state (lyophilization) did not affect the stability of the virus in whole blood; such virulent whole blood in vacuo in sealed glass ampoules was apparently fully active after storage for 16 months at room temperature and in the light. In one test virulent serum, dialyzed in a No. 300 cellophane bag against cold running water for 6 days, became inactive, indicating that the virus had been removed from the serum by dialysis (diffusion through a membrane). Tests also indicated that the serum inactivated by dialysis had no value as an immunizing agent.

BOVINE BRUCELLOSIS (BANG'S DISEASE)

PERSISTENCE OF VACCINAL IMMUNITY BEING STUDIED

In the control of brucellosis, or Bang's disease, the effectiveness of strain 19 vaccine has been generally accepted and its use is increasing. One factor, however, on which definite information is lacking is the duration of resistance induced by this strain in cattle vaccinated as calves. Investigations of this factor have been carried on for several years. At the end of the last fiscal year, four groups of cattle vaccinated as calves, with control animals maintained under similar conditions, were being exposed during their second, third, fourth, and fifth pregnancies respectively, to virulent cultures of *Brucella abortus*. There were 18, 17, 19, and 11 vaccinated animals in the respective groups of principals, and a total of 57 unvaccinated control animals. Periodical blood tests and examinations of placental tissues of all these cattle at each pregnancy have been made during the entire period of segregation since vaccination. All the animals, including the controls, remained free from *Brucella* infection prior to artificial exposure. A study of the vaccinal agglutinin response in the vaccinated groups showed that a large majority returned to negative within the usual period of 6 months.

Much interest has been displayed in the intradermic method of vaccination with minute doses of the vaccine. The blood titer following such intradermic vaccination and the blood opsonic index (the ability of certain white cells to ingest invading bacteria) appear to be of the same degree as those produced by the subcutaneous injection of the regular 5 cc. dose. However, nothing is known as yet of the degree

or persistence of immunity resulting from intradermic vaccination. Tests are in progress, but sufficient data to prove the value of this type of vaccination will not be available for several years.

PRODUCTION OF BRUCELLA VACCINE AND ANTIGEN

During the year 2,741 batches of strain 19 *Brucella abortus* vaccine, representing more than 2,500,000 doses, were prepared commercially. These were tested by the Bureau, and 191 batches, or 7 percent, were condemned as unsatisfactory. Approximately 205,000 doses of vaccine were produced by the Bureau and distributed to the various States for use in the vaccination of calves in the Federal-State program for the control of bovine brucellosis. All *Brucella* antigen used in blood testing in the Federal-State program was also prepared and distributed by the Bureau.

SWINE BRUCELLOSIS

GERMS OF THE DISEASE ELIMINATED FROM INFECTED SWINE

Studies on swine brucellosis during the year showed that the disease is eliminated from the bodies of infected animals in the following ways in their order of importance: Uterine discharges at time of abortion or farrowing, udder secretions, semen, urine, and probably intestinal excretions. The uterine discharges, urine, and intestinal excretions contaminate the premises and offer exposure to all animals in the herd. Evidence obtained during the year shows that swine, especially young pigs, become infected with brucellosis through feed or drink. In pigs born of infected dams, especially dams having udder infection, the causative organism, *Brucella suis*, was found in the blood in some instances for at least 12 months after weaning.

The boar had previously been found to be a very important factor in the spread of swine brucellosis, and evidence obtained during the year accentuates this danger. In the boar, genital infection localizes early in the epididymis and seminal vesicles, where it appears in the form of multiple abscesses. The process usually becomes progressively extensive and may eventually cause complete loss of the gland involved.

BLOOD AGGLUTINATION TEST NOT ENTIRELY DEPENDABLE

The blood agglutination test, which is the basis of control procedures in bovine brucellosis, has decidedly less value as a control medium in swine brucellosis. In a group of pigs segregated for 12 months after weaning, cultures of *Brucella suis* were obtained from the blood stream of all the animals at some time during the period. However, many of these animals, although known to be harboring the causative organism, were negative to the agglutination test. A few similar cases have been found in adult infected sows. Also, the agglutination titer in infected swine tends to diminish much more quickly than in cattle. For this reason the agglutination test is not a dependable basis for the disposal of individual animals but is of value in determining whether or not infection exists in the herd. Titers of 1:25 to 1:100 in an infected herd would indicate the presence of infection and if eradication of the disease is based on the test, such animals should be removed

as possible sources of infection. Work is being continued on other antigens in the hope that one more specific to the infection may be found.

MASTITIS OF CATTLE

A preliminary investigation of the use of penicillin in treating chronic bovine mastitis has been undertaken. As a refined product is not available for this work, small quantities of a culture filtrate were prepared by growing *Penicillium notatum* on corn steep liquid medium. The filtrate varied in penicillin content from 68 to 95 Oxford units per cubic centimeter. It was used to infuse 100 quarters of 59 cows. *Streptococcus agalactiae*, the principal species of bacteria causing the disease, was eliminated from 58.8 percent of 76 quarters, other streptococci from 48.5 percent of 19 quarters, and staphylococci from 60 percent of 5 quarters. These encouraging results with a product of relatively low unitage suggest that a product of higher penicillin content might prove to be more effective in treating mastitis.

In the cooperative project at the University of Maryland, the estimated cost of drugs and veterinary service in streptococcal mastitis, including milk tests before, during, and after treatment, in a dairy herd containing 46 cows was \$610.15. Twenty-four of the cows were infected with *Streptococcus agalactiae* and 4 with other types of streptococci; of the 28 infected animals, 21 responded to treatment and 7 were removed from the herd because further treatment was considered uneconomical. The cost of this work seems high but, when consideration is given to the present condition of the herd as compared with that prior to treatment and the value of a herd with a minimum amount of mastitis, the procedure may be considered sound from an economic standpoint.

JOHNE'S DISEASE IN CATTLE

In studies at the Regional Animal Disease Research Laboratory, Auburn, Ala., on Johne's disease and its diagnosis and the relationship of the causative agent of this disease to other similar organisms, about 15,000 comparative tests were made during the year. These tests were made on cattle sensitized with the Johne's bacillus, tubercle bacilli of the avian, bovine, or human types, or with *Mycobacterium phlei*, a harmless organism. More than 25 products, many obtained by chemical treatment of johnin and tuberculin of different types, were tested. The important results were the following: There was a considerable variation in the reactivity of individual cattle sensitized to the same material. Cattle artificially sensitized with Johne's bacilli gave more pronounced reactions than naturally infected animals. By using precipitated johnins or tuberculins, or by using johnins or tuberculin of known potency, it was found possible to determine whether a reactor had been sensitized by human or bovine tubercle bacilli on the one hand or by avian tubercle bacilli or Johne's bacilli on the other. Cattle sensitized with the harmless *phlei* organism could be differentiated from those sensitized with disease-producing Johne's bacilli or tubercle bacilli. However, the results indicate that sensitization with *M. phlei* was not an important factor in causing nonspecific reactions to johnin or tuberculin. The products obtained from johnin and tuberculin by chemical treatment were less

potent and no more specific than the materials from which they were derived. These studies indicate that it may be possible to develop diagnostic products that will aid in reducing the number of no-visible-lesion reactors—animals that do not have the specific disease for which they were tested.

SWINE ERYSIPELAS

SWINE ERYSIPELAS VACCINE CONTINUES TO GIVE GOOD RESULTS

Simultaneous vaccination with live-culture vaccine and hyperimmune serum to immunize swine against erysipelas continues to be conducted on an experimental basis and has been extended to include Nebraska, Iowa, South Dakota, Missouri, North Dakota, Illinois, Nevada, Kentucky, Oregon, Washington, Idaho, Tennessee, and Georgia. Last year 16,971 herds, including 1,128,385 hogs, were vaccinated in these cooperating States. Reports received during the year show that the results obtained from vaccination are very satisfactory.

To assure a supply of safe and potent vaccine, each lot produced was subjected to rigid tests. Of 596 lots tested, 84.3 percent were found to be satisfactory; and 15.7 percent were unsatisfactory and were destroyed. The results obtained from tests of vaccines of various ages showed that the expiration dates formerly set for the vaccine should be shortened and, accordingly, the period was reduced from 60 to 40 days. As a further step in preventing the possible spread of the disease by hog cholera virus, 400 serial lots of virus were tested, of which 4 percent were found to contain living swine erysipelas organisms and were condemned. Standard anti-swine-erysipelas serum was distributed to licensed manufacturers for use in controlling the standardization of antiserums produced during the year.

ANTHRAX

In studies during the year, the viability of *Bacillus anthracis*, the organism causing anthrax, was subjected to varying tests, with the following results: Stock cultures of *B. anthracis*, maintained on plain agar for as long as 11 years, remained fully virulent for guinea pigs in 0.25 cc. doses; spores contained in dried blood or spleen on cotton swabs were fully virulent after 6 years' storage at room temperature in a cabinet exposed to light; frozen cultures of *B. anthracis* in serum broth held for 10 years at -5° to -10° C. were both viable and virulent; two different suspensions of spores in normal saline resisted repeated rapid freezing at -72° to -77° and thawing at $37\frac{1}{2}^{\circ}$ 45 successive times; saline suspensions of spores from two different strains resisted heating to 80° for 30 minutes but were destroyed in at least 2 minutes by heating 99° to 100° and in one to two minutes by plunging immediately into boiling water.

PARATYPHOID INFECTION IN SWINE

At the beginning of the year, a bacteriophage, or bacteria-destroying agent, capable of attacking *Salmonella choleraesuis*, the organism associated with the cause of a paratyphoid infection, was found in the feces of some swine. There have been particularly two features of this disease for which no satisfactory explanations have been obtained.

One has been the failure of cultures of *S. choleraesuis*, when fed to swine, consistently to produce disease, and the second has been the difficulty in recovering the organism from the feces after such exposure. Tests on culture media with the phage suggested that it may modify the course of paratyphoid infection. It also is a factor capable of influencing the findings when culturing swine feces for the presence of *S. choleraesuis*.

One group of pigs on natural feeds failed to show significant infection when fed a culture of *S. choleraesuis*. Tests for the presence of phage in the feces of these pigs before exposure were positive. Four months later a group of pigs from the same source, also on natural feeds, failed to show significant infection, even though tests for the presence of phage in the feces before exposure were negative. A group of young pigs on purified rations containing varying amounts of vitamins failed to show any evidence of infectious disease over a maintenance period of several weeks. They were quartered in individual pens with wire floors. Tests for the presence of phage in the feces of these pigs were positive in almost all cases. None of these pigs were exposed to *S. choleraesuis*.

Six months later a similar group of pigs was maintained in like manner for 6 weeks, when part of them were exposed with *S. choleraesuis*. Disease occurred in all the exposed pigs. These animals either died or were destroyed within the 3-week period following exposure. Post-mortem examinations revealed intestinal involvement. Tests for the presence of phage in the feces of these pigs before exposure were negative. After exposure, phage appeared in the feces of several of the pigs.

On the basis of these tests, no conclusions were made on the ability of phage to modify the course of paratyphoid infection in swine.

LOSSES FROM STOCK-POISONING PLANTS REDUCED

Eupatorium wrightii is one of the very toxic plants and has caused heavy losses in cattle in southern New Mexico and adjacent areas over a period of many years. Work on this plant, which was begun in the fall of 1942, is now practically completed. Although losses occur only during the fall, from October to December, when other feed is scarce, the summer growth was found to be as toxic as that collected in November. The toxic and lethal doses of the plant for cattle have been determined and other information provided by the investigation that will enable cattlemen to avoid most of the loss occasioned by the plant.

SEROLOGICAL DIAGNOSIS OF DOURINE

In continuing the program of dourine eradication in horses, 19,819 serum samples were subjected to the complement-fixation test and only 124 were found to be positive.

IMPROVED MEDIUM FOR PULLORUM-DISEASE STAINED ANTIGENS

The antigens used in testing for pullorum disease are derived from cultures of *Salmonella pullorum* that have been grown on artificial culture media. Last year a colloidal sulfur glycerol medium was devised that affords heavier yields of antigen than have been obtained

on any medium hitherto used. Precipitated sulfur and "wetable" sulfur were tried as substitutes for the colloidal sulfur. The yield of culture from media containing either of these forms of sulfur was only slightly less than when colloidal sulfur was used. However, other characteristics of these materials reduced their suitability as substitutes.

As beef infusion and peptone are also used in the sulfur-glycerol medium, possible substitutes for these were investigated. The use of commercial beef extracts in place of the beef infusion resulted in only slightly decreased yields. One brand of peptone consistently afforded slightly greater yields. However, all afforded satisfactory yields. Incidentally, of 10 different strains of *S. pullorum* cultivated on the sulfur medium, only 4 grew well.

INVESTIGATIONS OF FOWL TYPHOID IN BROILER PLANTS

Investigations were begun during the year on fowl typhoid in the broiler industry of Delaware and the Eastern Shore of Maryland. Thousands of chickens died annually from this disease owing to the inadequacy of present control procedures under broiler-raising conditions. Accordingly, studies were begun on modes of transmission, serological diagnosis, and methods of control of the disease through laboratory and field investigations.

In addition to the natural portal of entry of the causative organism, which is the alimentary tract, it was found that the chicken may be infected artificially by intravenous, subcutaneous, intradermic, intramuscular, and intraperitoneal inoculation and by instillation of *Shigella gallinarum* on the conjunctiva and cloaca. The sick bird may spread the organism in the secretions from the eyes, nose, and mouth as well as in the feces.

From approximately 100 cultures of *Sh. gallinarum* an antigenic strain has been selected which appears superior to the pullorum antigen in detecting birds that are infected or carriers of fowl typhoid. To what extent this typhoid antigen will detect carrier birds from an infected flock remains to be determined both by hatchability tests and by post mortem examination. Two flock owners are cooperating in a test of the efficiency of this typhoid antigen for use in eliminating the disease from their flocks.

A very active bacteriophage, or bacteria-destroying agent, has been isolated from each of two natural outbreaks of the disease. These have been serial-passaged in broth a number of times in an attempt to increase their ability to destroy *Sh. gallinarum* when injected into an infected bird.

LYMPHOMATOSIS (AVIAN LEUKOSIS COMPLEX)

At the U. S. Regional Poultry Research Laboratory at East Lansing, Mich., the development and maintenance of stock free from avian leukosis complex (lymphomatosis), through genetic studies has resulted in furthering knowledge on the cause and transmission of this disease. This free stock will also be of great value in the further study of the normal histology of the chicken, a thorough knowledge of which is essential in order to interpret correctly the microscopic findings in suspected cases of lymphomatosis.

Experimental results at the laboratory indicate that transmission of the disease may take place under natural conditions when healthy birds come in contact with infected stock. In 1943, day-old chicks from stock "free" of lymphomatosis were hatched, brooded, and maintained with the mixed population of chickens in which many cases of the disease developed. By the time 165 chickens from the "free" stock attained an average age of 300 days, 26.7 percent of them had died from lymphomatosis. One hundred of their sibs, which were brooded and maintained in isolation and under rigid quarantine, were free of any clinical manifestations of the disease at 300 days of age.

Evidence, additional to that previously reported, was obtained to incriminate the hatching egg as an important means of transmitting the disease. In a carefully controlled experiment the disease was produced by injecting chickens with embryonic material from eggs produced by a group of hens in which the incidence of lymphomatosis was high, whereas no disease resulted when embryonic material from eggs produced by a group of hens free of the disease was similarly injected.

Studies were made on the transmission, pathology, and immunology of a transmissible tumor which produced lesions in some respects similar to those seen in the avian leukosis complex. It was found that grossly and histologically, one strain has many similarities to lymphomatosis; when implanted by various routes and in appropriate dosages, it produces a high incidence of local tumors that, upon regression, render the birds immune to subsequent implantation of the same tumor. Immunity obtained with this tumor is of particular interest because it appears in all birds that have survived an active growth of the tumor, it apparently cannot be overwhelmed by very large or repeated doses of the same agent, and it is present over a prolonged experimental period. It was found also that this strain may be frozen and stored without a significant reduction or alteration in its capacity to produce typical tumors in the pectoral muscle. Its chief value at the present time is for immunological studies as a possible source of the agent and for comparative studies related to the pathogenesis of lymphomatosis.

LIVESTOCK AND POULTRY PARASITE INVESTIGATIONS

Scientific investigations of livestock and poultry parasites were conducted in the Zoological Division under the direction of Benjamin Schwartz, principal zoologist in charge. During the year, emphasis was placed on developing practical, labor-saving control measures against parasites that interfere with the economical production of animal and poultry products and are responsible for livestock losses and for condemnations under meat inspection.

NEW FACTS ON BOVINE COCCIDIOSIS

Investigations on bovine coccidiosis at the Regional Animal Disease Research Laboratory, Auburn, Ala., disclosed valuable new information on the development of coccidia and their effects on host animals. Such knowledge is essential in developing and perfecting control measures.

In contrast to frequent cases of mixed infections reported in scientific literature, infections in young calves were produced, this year,

with a single pathogenic species known as *Eimeria bovis*. The severity of the disease varied with number of oöcysts, which were given by mouth. A dose of 1,000 oöcysts, each containing 8 infective organisms, induced an infection but caused no significant symptoms; 25,000 usually produced a nonbloody diarrhea of brief duration; 125,000 or more usually caused, after an incubation period of 18 days, a severe form of the disease, characterized by bloody diarrhea, loss of appetite, and elevation of temperature, ending in death. Post mortem observations disclosed hemorrhage and erosion of the mucous linings of the cecum and colon. Calves that had recovered from either an experimental or natural infection with *Eimeria bovis* tolerated large doses, even up to a million oöcysts, and developed only comparatively light symptoms.

Further studies indicated the approximate time and place that the sporozoites (infective form of the organisms) were freed from their cysts. Eighteen hours after experimental ingestion of oöcysts by a 2-day-old calf, the sporozoites were found, free, in the lower portion of the small intestine. Empty cysts were found in the cecum and colon, indicating that emergence from the cyst took place in the small intestine. That deduction was later confirmed by finding empty oöcysts in fluid filtered from the contents of the upper half of the small intestine. It is probable that pancreatic juice, bile, or both influence the emergence of the organisms from their cysts. Observations were likewise made of stages in the development of these coccidia.

BORAX BENEFICIAL AGAINST COCCIDIOSIS IN POULTRY

Coccidiosis, especially the cecal type of the disease caused by *Eimeria tenella*, is a serious obstacle to poultry raising. It has been estimated that about 12 to 20 percent of all baby chicks hatched in this country die from this disease before they reach the age of 1 month. Of the many substances that have been tried, none have proved to be satisfactory, and the only ones that have shown beneficial action are elemental sulfur and a few of the newer sulfa drugs, but these have disadvantages.

In small-scale tests of 13 boron compounds, about 5 gave some protection against the disease. None appeared to be more effective than sodium borate, which is commercially available as borax. Tests of different methods of administering the chemical were carried out on 19 groups of baby chicks, each group comprising from 20 to 25 birds. There was no significant effect on the course of the infection when the chemical, mixed with mash at the rate of 2 percent, was given to the birds during the first 3 days after they were inoculated with the infective organism. When fed through the fourth day, however, the borax provided nearly complete protection. Administration of the drug could be delayed until the third day after artificial exposure without affecting the efficacy of the treatment, provided the drug was continued through the fourth day. Results comparable to those obtained with 2 percent of borax in the mash were also obtained when 0.3 percent solution of the chemical was provided as drinking water. The experimental work has not progressed far enough to warrant general recommendations for applying the findings mentioned.

CARRIERS OF ANAPLASMOSIS ENDANGER HEALTHY CATTLE

Experiments conducted during the year throw considerable light on the role of carriers of anaplasmosis—cattle that have recovered from the disease but still contain small numbers of the causative organisms (anaplasms) in the blood—in transmitting this disease to susceptible cattle. Work done in 1941 showed that carriers of anaplasmosis either contain too few causative organisms in the peripheral blood—the blood that circulates through the skin—to infect susceptible cattle, or that the organisms that they contain do not get to the skin. At any rate, in a carefully planned and controlled experiment carried out that year, attempts to transmit the disease from a carrier animal to three susceptible ones, through the bites of horseflies, yielded negative results.

During this fiscal year a bovine, nearly 5 years old, which had been infected experimentally the previous year and had made a complete recovery as far as the absence of symptoms was concerned, showed, during a period of 7 consecutive days, small numbers of anaplasms in the peripheral blood. In short, the animal suffered a slight relapse that would have been overlooked had not its blood been examined periodically. At various times during the 7-day period, horseflies were allowed to suck the blood of the carrier and then were quickly transferred to two susceptible calves to continue their blood sucking. The two calves that were bitten by the horseflies developed anaplasmosis after the usual incubation period.

This experiment shows, therefore, that a carrier is definitely a source of danger to a susceptible bovine. The anaplasms in a carrier animal may become sufficiently numerous in the blood to reach the skin and infect horseflies, which, in turn, can infect healthy susceptible cattle. The result suggests, moreover, that the introduction of one or more carrier animals into areas where the disease is absent may start an outbreak of anaplasmosis, if the presence of the organisms in the peripheral blood of the carriers coincides with the prevalence of horseflies. A severe outbreak of anaplasmosis occurred in Kansas during the year, with a death loss of \$2,500,000. The available evidence indicates that this outbreak probably started after the introduction into Kansas of carrier cattle during the summer months, when horseflies were prevalent.

SWINE SARCOCYSTS PROPAGATED BY RODENTS AND OTHER ANIMALS

Studies were continued on the mode of transmission to swine of the minute muscle parasites known as sarcocysts (*Sarcocystis miescheriana*), the cause of mushy hams. It was determined that animals other than swine also propagate these organisms. Rats, mice, cats, dogs, and chickens, as well as pigs, became infected when they ate the flesh of pigs that harbored the organisms. Moreover, when raw, infected pork was eaten by a susceptible animal an intestinal infection developed. Some pigs so infected died a few days after eating the infected pork, others lived for several weeks, whereas still others survived the infection but developed a temporary paralysis and their growth was retarded. The affected animals discharged with their droppings microscopic, sporelike bodies. These, when swallowed by susceptible pigs, made their way to the muscles and ultimately developed there into typical sarcocysts.

PHENOTHIAZINE IN SALT FOR BLOODWORMS IN HORSES

Internal parasites, especially bloodworms (*Strongylus*), seriously affect the efficiency of horses. Phenothiazine is the most effective drug for removing these pests, but a full dose (30 to 50 grams, or about 1 to 1½ ounces) is sometimes poorly tolerated. Small daily doses of about 2 grams have been found to inhibit the development of bloodworm larvae in the feces of treated animals and are not known to produce injury. They also have a beneficial though delayed anthelmintic effect. In addition to the factor of safety provided by small doses, the administration of phenothiazine in salt thus appeared to offer many of the advantages for horses that it has for sheep and goats.

Phenothiazine-salt mixtures containing 10 percent of the drug, as employed for sheep, proved to be unpalatable to horses. Accordingly, they consumed significantly less of the medicated mixtures than they did of plain salt. To obtain information on the proper dose with respect to both efficiency and palatability, 27 tests were made in which groups of 2 to 10 animals were maintained for 36 to 166 days on loose mixtures of medicated salt containing 2 to 5 percent of the drug. Mixtures of 1 part of phenothiazine and 19 parts of salt were tested on 4 animals for 64 days. The average daily consumption of the drug was 1.2 grams per animal, but all the animals did not consume the mixture in equal amounts. In only 1 animal was the therapy successful, as determined by periodic fecal examinations. There was only a slight reduction in the numbers of larvae in the feces of 2 other animals. Six horses, receiving for 36 days a mixture of 1 part of phenothiazine and 30 parts of salt, consumed an average of 1.4 grams of the drug per day per animal. An apparent reduction in the number of worms was noted in only 2 horses. Two other horses (yearlings) were already heavily infected when the "salting" was begun and their condition grew gradually worse. This observation suggested that preliminary full doses of the drug might have been helpful. On the other hand, mixtures containing only 2 or 2½ percent of the drug (1:40 and 1:49), tested on 5 and 10 animals, respectively, for varying periods, generally gave satisfactory results.

One mare with a day-old foal was placed on a 1 to 49 mixture for 166 days and then changed to a 1 to 40 mixture. The first infective strongyle larvae appeared in the feces of the colt when the latter was about 225 days old. Another foal, under comparable circumstances, did not show larvae in the feces until it was about 50 days old. When the phenothiazine-salt treatment was not given, foals at the Beltsville Research Center have sometimes passed eggs in their droppings at 2 weeks of age. Even under the most careful management, infection has been delayed not longer than 90 days.

All the above experimental animals were weighed at intervals, blood examinations were regularly made, and the general condition of each animal was noted daily. The mixture of phenothiazine and salt had no harmful effects and all the horses, including those whose infections were not markedly reduced by the medication, appeared to have better coats and a better general condition during the treatment. Free-choice medication for horses offers promise, but many aspects of the problem are yet unexplored.

HEXACHLORETHANE REMOVES LIVER FLUKES FROM CATTLE

The hexachlorethane-bentonite suspension—a preparation developed by the Bureau and described in last year's report—for the removal of liver flukes from cattle was tested on nearly 4,200 animals in the Gulf coast region of Texas, under cooperative agreement with ranchers. It was found that when an unthrifty condition of the cattle was due to flukes, there was a remarkable improvement in the appearance of the animals a short time after treatment. Cattle whose breeding activities had decreased because of fluke infection regained their health and resumed normal breeding. Animals with very heavy infestations did not recover despite the removal of the flukes because of permanent damage to the liver.

The reaction of cattle to the treatment depended on their physical condition. Fluky cattle that were in good or fair condition at the time treatment was given showed no unfavorable reaction to treatment with 100 cubic centimeters of the suspension. Weak and emaciated cattle usually went off feed for a day or two and showed slight symptoms of intoxication, manifested by grogginess, after which they recovered. Extremely debilitated cattle usually were unable to rise without help the second day after treatment and died about 4 to 6 days later.

The efficacy of the treatment on 476 cattle in fair condition that passed liver fluke eggs with their droppings prior to treatment was determined. When the animals were reexamined 2 to 3 weeks after treatment, only 27, or 5.6 percent, were still passing eggs. Twelve of the treated cattle that did not pass any eggs within 2 to 3 weeks after treatment were reexamined repeatedly for 5 months, with consistently negative results. These observations indicate that most treated cattle became free of egg-producing, mature flukes following treatment with a full dose of hexachlorethane-bentonite suspension.

In addition to this indirect method of determining the efficacy of the treatment, post-mortem examinations of 34 treated cattle were made. The average number of flukes per animal was only 2.7, whereas in 7 comparable untreated cattle, also examined post mortem, the number of flukes per animal averaged approximately 40. In the treated animals, moreover, the flukes recovered were predominantly young, whereas in the untreated animals most of the flukes were fully or nearly grown.

This method of treatment is being adopted in several other States. Ranchers in Texas, other than those cooperating with the Government, obtained their own supplies of the suspension, now available commercially, and used it successfully. The treatment is being used also in Florida, and inquiries concerning it are coming in from the Rocky Mountain States and other sections of the country where liver flukes are a menace to cattle production.

HOOKWORMS PRODUCE ANEMIA AND LOSS OF WEIGHT IN SHEEP

In experiments to determine the effects of hookworms (*Bunostomum trigonocephalum*) on lambs, it was found that the animals became infected when the larvae were placed on the skin, but not when they were administered by mouth. The penetration of the larvae

through the skin produced a local inflammatory condition. Blood appeared in the droppings 25 days after infection and persisted throughout the course of the infection. The hemoglobin and red blood cell counts decreased gradually, reaching the lowest point 11 to 14 weeks after infection, when a slow recovery became manifest.

The results showed that hookworm infection in lambs, uncomplicated by the presence of other roundworms, produced anemia with accompanying retarded growth. The extent of the injuries varied with the number of worms harbored. Losses of blood and of weight occurred long before the parasite eggs could be found in the droppings.

PHENOTHIAZINE SAFE FOR TREATING CALVES

In view of occasional reports of ill effects from the use of phenothiazine for treating calves to remove stomach worms, nodular worms, and other injurious roundworms, experiments were carried out at the Regional Animal Disease Research Laboratory, Auburn, Ala., to determine the safety of this drug for these animals. Administered at a rate of 0.4 to 0.9 gram per pound of body weight—the smaller dose being twice the standard therapeutic, or full dose—the drug produced no permanent injury to calves on a good diet. Some of the calves receiving the larger dose, which is $4\frac{1}{2}$ times the therapeutic dose, showed symptoms of intoxication for 24 to 48 hours. Two weaned calves on a diet of poor-grade Johnson grass and a limited amount of cracked corn had no anemia or any other unfavorable reaction after treatment with standard therapeutic doses of phenothiazine, namely, 0.2 gram per 100 pounds of weight. Other calves that received 0.4 gram of the drug daily for 64 days grew normally and showed no bad effects from this medication.

It is concluded, therefore, that in standard therapeutic doses, phenothiazine is a safe anthelmintic for calves. The occasional ill effects stated by some persons to have been produced by phenothiazine in cattle could not be confirmed. Usually other factors were found to be the cause of alleged phenothiazine intoxication or other injury.

SHEEP THRIVE UNDER CONTINUOUS PHENOTHIAZINE-SALT TREATMENT

In consequence of recommendations by many agencies, based largely on results obtained by the Bureau, the administration of phenothiazine in salt to control gastrointestinal parasites of sheep is already an established practice with many stock raisers. Because the measure involves continuous ingestion of phenothiazine, the effect of this drug on the general condition of the animals is a matter of concern. Therefore, in addition to further study on the effectiveness of the medicated salt in removing parasites, observations were made to ascertain whether its use lowered the amount or quality of the fleece or meat, the fertility of breeder stock, or the health and growth of the lambs.

A breeding flock of 81 crossbred ewes in 1943 and 88 in 1944 was successfully maintained during its second year by using, as the only medication, a mixture of phenothiazine and salt in the proportion of 1:9 for about 8 months of the year. Lambing practices permitted access to the drug mixture for this period only, although the practice is regarded as desirable for the entire year. The average fleece weights

for the same 50 ewes in 1943 and 1944 were, respectively, 6.47 and 7.01 pounds, indicating definitely that wool production was not decreased by continued medication during the second year. The average weight of 6-week-old male single lambs in 1943 was 34.1 pounds; of females, 29.5 pounds. In 1944 the weights were 32.6 and 28.7 pounds, respectively. Twin male lambs 6 weeks old averaged 21.8 pounds each in 1943 and 24.6 pounds in 1944. For the female twins, the comparable figures were 20.6 and 23.7 pounds. Average weights of the lambs, therefore, were not lowered by treating the breeder flock a second year. In 1943, 83 lambs were dropped by 60 ewes; in 1944, 87 lambs by 76 ewes. Periodic fecal and blood examinations, together with post mortem examinations of a few of the animals, indicated that parasites were well controlled and that the animals were in excellent general condition during the year. Moreover, during the 2 years of treatment, lungworms and intestinal wireworms (*Nematodirus*) were nearly eliminated, although there is no evidence to show that this result was brought about by the use of the drug.

PHENOTHIAZINE AND SALT CONTROL PARASITES IN GOATS

To determine further the feasibility of controlling parasitism in goats by free access to phenothiazine and salt, 1 part of the drug and 9 parts of salt were fed throughout the year to 11 goats. The average salt consumption per goat per day was 6.63 grams and the amount of drug 0.66 gram. Although common stomach worm (*Haemonchus*) eggs were usually present throughout the test, their numbers were small. The other parasites, including *Trichostrongylus*, were well controlled. The animals were in good health throughout the experiment. Eleven healthy kids were born to the 8 females of the test group after approximately a year of treatment, indicating that reproduction was unimpaired.

In some parts of the country where goats and sheep graze over large areas, the animals are salted only once a week. Consequently, an experiment was set up to determine whether parasites could be controlled by a system of weekly salting with a mixture of phenothiazine and salt. For a period of 1 year a group of 12 goats of all ages was salted every Monday with 1 part of phenothiazine and 7 parts of loose salt, 2 cups of grain being added to the mixture. The average weekly consumption per animal was approximately 26 grams of salt and 3.65 grams of the drug. Fecal examinations were made weekly. The results were generally satisfactory. The common stomach worm proved to be the most difficult parasite to control, as shown by the fact that individual animals passed, during the 52-week period, 200 to 300 eggs of this parasite per pellet for periods of 1 to 3 weeks at a time. Nodular worms were uniformly well controlled. The animals remained in good health throughout the experiment.

SODIUM FLUORIDE EFFECTIVE AGAINST ROUNDWORMS OF HOGS

During the last year 81 substances or combinations of substances were tested for their ability to remove parasites from swine, sheep, goats, dogs, cats, and poultry. Particular attention was given to a search for a suitable drug for removing roundworms from swine, since these parasites cause heavy losses and none of the drugs currently

available remove on the average more than 70 percent. Sanitation or special dietary management affords the best means of control, but under some conditions, especially during periods of labor shortage, an effective medication is desirable as a supplementary or substitute measure.

Tests with sodium fluoride suggested that this chemical merits consideration as a swine anthelmintic. Six lots of pigs, totaling 48 animals, were treated individually or in groups with the chemical administered in the feed in a dosage of 1, 1.5, and 2 percent. Most of the treatments were for 1 day. One was for 3 consecutive days, and one of the single-day treatments was repeated after 1 week. The treatments were highly effective against ascarids, removing from 96 to 100 percent of these worms. It was nearly as good against stomach worms, but only moderately effective against nodular worms, removing less than half of them, and of only slight value, in most of the tests, for removing whipworms.

When sodium fluoride was given to the animals in the dosages described, the only unfavorable effects were occasional vomiting, slight loss of appetite, and soft feces, and these effects were of short duration. However, when the chemical was fed for 1 day at the rate of 4 percent of the feed, there were definite toxic symptoms, and dosing at the rate of 5 percent resulted in the death of 1 pig 2 days after treatment. The symptoms were vomiting, loss of appetite, depression, weakness, soft feces, trembling, and death. Post mortem examination revealed severe gastroenteritis and congestion of the liver and kidneys. To obtain further information on the toxicity of sodium fluoride, the chemical was administered in sizable dosages to 4 horses, 1 sheep, and some chickens. The only unfavorable effects were lessened appetite for 1 day after treatment and soft feces for a somewhat longer period.

These preliminary results suggest that sodium fluoride possesses unusual action against gastrointestinal parasites of swine, particularly ascarids, and that, in suitable doses, it may be better tolerated by these animals than one might expect from the poisonous nature of the drug. No recommendations are yet warranted.

PROMISING NEW CHEMICALS FOR REMOVING PARASITES FROM DOGS

For reasons of economy, dogs, rather than animals of the larger classes of livestock, are used in testing the safety and effectiveness of many chemicals of unknown action. Nevertheless, the information obtained in the control of parasites in the dogs themselves is significant, because these animals are playing an increasingly important role in both war and peacetime pursuits. A chemical known as perthiocyanic acid proved to be an effective drug for removing tapeworms. Dosages of 0.1 to 0.2 gram per pound of body weight removed all 37 *Taenia* from 3 dogs and 73 percent of 78 *Dipylidium* from 8 dogs. Another substance, known chemically as para-tertiary-butyl phenol and designated as "butylphen," given at dose rates of 0.1 to 1.0 gram per pound of body weight, removed an average of 97 percent of both hookworms and ascarids and 74 percent of whipworms. These results compare well with those of any other drug used on dogs. Both of the drugs tested were well tolerated by the animals.

ROTENONE-CONTAINING DUSTS FOR DESTROYING CATTLE GRUBS

During the year 337 cattle infested with cattle grubs were treated experimentally with rotenone-containing dusts, in Colorado, New Mexico, and Texas. Cube powder was mixed with Tripoli earth and other carriers and applied to the backs of cattle in quantities of 2 to 3 ounces. In terms of grub mortality, the efficacies ranged from 21 to 92 percent, the average being 60 percent. Early in the season the grub mortality, following treatment, was relatively low, but as the season advanced mortality increased. This was due to the fact that the dusts were relatively ineffective against young grubs but were generally effective against the grown grubs.

Of the carriers used, Tripoli earth, ground either once or twice, appeared to be the most effective, and sulfur was the least effective. Pyrophyllite was satisfactory as a carrier for cube, but it did not appear to activate the latter. Dusts acted more slowly on grubs than washes and dips. These had more consistent efficacy, which was 90 percent or more.

FIXED-NICOTINE DIPS OF LIMITED VALUE AGAINST SHEEP TICKS

Nicotine adsorbed on bentonite (fixed nicotine) was used experimentally as a dip for the destruction of sheep ticks. The fixed nicotine was added at the rate of 2 pounds per 100 gallons of water and was used with and without wettable sulfur. When used, the wettable sulfur, which did not enhance the efficacy of the dip, was added at the rate of 10 pounds per 100 gallons of dip.

In New Mexico, 2,400 tick-infested range sheep were dipped once. Within 2 hours after the dipping only a few live ticks were observed; most of the ticks were dead. Thirteen days after the dipping, a few live ticks, many live pupae, and many dead ticks were seen. Subsequent inspections 34, 60, and 90 days after dipping showed progressively increasing numbers of live ticks and pupae.

In Colorado, three farm flocks totaling 793 ewes and lambs were also dipped once in a small portable vat having a capacity of 200 gallons and equipped with a suitable draining pen. At the first postdipping inspection, 8 days later, only occasional live ticks were found. Subsequent examinations 30, 60, and 90 days after dipping showed slowly increasing numbers of live ticks and pupae. Nine months after dipping the number of ticks found was approximately equal to that prior to dipping.

The fixed nicotine dip was harmless to the ewes and lambs in the quantities used, but unlike dilute derris or cube dips it failed to eradicate ticks in a single dipping. The fixed nicotine dip, however, offers a means of temporarily reducing the extent of infestation with sheep ticks in the absence of rotenone-containing powders for that purpose.

SERVICES TO FARMERS, STOCKMEN, AND OTHERS

The Zoological Division cooperated with the War Food Administration, the Food and Drug Administration, and other Federal and nonfederal agencies, to make available to farmers adequate supplies of medicaments for treating animals and safeguarding farmers against inferior or useless medications.

ERADICATING SCABIES AND DOURINE AND ADMINISTERING INTERNATIONAL QUARANTINES

The Bureau activities relating to the control and eradication of scabies of sheep and cattle, dourine of horses, and other animal diseases were conducted by the Field Inspection Division under the direction of S. O. Fladness, principal veterinarian in charge. Regulations for preventing the introduction and dissemination of livestock diseases of foreign origin and regulations governing the inspection, humane treatment, and safe transport of animals for exportation also were administered by this Division.

SHEEP SCABIES MAINLY IN MIDWEST

Scabies of sheep is a communicable disease caused by minute insect-like parasites known as scab mites. Common scabies, which is the most serious form of the disease, usually spreads rapidly after it is introduced into a flock. The irritation and other effects of the disease cause a decrease in wool production, loss of weight, unthriftiness, and in some instances the death of a large number of animals. Most of the eradication work for the year was in the Midwestern farm States, where common scabies is mainly confined. Eradication was begun in Arkansas, Indiana, and Michigan. In all the cooperating States except Louisiana, where circumstances have made it necessary to defer dipping, satisfactory progress has been made. In Illinois, where cooperative work was begun last year, particularly promising results have been achieved. The total number of inspections in the field was 8,951,460 and the number of supervised dippings was 660,484. Infection was found in 762 flocks, 33 percent less than in the previous year.

CATTLE SCABIES ALMOST ERADICATED

Cattle scabies, or mange, also is caused by mites and, unless properly treated, results in heavy losses through reduction in weight, unthriftiness especially in young animals, and increased mortality. A few cases of common scabies were found in the previously infected areas in Kansas and Nebraska and in cattle-feeding areas in the Midwest. This fact shows the need for continual vigilance to guard against the spread of any undetected infection. The Bureau also assisted in eliminating several cases of sarcoptic scabies in widely separated States. This type of scabies is not so serious economically as the common variety but is more difficult to eradicate. During the year 1,281,454 inspections were made in the field and 100,582 dippings were supervised in cooperative work. Cattle in infected herds numbered 6,375, or about 23 percent less than in the previous year.

DOURINE OF HORSES GREATLY REDUCED

Complete eradication of dourine of horses is the objective in continuing the cooperative work with State authorities of Arizona and southern California. In the latter State no reactors were found in previously infected areas. The disease now appears to be limited to an area in the southern part of Arizona, chiefly to a large Indian reservation, where the work is carried on in cooperation with the Office of Indian Affairs of the United States Department of the Interior. Most of the horses in the infected area are wild and difficult to handle. Of the nearly 19,000 horses tested, fewer than one-third of 1 percent

were found to be affected with dourine and were destroyed. As the disease also exists in Mexico in territory adjacent to infected areas of the United States, the Bureau continued its cooperative work with Mexican authorities in testing more than 500 horses, of which 78 were found to be reactors and were destroyed. In determining whether the disease existed in the areas involved, blood samples from all horses were taken. Serum from each sample was forwarded to the Bureau's Pathological Division for the complement-fixation test.

OUTBREAKS OF ANTHRAX SPORADIC

Anthrax was not a serious problem during the year; only sporadic outbreaks occurred. However, Bureau employees continued to furnish assistance in administering preventive treatment to Indian-owned cattle on reservations where the infection is known to exist.

INSPECTION OF IMPORT ANIMALS

All livestock offered for importation were inspected to determine their freedom from disease, as this procedure is mandatory under the law. The statute prohibits the importation of domestic ruminants and swine from countries where foot-and-mouth disease or rinderpest exists. Since most of the livestock-producing countries outside North America are known to be infected with one or both of these diseases, the United States imports animals largely from Canada and Mexico. Under a wartime measure the Canadian Government does not permit the exportation of cattle and swine except those to be used for dairy or breeding purposes. As a result, imports from this country were comparatively small. Inspections at the various ports of entry during the year totaled 336,281, which is less than one-half the normal importations. The number and kind of animals inspected are shown in table 3.

TABLE 3.—Animals inspected for importation, fiscal year 1944¹

Port of entry	Cattle	Swine	Sheep	Goats	Horses and mules	Asses	Other animals
Canadian border ports.....	58,668	479	3,061	41	25,447	7	23
Mexican border ports.....	242,875	200	360	9	2,845	164	306
Total.....	301,543	679	3,421	50	28,292	171	329
Held in quarantine.....			13	5	109		
Refused entry—							
From Mexico.....	7,163				97	13	
From Canada.....	149				3		
Under bond for reexport.....	23,143	203	250		315		

¹ Not including a few hundred importations from overseas.

² Of this number, 435 were mules.

³ All these animals were mules.

⁴ Rejected because of tick infestation.

The Bureau received valuable assistance from the Bureau of Customs and the Public Health Service in the enforcement of its import regulations. At ocean ports, Public Health officials obtained for Bureau inspectors 15,132 declarations of shipmasters reporting the presence or absence aboard their vessels of prohibited livestock, meat, and garbage. Customs officials cooperated in preventing the landing of such animals and products. Prohibited meats were present on 2,108 vessels and prohibited animals on 28. The animals, totaling 70, were

slaughtered and parts of the ship occupied by them were disinfected under supervision. Garbage containing any prohibited meats was not permitted to land except for destruction.

CONTROL OF IMPORT ANIMAL BYPRODUCTS, HAY, AND STRAW

Regulations governing the sanitary handling of import animal by-products, hay, and straw were carefully administered to prevent the introduction of foot-and-mouth disease or rinderpest from countries where these diseases exist. Tanneries and other processing establishments, in order to obtain permission to receive restricted import products, were required to furnish separate storage and proper facilities for disinfecting the products themselves or for disinfecting or controlling the effluents resulting from their manufacture. Cars, trucks, shipping compartments, and premises used in the handling of these products were disinfected. The total number of cars treated was 1,399. Importers were required to destroy, under supervision, uncertified hay and straw packing materials from infected countries. Animal manure was not allowed importation from countries other than Canada without special permit. Strict control was continued in the handling of animal glands imported from countries where foot-and-mouth disease or rinderpest exists for processing into pharmaceutical products.

INSPECTION AND SAFE TRANSPORT OF EXPORT ANIMALS

In compliance with the regulations of the Department and in order to meet the requirements of the countries of destination, 26,026 animals were inspected prior to exportation. Supervision was maintained over the equipment of vessels carrying export animals to assure that space and fittings necessary for their humane treatment and safe transportation were provided. The number and kind of animals inspected for export are given in table 4.

TABLE 4.—*Inspection and testing of animals for export, fiscal year 1944*

Kind of animal	To Canada	To Mexico	To other countries	Total
Cattle.....	112	9,343	738	10,193
Swine.....	5	8,684	222	8,911
Sheep.....	63	2,537	27	2,627
Goats.....	12	108	51	171
Horses.....	170	893	427	1,490
Mules.....	2	85	2,512	2,597
Donkeys.....	2	2	31	35
Other animals.....	1	1	.....	2
Total.....	365	21,653	4,008	26,026

1 Of this number, 31 were jacks.

INTERSTATE TRANSPORTATION OF LIVESTOCK, TICK ERADICATION, AND HOG CHOLERA CONTROL

On September 1, 1943, the Division of Tick Eradication and Special Diseases and the Interstate Inspection Division were consolidated and continued as the Interstate Inspection Division under the direction of William M. MacKellar, principal veterinarian in charge. The activities of this Division during the year related to the interstate transportation of livestock, eradication of the cattle fever tick, and control of cholera and related swine diseases.

CONTROL AND SUPERVISION OF INTERSTATE TRANSPORTATION OF LIVESTOCK

In supervising the interstate transportation of livestock to prevent spread of diseases, Bureau inspectors, at 48 stockyards in 46 cities, inspected 23,412,083 cattle, 29,150,427 sheep, and 45,152,111 swine. Of these animals, 1,707 cattle and 288,908 sheep were dipped for scabies and 438,166 swine were immunized against hog cholera under Bureau supervision to comply with the regulations of the Department and the various States to which they were destined for distribution for feeding and breeding purposes.

Bureau inspection forces continued their efforts to reduce to a minimum losses in stocker and feeder cattle, sheep, and swine from infectious diseases. All pens, chutes, and alleys in which infected animals were handled in public stockyards were cleaned and disinfected under Bureau supervision.

During the year 372 cars carrying animals affected with communicable diseases were received at Bureau stations. Under Department regulations or on request of Canadian Government, State, and railroad officials, 3,518 cars were cleaned and disinfected under supervision of Bureau employees. A large number of trucks were also cleaned and disinfected, under Bureau supervision, after use in the interstate transportation of animals affected with contagious, infectious, or communicable diseases.

Veterinary inspectors at public stockyards continued to give particular attention to inspection of all ruminants and swine for foot-and-mouth disease, no case of which was found. Bureau employees at public stockyards devoted much time to segregating and expediting the movement of cattle that had reacted to the tests for brucellosis and tuberculosis through the yards to slaughtering establishments.

ENFORCEMENT OF TRANSPORTATION AND QUARANTINE LAWS

Although the enforcement of the 28-hour law has been transferred from the Bureau of Animal Industry to the Food Distribution Administration, employees of the Bureau stationed at public markets cooperated in the enforcement of the law by collecting and reporting evidence on alleged violations. There were reported to the Bureau 25 alleged violations of the quarantine laws. Five alleged violations were transmitted by the Bureau to the Solicitor for prosecution. In cases decided in favor of the Government, fines imposed amounted to \$1,450.

FURTHER PROGRESS IN TICK ERADICATION

Eradication activities were conducted in cooperation with State, county, and Territorial officials and cattle owners of the South and of Puerto Rico. At the close of the year 90 veterinarians and other Bureau employees were working with 46 State, 13 county, and 90 Territorial employees engaged in the project. Under their supervision 8,604,776 inspections or dippings of cattle and 700,602 inspections or dippings of horses and mules were conducted. In Puerto Rico extensive dipping was continued to cope with scattered infestation in many sections. On this island, where the tropical variety of the fever tick (*Boophilus annulatus* var. *australis*) is prevalent, it was necessary to treat sheep and goats on infested premises, and 558,678 inspections or dippings of these animals were made.

TICK REINFESTATION BY DEER CONTROLLED

The perpetuating, by deer, of fever tick infestation in the Big Cypress Swamp area in Collier and Hendry Counties, Fla., mentioned in several previous annual reports, is believed to have been brought under control. Consequently, deer hunting in this swamp by eradication forces was discontinued in August 1943. Since that time several inspections of cattle ranging in the swamp indicate this area to be tick-free, and Collier and the remainder of Hendry Counties, the last area in the State held under Federal quarantine, were released on December 1, 1943. At the same time parts of 8 counties along the Mexican border in Texas also were released. The total area released in Florida and Texas on that date totaled 5,551 square miles.

FEVER TICK INFESTATION FROM MEXICO

During the year a small area near the international boundary in San Diego County, Calif., was reinfested, evidently by ticks brought from Mexico. This reinfestation involved only a small number of cattle and was promptly cleaned up by systematic dipping.

In the lower Rio Grande Valley of Texas, adjacent to the Mexican border, stray or smuggled animals from Mexico again brought fever ticks to the United States on several occasions during the year. It appears that this situation will continue until some artificial barrier, such as a drift fence, is provided in that area. A Federal quarantine is maintained on a narrow strip along this border from Del Rio, Tex., to the Gulf of Mexico, and the constant patrolling by Bureau inspectors of this buffer area was effective in preventing the spread of ticks to the released area of Texas.

MOVEMENTS OF ANIMALS FROM QUARANTINED AREAS

In the enforcement of Department regulations governing the interstate movements of cattle and horses from areas quarantined for tick fever, 3,952 cattle were inspected or dipped and inspected, for which 56 certificates were issued authorizing their interstate movement as noninfectious. Horses and mules numbering 435 were also inspected in the quarantined area, and 60 certificates were issued authorizing their movement from such areas.

HOG CHOLERA AND RELATED SWINE DISEASES BEING CONTROLLED

Twenty-nine veterinarians assigned to the investigation and control of outbreaks of hog cholera and related swine diseases made 47,061 farm inspections and consulted farmers, veterinarians, State officials, and others. Educational work was continued by these veterinarians, who attended 228 meetings at which 13,262 persons were present. In their field work, Bureau veterinarians continued to emphasize the importance of better sanitation and early and correct diagnosis of swine diseases. They visited 6,723 farms as a result of requests from swine owners for advice and assistance in handling swine diseases, sanitation, and related problems.

Reports from field veterinarians, particularly in the Corn Belt, indicate that swine erysipelas is becoming more prevalent and that this disease is gradually spreading to other sections of the country. In Illinois, Idaho, Iowa, Kentucky, Missouri, Nebraska, North Dakota, Oregon, South Dakota, and Tennessee, these employees assisted in diagnosing the disease, selecting suitable herds for treatment, and

checking the results obtained in the experimental use of the serum-culture method of vaccination. During the year this treatment was applied by cooperating veterinarians to 16,971 herds, containing 1,128,385 hogs, and the results obtained were generally reported satisfactory. In cooperation with the Pathological Division, the experimental use of crystal violet vaccine, under average farm conditions, was continued in Alabama, Georgia, Illinois, Iowa, North Carolina, and Virginia. This vaccine was administered to 199 herds, containing 6,882 hogs. The results indicate that in properly selected herds the swine were adequately protected. Table 5 summarizes these activities in States where hog-cholera-control work was conducted by the Bureau.

TABLE 5.—Summary of hog-cholera-control work, fiscal year 1944

State	Farm inspections and consultations	Post-mortem examinations	Farms visited on request	Outbreaks reported to Bureau
Alabama.....	2,926	41	400	25
Arkansas.....	252	24	66	88
Florida.....	1,277	127	194	499
Georgia.....	2,109	150	212	259
Idaho.....	991	97	130	16
Illinois.....	6,439	673	631	419
Indiana.....	1,020	47	133	122
Iowa.....	4,464	425	526	1,269
Kansas.....	569	38	308	92
Kentucky.....	2,663	61	122	130
Maryland.....	3,137	101	973	178
Michigan.....	1,458	70	153	132
Mississippi.....	1,951	5	82	52
Missouri.....	2,837	95	157	77
Nebraska.....	1,190	194	480	84
North Carolina.....	1,465	57	558	572
Ohio.....	74	14	17	219
Oklahoma.....	3,494	51	110	65
Oregon.....	173	3	2	3
South Carolina.....	594	32	77	251
South Dakota.....	1,688	40	167	114
Tennessee.....	1,102	119	140	71
Texas.....	3,159	40	682	456
Washington.....	910	28	29	33
Wisconsin.....	1,109	282	374	66
Total.....	47,061	2,844	6,723	5,222

ERADICATION OF TUBERCULOSIS, BRUCELLOSIS, AND JOHNE'S DISEASE

Eradication of tuberculosis from livestock and poultry was conducted in cooperation with States, counties, and livestock owners. Elimination of brucellosis (Bang's disease) and Johne's disease (paratuberculosis) in cattle was conducted on a similar basis. The work was carried on in the Tuberculosis Eradication Division under the direction of A. E. Wight, principal veterinarian in charge.

CONTINUED TUBERCULIN TESTING A NECESSARY PREVENTIVE MEASURE

Tuberculosis eradication during the year consisted in retesting herds to detect and remove any infection that may have developed. This procedure is necessary to maintain the modified accredited status that has been applied to the 48 States, Puerto Rico, and the Virgin Islands since November 1, 1940. In order to qualify as modified accredited, an area must have reduced the infection to less than 0.5 percent of the cattle in that area, or practical eradication. Such an area is considered

to be practically free of tuberculosis for a period of 3 years, when it must be retested to prevent recurrence of the disease.

During the year, 8,894,466 cattle in 524,927 herds were tuberculin-tested. The percentage of reactors was 0.2, which is a slight increase over the degree of infection reported for the previous year (table 6). This result emphasizes the importance of conducting the necessary amount of retesting of cattle and removing reactors. During the present war it has been impossible to conduct the required amount of work owing to a lack of available veterinarians and other conditions brought on by the war. At the end of the year, 6,153,069 herds, containing 64,519,652 cattle, were under supervision for the eradication of the disease. This work was conducted from 47 field stations. The total Federal expenditure—both operating expenses and indemnities for condemned cattle—was about \$1,350,000. The combined State, Territory, and county expenditure was about \$2,745,000, of which approximately \$2,275,000 was for operating expenses and the remainder for indemnity.

TABLE 6.—Official tuberculin testing, fiscal years 1935-44¹

Year ended June 30—	Cattle tested		Reactors		Year ended June 30—	Cattle tested		Reactors	
	Number	Number	Number	Percent		Number	Number	Number	Percent
1935.....	25,237,532	376,623	1.5		1940.....	12,222,318	56,343	0.5	
1936.....	22,918,038	165,496	.7		1911.....	12,229,499	40,702	.3	
1937.....	13,750,308	94,104	.7		1942.....	10,933,086	23,008	.26	
1938.....	14,108,871	89,359	.6		1943.....	9,308,936	17,167	.18	
1939.....	11,186,805	60,338	.5		1944.....	8,894,466	18,338	.2	

¹ Data for previous years appear in former annual reports and may also be obtained, on request, from the Bureau of Animal Industry.

PAYMENT FOR CATTLE CONDEMNED FOR TUBERCULOSIS

Federal legislation provides that Federal payment for cattle condemned because of tuberculosis or paratuberculosis cannot exceed one-third of the difference between the appraised value and the salvage, the maximum to be \$25 for grade cattle and \$50 for registered purebred cattle. Further, the Federal payment cannot exceed the amount paid by the cooperating State, Territory, county, and municipality. For the year, the average appraised value of reactors on which Federal indemnity was paid was \$154.53; Federal payment, \$21.72; and State payment, \$36.07. The owner also received the salvage value of the animal, the average being \$59.93, which is about \$5 less than the amount received in 1943. Of the reactors on which Federal payment was made, 7 percent were registered purebred cattle.

TUBERCULIN TESTING OF CATTLE FOR INTERSTATE SHIPMENT

Approved veterinary practitioners in the 48 States continued to conduct tuberculin testing of cattle for interstate shipment. On June 30 there were 12,771 veterinarians on the approved list. These veterinarians tested 18,484 lots, containing 147,346 cattle, of which only 10 reacted. Testing for interstate shipment of cattle is included in the total testing reported in table 6.

POULTRY TESTED FOR TUBERCULOSIS

The survey of farm poultry flocks in connection with the testing of cattle for tuberculosis was continued. Observations were made on 62,012 flocks containing 9,872,895 fowls in 9 States. Infection was reported in 1,242 of these flocks.

As an additional project, about 15 Bureau veterinarians were assigned to the avian tuberculosis eradication work in the Midwestern and North Central States, where the disease is most prevalent. They visited 11,313 farms, inspected 2,065,344 fowls, and reported infection on 1,341 farms. They also applied the tuberculin test to 295,292 fowls, of which 2.7 percent reacted.

ERADICATION OF JOHNE'S DISEASE

Johne's disease, also known as paratuberculosis, is a bacterial disease that produces a chronic diarrhea in cattle and also affects sheep and goats. During the year, 2,578 cattle in 11 States were tested with either johnin or avian tuberculin to determine whether they were affected with the disease. About 3.2 percent of the animals reacted and were condemned.

WARTIME DIFFICULTIES IN ERADICATING BRUCELLOSIS IN CATTLE

• Progress in eliminating brucellosis in cattle has been somewhat retarded owing to wartime conditions. An insufficient number of veterinarians are available for regular employment. Furthermore, those in practice are unable to devote as much time as usual to the eradication of this serious disease because of the great demand for their services in treating livestock for other diseases or injuries. Because of the shortage of labor, herd owners are very busy with farm and ranch operations and find it difficult, therefore, to assemble their cattle for testing. More reinfection than usual, caused by adding cows to herds in an effort to increase milk production, has been reported. Fences in many localities are in poor condition and allow cattle to go from one herd to another. In addition it is difficult to obtain means of transportation for employees assigned to the work.

During the fiscal year, 5,235,912 blood tests were applied to cattle in 386,266 herds, a considerable number of these being retests. Of the cattle tested, 226,079, or 4.3 percent, were reactors. This figure includes 7,499 reactors held in calfhood-vaccinated herds for which Federal indemnity will not be paid. All antigen used in the official testing of cattle for brucellosis was furnished by the Animal Disease Station of the Bureau.

In order to be designated as a modified accredited area, an area must have not more than 1 percent of the number of cattle reacting to the last complete test, and not more than 5 percent of the total number of herds infected. At the close of the year, 591 counties, located in 22 States, were in this classification. These counties, which are about 19 percent of the total number in the United States, contain approximately 5,565,000 dairy and breeding cattle. Area work was being conducted in an additional 150 counties in 24 States. North Carolina is the first and only State whose entire area has qualified as modified accredited.

Most States have a plan for accrediting individual herds as Bang's disease-free. At the close of the year there were about 42,500 such herds, containing approximately 860,000 cattle. In the United States about 2,255,000 herds, containing approximately 17,325,000 cattle, were under official supervision for the eradication of this disease.

INDEMNITY PAYMENTS FOR BRUCELLOSIS-CONDEMNED CATTLE

Federal payment for cattle condemned as reactors was limited to one-third of the difference between the appraised value and the sal-

vage and could not exceed \$25 for grade animals and \$50 for registered purebred animals. Such payment was further limited to an amount not exceeding that paid by the cooperating State, Territory, county, and municipality. For reactors slaughtered, the owner received a State and Federal payment of indemnity in all States except California, Colorado, Indiana, Massachusetts, Nevada, Oklahoma, Texas, and Utah, where no provisions were made for a State payment. The owner received the salvage in all cases but could not receive from all sources more than the appraised value.

Federal payments to owners for condemned cattle during the year were about \$1,990,000, and the Federal operating expenses were about \$1,805,000. The States and counties expended about \$2,700,000 for indemnity for brucellosis, their total indemnity having been about \$15,750,000 since the cooperative work was begun in 1934. Operating expenses of the States and counties were about \$1,045,000, and their total operating expenses since 1934 about \$5,600,000. The average appraisal for cattle reacting to the test for which Federal indemnity was paid was \$143.34; salvage, \$59.75; Federal indemnity payment, \$19.30; and State indemnity payment, \$22.54. Of the reactors slaughtered, 10 percent were registered purebred cattle.

DEMAND FOR CALFHOOD VACCINATION INCREASING

As one phase of brucellosis eradication in cattle, 392,232 calves were treated with strain 19 of the *Brucella* vaccine during the year. This is an increase of about 14,000 over the number vaccinated during the previous 2½ years, which marked the beginning of this work. The vaccine is administered under official supervision in cooperation with the State livestock sanitary officials in nearly all the States and in Puerto Rico.

About two-thirds of the animals vaccinated during the year were in herds whose owners retained most of their adult reactors under State regulations and disposed of them for beef when they were no longer useful for dairy or breeding purposes. No State or Federal indemnity payment will be made for them at any time. In the remaining herds, the adult reactors were slaughtered and the owners received partial compensation for them from the State and Federal Governments, in addition to the salvage. In a limited number of herds in which this disease was very active and serious, the vaccine was administered to cattle more than 8 months of age with fair results. A considerable amount of unofficial vaccination was conducted during the year, as evidenced by the large quantity of vaccine produced by licensed establishments.

VIRUS-SERUM CONTROL

The regulation of establishments producing biological products for use in animals, the importation of such products and organisms or vectors, and the administration of the marketing agreement for handlers of anti-hog-cholera serum and hog cholera virus were continued by the Division of Virus-Serum Control under the direction of D. I. Skidmore, principal veterinarian in charge.

WORK AT LICENSED ESTABLISHMENTS

At the close of the year, operations were being supervised in 73 licensed establishments in 56 cities and towns in 20 States. Inspectors were detailed to 40 of these establishments, and they supervised all

essential operations connected with the production of anti-hog-cholera serum and hog cholera virus. The production of other biological products by licensed establishments was supervised by inspectors making periodic visits for the purpose. Their duties included checking methods of production and testing the products, collection of samples, release of products for marketing, and supervision of the destruction of unsatisfactory products. During the year an outbreak of vesicular stomatitis, a disease resembling foot-and-mouth disease, occurred in a licensed establishment producing anti-hog-cholera serum and hog cholera virus. As this establishment was directly supervised by inspectors of the Division, the disease was detected in its early stages and promptly eradicated through the cooperative efforts of the Pathological Division, Division of Virus-Serum Control, and the licensee. Considerable quantities of anti-hog-cholera serum and hog cholera virus on hand in this establishment were withheld from the market until they were proved to be safe. All the serum at the time of preparation had been pasteurized at a temperature above the thermal death point of the vesicular stomatitis virus.

In the course of their supervision of licensed establishments, Bureau inspectors made 5,863,269 examinations of animals and 70,476 rejections. The inspected animals included 898,082 hogs and 1,031 calves offered for admission to licensed establishments. Of these, 10 hogs and 1 calf were rejected and denied admission. These inspectors also supervised 8,270 potency and 6,905 purity tests of anti-hog-cholera serum; supervised 3,273 purity and safety tests of simultaneous virus, conducted in duplicate, with pigs and pigeons as test animals; also collected and forwarded to the Bureau 3,546 representative samples of products and 67 subcultures of organisms from licensed establishments. They also supervised the destruction of 175 batches of *Bruceella abortus* vaccine and 15 batches of hog cholera virus found by Bureau tests to be unsatisfactory for marketing. Bureau inspectors reviewed reports, submitted by licensees, of 1,455 tests of antiencephalomyelitis serum, anti-hemorrhagic-septicemia serum, anti-swine-erysipelas serum, encephalomyelitis vaccine, and rabies vaccine.

BIOLOGICAL PRODUCTS PRODUCED AND DESTROYED

Table 7 shows the quantities of biological products produced and destroyed in licensed establishments under Bureau supervision.

TABLE 7.—*Biologicals produced and destroyed in licensed establishments, fiscal year 1944*

Product	Quantity		Product	Quantity	
	Pro-duced ¹	De-stroyed ²		Pro-duced ¹	De-stroyed ²
Anti-hog-cholera serum			Bacterins		
cubic centimeters..	2,034,080	10,528	cubic centimeters..	189,546	5,565
Other serums.....do....	80,909	2,419	Mixed bacterins.....do....	111,996	5,699
Hog cholera vaccine.....do....	8,595	6,106	Diagnostics.....do....	204	31
Hog cholera virus.....do....	536,086	21,162	Toxoids.....do....	853	32
Aggressins.....do....	11,126	70	Other vaccines and viruses		
Aggressins.....disks..	104	4	cubic centimeters..	38,548	10,862
Antitoxins			Do.....disks..	620	53
cubic centimeters..	2,530	2,314	Do.....milligrams..	33,414	5,028

¹ Detailed information on the production of products within these classes will be furnished on request.

² Includes products in course of preparation and those finished for marketing.

BIOLOGICAL PRODUCTS AND ORGANISMS OR VECTORS IMPORTED

Supervision of the importation of veterinary biological products and organisms or vectors from foreign countries was continued with the cooperation of Treasury and Post Office Departments. Six special permits were issued permitting importation of one shipment, in each case, of organisms or vectors, as defined by amendment 14 to B. A. I. Order 276.

Thirty shipments of veterinary biologics were offered for admittance to this country, and all were found to be products that had been exported from the United States and returned for various reasons.

BIOLOGICAL PRODUCTS CERTIFIED FOR EXPORT

Table 8 shows the quantities of biological products certified for export. Bureau inspectors issued 509 certificates to accompany these products.

TABLE 8.—*Biological products certified for export, fiscal year 1944*

Product	Quantity	Product	Quantity
	<i>Thousands</i>		<i>Thousands</i>
Anti-hog-cholera serum.....cc.....	14,481	Antitoxins.....units.....	8,086
Other serums.....doses.....	105	Bacterins.....doses.....	2,648
Hog cholera virus.....cc.....	419	Diagnostics.....do.....	15
Aggressins.....doses.....	201	Vaccines.....do.....	430

SERUM-MARKETING AGREEMENT AND ORDER

Administration of the serum-marketing agreement and order was continued. At the close of the year, 244 handlers of anti-hog-cholera serum and hog cholera virus were operating under the agreement and order. Of these, 38 were producers and 206 were distributors.

ORGANIZATION OF THE BUREAU OF ANIMAL INDUSTRY

Chief: A. W. MILLER.

Special Consultant to Chief: W. A. HAGAN.

Assistant Chief: HUGH C. MCPHEE.

Assistant Chief: HARRY W. SCHOENING.

Assistant Chief: PAUL E. HOWE.¹

Business Manager: J. R. COBBAN.

Assistant Business Manager: N. A. OLMSTEAD.

Animal Husbandry Division: HUGH C. MCPHEE, *Head Animal Husbandman in charge.*

Field Inspection Division: S. O. FLADNESS, *Principal Veterinarian in charge.*

Information Division: D. S. BURCH, *Information Specialist in charge.*

Interstate Inspection Division: W. M. MACKELLAR, *Principal Veterinarian in charge.*

Pathological Division: HARRY W. SCHOENING, *Principal Veterinarian in charge.*

Tuberculosis Eradication Division: A. E. WIGHT, *Principal Veterinarian in charge.*

Division of Virus-Serum Control: D. I. SKIDMORE, *Principal Veterinarian in charge.*

Zoological Division: BENJAMIN SCHWARTZ, *Principal Zoologist in charge.*

¹ On military furlough.

**REPORT OF THE CHIEF OF THE BUREAU OF DAIRY
INDUSTRY, AGRICULTURAL RESEARCH ADMINISTRA-
TION, 1944**

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1944.

DR. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I submit herewith a report of the work of the Bureau of Dairy Industry for the fiscal year ended June 30, 1944.
Sincerely yours,

O. E. REED, *Chief.*

AS A RESULT OF WARTIME DEMANDS the dairy industry is now producing and marketing approximately 15 billion pounds more milk annually than in the years immediately preceding the war. About two-fifths of the increase, or 5 percent of the total annual production, is going into lend-lease products. Military outlets take the rest of the increase, and more.

In the post-war period, when purchases for these outlets begin to decline, the dairy industry will be faced with the choice of either reducing milk production on the farm and curtailing operations in processing plants or increasing domestic consumption sufficiently to absorb the amount now going into lend-lease and a large part of the military purchases.

Many people in the United States are not now getting all the dairy products they need or want. Whether or not domestic consumption can be increased sufficiently to maintain the present output of the dairy industry, however, will depend not only on the post-war buying power of the people but on the combined efforts of dairy farmers, processors, and distributors to stimulate greater consumption through the use of educational and advertising programs. The effectiveness of such efforts will in turn depend on improving the quality, palatability, and safety of all dairy products, increasing the efficiency and economy of processing and distribution, and, above all, improving the average productivity per cow and per acre in order to decrease the farmer's cost of milk production. Greater efficiency on the farm and in the factory and savings in distribution costs to the consumer would make it possible to supply more milk to more people at less cost.

During the year the Bureau of Dairy Industry has continued to give attention to some of the basic problems involved in improving the quality of dairy products and the efficiency with which they can be produced, processed, and distributed. The nature of some of these problems and the progress in solving them are indicated in the following pages.

MILK AND DAIRY PRODUCTS INVESTIGATIONS

RESEARCH HELPS CHEESE MANUFACTURERS

The wartime demand for large quantities of high-quality Cheddar cheese, together with the scarcity of labor and of critical materials, created a number of new problems which required the attention of research workers. Improvement or modification of the methods of manufacturing and curing cheese was needed to increase the proportion of high-grade cheese and prolong the keeping quality, and some means of speeding up the rate of ripening also seemed desirable, particularly in producing cheese for lend-lease shipment.

For several years the Bureau has advocated that all milk intended for cheese making be graded; and also that it be pasteurized, regardless of quality, in order to enable the cheesemaker to control the making process more exactly. Cheese manufacturers generally are adopting the Bureau's method as rapidly as the availability of pasteurization equipment will permit. Introduction of the method in seven States that are producing cheese for shipment overseas has resulted in a marked improvement in the average grade. The work in Minnesota and Indiana has been practically completed and the results tabulated. In the Minnesota factories that were assisted by Bureau field men, the average percentage of U. S. No. 1 cheese was increased from 36 percent in 1942 to 99 percent in 1943. The production of U. S. No. 2 cheese in the same period decreased from 36 to 0.85 percent, and the production of undergrade cheese decreased from 27.8 to 0.12 percent.

The possibility of curing cheese in much less time than has been required heretofore is being investigated. Preliminary results reported last year indicated that certain strains of starter organisms are much more suitable than others for promoting ripening and the development of flavor, and that the ripening process can be carried out successfully and more quickly at 60° F. than at 50° or lower, provided the milk is of good quality and is pasteurized. Results of trials during the past year supported the previous conclusions, indicating that the development of flavor and the rate of ripening are influenced by the starter organisms, by the amount of acid formed during the making process, and by the temperature of curing. Studies during the year involved the isolation and testing of additional organisms for possible use in cheese starters, and the development of a laboratory test for biacetyl (a flavor compound) in Cheddar cheese. The test provides an easy and rapid means of measuring the amount of flavor developed in cheese.

One objection often cited against the use of pasteurized milk in making Cheddar cheese is that it slows down the rate of ripening. Experiments during the year indicated that if the milk has a high bacterial content the rate of ripening, or proteolysis, is retarded by pasteurizing the milk. When such milk is not pasteurized, however, the resulting cheese is very inferior in quality and abnormal in composition. On the other hand, if the milk is of high quality, pasteurization has no significant effect on the rate of ripening of the cheese.

During the year a number of companies indicated an interest in using the Bureau's new method of dehydrating natural Cheddar cheese, which was announced a year ago. One commercial company used the method in preparing 6 million pounds of dehydrated, compressed

cheese-soya soup stock, of which 20 percent was dehydrated cheese. The new method of dehydrating cheese reduces the weight by 35 percent and the shipping or storage space by about 40 to 46 percent, and also makes it possible to transport and utilize the cheese without waste even though refrigeration is not available. Research on the method itself has been completed, but certain long-time keeping-quality tests are still under way.

LOW OXYGEN CONTENT IS KEY TO KEEPING QUALITY OF DRIED MILK

It has long been recognized that the deterioration of dairy products that contain fat, such as butter and dried whole milk, is caused largely by oxidation of the fat. Commercial companies have used various procedures in an attempt to retard the oxidation process, including the use of antioxidants, low storage temperatures, and, in the case of dried whole milk, the use of inert gas to replace oxygen, but without complete success.

During the year the Bureau of Dairy Industry completed a fundamental study, with pure butterfat, to determine the relationship between oxygen concentration and the rate of deterioration of the fat. The results showed that as the amount of oxygen available for contact with the fat was reduced, the rate of oxidation or spoilage of the fat was slower, indicating that it would be possible to keep butterfat indefinitely without spoilage if it were packaged entirely free of oxygen.

The results of the fundamental study were confirmed by an analysis of the oxygen content and flavor score of 1,200 paired samples of dried whole milk that were packed and submitted by several commercial companies. One sample of each pair had been packed in air, that is, with no attempt to remove the oxygen by vacuum; the other sample was evacuated and packed in nitrogen. The samples packed in air contained 21 percent oxygen, whereas the nitrogen-packed samples varied considerably in the amount of oxygen present. Some of the latter contained as much as 13 percent of oxygen, indicating very poor methods of evacuation and packing to exclude oxygen. Samples that contained about 3 or 4 percent of oxygen were found to keep twice as long as similar powder packed in air.

In the course of its research with dried whole milk, the Bureau concluded that considerable quantities of oxygen-containing gases were held within the powder by adsorption, even after the oxygen in the free space in the package had been reduced to 3 or 4 percent. Failure of the usual evacuation procedures to remove these residual gases was thought to be responsible for poor keeping quality in most instances. Consequently the amount and composition of the sorbed gases was studied, the rate and extent of their release was determined, and the conditions of evacuation which would give a final oxygen concentration of 1, 2, or 3 percent were established. The most practical method of attaining a concentration of less than 3 percent of oxygen in the container is through the use of a vacuum of more than 29 inches.

SIX PROCESSES NOW AVAILABLE FOR MAKING LACTOSE FROM CHEESE WHEY

Investigations relating to the manufacture of lactose, which have been under way intermittently for several years in the Bureau of Dairy Industry, were concluded during the year with the formulation of

six different processes for producing lactose from cheese whey. Heretofore lactose was made largely from the whey that is produced as a byproduct in the manufacture of casein.

One of the important wartime needs for lactose is as a food for growing the molds that yield penicillin. Estimates indicate that 6 or 7 million pounds are now required annually for this purpose; this is approximately the total amount produced in former years. Moreover, no practicable commercial method for producing penicillin synthetically—which would eliminate the need for lactose—is available as yet.

As a result of the new and better ways to recover lactose from the whey produced in cheese factories, combined with the penicillin development, great quantities of cheese whey may find an important new place in the post-war economy. The six new processes range from a simplified procedure which requires a minimum of equipment and labor but produces a crude product to a process requiring more labor and equipment but producing a sugar of high technical grade. Any of the processes may be modified by introducing parts of another process, thus enabling the manufacturer to formulate a procedure suited to his particular conditions. All processes require but one crystallization and yield grades of lactose suitable for many uses.

RESEARCH HELPS MANUFACTURERS OF WARTIME ICE CREAM

Approximately 80 percent of the annual production of cheese whey is fed to farm animals or is wasted. Efforts of Bureau research workers this year to find ways to use a larger proportion of the available whey for human food indicated that whey solids could be used in the manufacture of wartime ice creams.

Although whey solids are of very high food value they normally would not be used in ice cream because of their high milk sugar content, which would cause an objectionable sandy condition. Wartime restrictions, however, required a low nonfat-solids content in relation to fat, and this left room for more milk sugar in ice creams without the danger of sandiness.

The studies showed that in ice-cream mixes ranging from 8 to 14 percent butterfat, whey solids could be used to replace 15.6 to 37.5 percent of the nonfat milk solids normally used, with no adverse effect on the quality of the finished product. Where skim-milk solids are not available or are needed for more important uses, the substitution of whey solids would be of value in keeping ice-cream production up to the maximum amount permitted under wartime conditions. Moreover, the use of whey solids would be much more logical than the use of the various nondairy product fillers that have been proposed from time to time.

Wartime restrictions on the amount of milk solids allotted to ice-cream manufacturers created renewed interest in the manufacture of sherbets as a means of extending the use of the available milk solids. To help these manufacturers, the Bureau made a study of the whipping properties of sherbets, with a view to determining the factors involved in controlling the overrun. It is generally accepted that the overrun should be low, but this has been difficult to accomplish. The experiments showed that the best quality of sherbet is obtained by drawing from the freezer at the lowest possible temperature and

taking the overrun then existing. The biggest factor affecting overrun is the sugar content, that is, the higher the sugar content the lower the overrun obtainable. Sherbets of unusually low milk-solids content whip slowly.

Help was also offered ice-cream manufacturers in the time-consuming and puzzling operation of calculating mixes. A simpler and more direct method of making the necessary calculations was developed and published. The method may be used for calculating mixes that are to be made by using concentrated dairy products directly, as well as for those that are to be made of unconcentrated dairy products and brought to final composition by evaporation or drying. The simple method of calculation is particularly timely in connection with the latter procedure, because of the large quantity of dried or powdered mixes now being made for military purposes.

BREEDING, FEEDING, AND MANAGEMENT STUDIES

CALF'S UDDER IS INDEX TO FUTURE PRODUCTION CAPACITY

Studies begun by the Bureau of Dairy Industry a number of years ago now show promise of providing dairy farmers with a method of judging the future milk-producing possibilities of young heifer calves.

In view of the fact that 5 or 6 million heifer calves must now be saved and raised each year in order to maintain the present dairy cow population in the United States and the fact that nearly one-third, or about 2 million head, turn out to be unprofitable milk cows, the economic importance of discarding the potentially low producers early in life is obvious. The cost of raising a heifer calf to milking age is about \$100.

The method is the outgrowth of an investigation to determine the significance of advanced or retarded mammary-gland development at any given age in heifer calves, as an indication of their milk-producing capacity at maturity. Each year since the study began the udders of all heifer calves in the Bureau's herd at Beltsville have been examined periodically by feel (palpation) at ages ranging from 1 to 18 months. At each examination a grade was assigned, indicating the stage of mammary-gland development as compared with breed averages or standards already established for the herd. Nine grades were used, a grade of 5 indicating that mammary-gland development conformed to the average. Grades 6 to 9, inclusive, were used to indicate progressive degrees of advancement above average and grades 4, 3, 2, and 1 progressive degrees of retardation below the average.

Many of the calves graded for mammary-gland development have now grown to milking age. A recent comparison of their production records with the grades assigned to them as calves showed that those with retarded development (those in grades 1, 2, and 3) produced on the average some 2,500 to 4,000 pounds less milk per year than those that were advanced in mammary development at the same age (those in grades 7, 8, and 9). The grades assigned at 4 months of age were found to be more indicative of potential producing ability than those assigned at any other age. There was also some indication that low grades were more significant of inferior production than high grades were of superior production.

Because the grades used in the Bureau's studies were established on the basis of the average or standard for mammary-gland development in the breeding herd at Beltsville, where the continued use of proved sires has raised the production to a uniformly high level, it now seems desirable to test the results further by obtaining similar data in other herds where the inheritance for milk production may have greater variability. A start has already been made in this direction by the Bureau's extension dairymen, who take every opportunity to explain the method of assigning grades to calves in the herds of farmers, breeders, and institutions, for comparison with the subsequent production records.

The evaluation of mammary-gland development in calves is not difficult, however; with very little practice any dairyman can become proficient in classifying the calves in a herd or group into three classes—advanced, medium, or retarded. These classes may be designated as A, B, and C; good, medium, and poor; high, medium, and low; or in any other way. By examining the calves as they reach the age of 4 months and keeping a record of the class in which each is placed, it is possible, when they come into lactation, to determine the reliability of the method for culling out the inferior individuals. It is necessary, of course, first of all to become familiar with the exact stage and size of glandular formation to be expected in a calf at 4 months of age.

HIGHLY DEVELOPED EXTERNAL MAMMARY VEINS NOT NECESSARY FOR HIGH PRODUCTION

For many years judges of dairy cattle have given considerable attention to (1) the abundance of mammary veins on the surface of the udder, (2) the size and length of the so-called milk veins on the abdomen, and (3) the size of the "milk wells," or holes, through which the abdominal veins enter the body, in the belief that these mammary characteristics were an indication of high milk-producing ability in dairy cows.

The Bureau of Dairy Industry, however, has now assembled evidence which shows there may be little if any relation between any of these characteristics and milk-producing ability and which also serves to explain why.

The evidence is the result of a study begun several years ago, in which cows at Beltsville are assigned grades for relative mammary-vein development at a given stage of lactation. A comparison of the grade for mammary veining and the milk-production record for 106 Holstein and 89 Jersey cows showed that neither an abundance of veining on the abdominal wall or on the surface of the udder nor the presence of large "milk wells" was indicative of high producing ability in these cows.

Up to the time Bureau experiments proved that milk secretion is a continuous process it was thought that most of the milk was formed in the udder while the cow was being milked. That theory was tied up with the supposition that, as a result of manipulating the teats at milking time, the udder became engorged by a sudden inrush of a large quantity of blood.

To obtain an estimate of the capacity of the circulatory system of the udder, the Bureau investigators injected liquid rubber (latex) under pressure into the blood vessels of an amputated udder that weighed 52 pounds. The amount of latex held by the arteries and veins was only about 4 pounds. This was a surprisingly low capacity, in view of the large quantity of blood passing through the udder during the 365-day period in which the cow produced 15,648 pounds of milk. The low capacity indicates that only a small proportion of the total blood content of the body was in the udder at any one time.

A detailed dissection was made of the latex-filled arteries and veins of this udder, and the courses of the veins through 25 other udders were traced in order to learn how the volume of blood required for milk production is brought to and returned from the udder. Following are some of the points brought out by these studies.

The subcutaneous "veins" on the surface of the udder have been reported by others to be lymph vessels, but these studies showed them to be continuations of the venous system of the udder. Studies of grades for abundance and prominence of these veins showed that they were more pronounced, at least in Holsteins, on udders of the closely attached, compact type than on the loose, flexible ones. It is possible that, in the compact type of udder in which there may be greater internal resistance, some of the venous blood may be forced to follow courses outside the boundaries of the glandular tissues.

It has been generally accepted that the blood leaves the udder by three main routes: (1) The chief internal veins (external pudic); (2) the subcutaneous abdominal veins (milk veins); and (3) the perineal veins (which occur in the region between the vulva and the rear of the udder). Many of the veins contain valves which control the direction of the flow of blood.

In these studies, all the valves in the perineal veins, except in the immediate proximity of the vulva, were found to be directing the blood toward the udder rather than away from it. The valves in the chief internal veins and in the "milk veins" pointed away from the udder, however, and apparently the return of blood from the udder is virtually limited to these two routes. Moreover, the dissections showed that the internal veins apparently are large enough in themselves to return all the venous blood from the udder. This provides further evidence that the size and abundance of abdominal veins are of little importance and explains why significant correlations between the degree of mammary veining and the level of producing ability were not obtained in these studies.

INBREEDING REDUCES BODY WEIGHT MUCH MORE THAN SKELETAL SIZE

An analysis of the production records of 71 grade Holstein cows and of more than 30 items representing measurements of their external and internal anatomy, which was completed during the year, gave some interesting information about the comparative effect of inbreeding and outbreeding on the form, size, anatomy, and producing capacity of dairy cows.

The cows were divided into 4 groups on the basis of the intensities (coefficients) of their inbreeding. The outbred group consisted of 22 cows ("0" coefficient). The 49 inbred cows included 27 with coefficients of 29 or less, 15 with coefficients between 30 and 49, and 7 with coefficients of 50 or above.

The study showed that inbreeding in this experiment caused a decline of approximately 15 percent in body weight or mass but did not affect skeletal size to any significant extent.

Some of the internal organs—notably the heart—were reduced in weight in the most intensely inbred cows, almost as much as the body mass. Weight of brain and weight of empty stomachs were reduced about 10 percent, but weight of lungs was definitely higher in the inbred cows. Length of intestines was only slightly affected.

The endocrine glands, on an average, were reduced in size. Greatest reductions were in weights of parathyroids, pituitary, and pancreas; no significant change occurred in weights of pineal or adrenals; the heaviest thyroids were found in the most intensely inbred group.

It may be significant that the pituitary body, which supposedly is closely tied up with the physiology of growth and lactation, declined in weight to 80.2 percent in the most highly inbred group; that milk and butterfat production declined to 92.2 and 82.6 percent, respectively; and that the items representing body mass declined to 86.4 percent of the values represented by the outbred cows. Weight of udder decreased even more (to about 60 percent), but this may have been compensated for to some extent, in the matter of producing ability, by a greater degree of porosity in the mammary tissue, indicated by the high relation of capacity to weight of udder in most of the inbred groups.

As inbreeding increased and the size of the cows became smaller the organs and body parts, on an average, represented a larger proportion of the total animal structure. That is, the organs did not decline to as great an extent as did body mass. Most notable exceptions were weights of parathyroids, udder, pancreas, and pituitary body.

AVERAGE PROVED SIRE FERTILE TO 10½ TO 12 YEARS OF AGE

Proved sires are wanted by individual dairy cattle breeders, by farmers with good commercial herds, and for use in artificial breeding associations. But proved sires are relatively scarce and the good ones are usually held at high prices.

The cash value of a proved sire should be based primarily on his demonstrated ability to sire daughters which will outproduce their dams under the same environmental conditions, but it will also depend on the number of years of useful service the buyer can expect of the sire. Unfortunately, bulls do not continue in service as long as some other animals. Some stallions, for example, have been in service after 30 years of age. More than 20 years of experience with proved sires in the Beltsville herds affords interesting information on the life expectancy of proved sires that have been kept under uniformly favorable conditions. Table 1 gives the age and the condition at time of death of 24 proved sires that were kept in the Beltsville herds as

they were serviceable

TABLE 1.—History of 24 proved sires in Beltsville herds

Breed, name, and number	Date of birth	Age at last successful service	
		Yr.	Mo.
Holstein sires:			
Johan Woodcrest Lad 11th 103987.....	Feb. 17, 1912	10	11
Denton Colantha Sir Rag Apple 87426.....	Apr. 21, 1911	16	7
Ponderosa Pietertje Ormsby 189058.....	Dec. 30, 1915	9	3
Varsity Derby Matador 234809.....	Mar. 6, 1918	13	1
Pride of the Bess Burkes 294574.....	Feb. 9, 1920	10	0
Count Piebe Hengerveld Ormsby 444324.....	Nov. 24, 1923	7	11
Chief Piebe Ormsby Burke 4-4088.....	Feb. 27, 1924	17	0
Pride Ormsby Gerben Colantha Ona 603883.....	Dec. 25, 1928	14	8
King Ormsby of Iodak 576357.....	Jan. 17, 1929	8	5
Douglas Buttercup Hark 660575.....	Nov. 21, 1931	12	5
Jersey sires:			
Karnak's Noble 4th 115589.....	June 30, 1913	9	10
Hood's Sophie's Tormentor 145709.....	Oct. 8, 1915	6	11
The Moose O' Fernwood 137024.....	Apr. 30, 1915	12	2
Tiddledywink's Raleigh 158391.....	July 29, 1917	9	11
Sophie's Torono 23d 167335.....	Feb. 3, 1918	10	5
Oxford May's Int. Owl 205447.....	Feb. 24, 1922	9	5
Raleigh's Dorothy's Senator 203000.....	Apr. 1, 1921	12	10
Sophie's Phoenix 222930.....	Aug. 21, 1923	11	9
Marston's Interested Owl 23-782.....	Mar. 19, 1924	11	7
May Owl Moose 342746.....	Jan. 15, 1931	10	0
Jerseys still in service:			
May Owl Owlot Gamboge 344307.....	Apr. 12, 1931	13	3
Phoenix Sophie Owl Fox 357462.....	Jan. 19, 1933	11	6
Mars Owl Sophie Jacoba Owl 361659.....	Nov. 8, 1933	10	8
Twice Senator of Twie Sophia 365723.....	July 3, 1934	10	0

All but 2 of these bulls were in service in other herds before they were brought to Beltsville. The 10 Holstein sires are all dead. Their average age at time of last successful service was 12 years. Only 3 became sterile and were slaughtered; the other 7, were still fertile when death resulted from swallowing a foreign body, from accident, or from some other cause.

Of the Jersey sires 10 are dead, 4 of which were still fertile at the time of death. These 10 averaged 10½ years of age at the time of the last successful service. The average age of the 4 Jersey sires that are still in service is higher than that of the other 10 sires at last service.

On an average, the Holstein bulls were useful to the age of 12 years and the Jerseys to 10½ years of age.

SYNTHETIC UREA PROVES SATISFACTORY IN DAIRY RATIONS

Short supplies of protein feeds in recent years have focused the attention of research workers on the possibility of using synthetic urea to meet the protein requirements of dairy cattle.

Made from coal, air, and water, urea looks like fine stock salt. It contains no protein itself but it does furnish the nitrogen needed to make protein in the animal body. The bacteria in the paunch of the cow and other ruminating animals combine the nitrogen of the urea with other feed constituents to make protein in much the same way

that plants take nitrates from the soil to make protein. Unlike ruminants, hogs and poultry cannot use urea to synthesize protein in the body.

In a 5 months' feeding experiment at Beltsville, cows fed corn silage made with the addition of 0.5 percent urea produced practically as much milk as when they were fed untreated silage and the urea was fed with the grain ration. There was no advantage in putting the urea in the silo with the corn. Cows fed urea as the principal source of protein declined only 13.5 percent in milk production in 100 days, which was only about two-thirds as much as would ordinarily be expected on other feeds.

Other feeding experiments showed that soybean meal can be replaced with an equal weight of low-protein feed plus one-seventh as much urea without affecting milk production materially one way or the other. The greatest usefulness for urea on dairy farms will be on those where plenty of grain is grown but where there is need for additional protein. This need can be supplied with urea more cheaply than with oilseed meals. The cost of urea is not likely to exceed 1 cent per cow per day.

TIME OF DAY OF CUTTING OF ALFALFA DOES NOT AFFECT YIELD

Investigations at a State agricultural experiment station indicated that much higher yields of dry matter and carbohydrates would be obtained by cutting hay crops in the afternoon instead of the morning. Similar studies to check these results were recently completed at Beltsville, in which a series of plots of alfalfa were mowed at 2-hour intervals from 7 in the morning until 7 the following morning. The cuttings were weighed and analyzed separately. From morning to evening there was no appreciable increase in the yield of dry matter, protein, ether extract, fiber, or carotene, though there was a decrease in mineral matter and possibly a slight increase in carbohydrates. Altogether the differences in the yield and the changes in composition were not of sufficient magnitude to make it worth while for farmers to mow hay at any certain time of day or night. Weather forecasts and convenience with reference to other farm work are more important considerations.

COWS LIKE MOLASSES ON PASTURE-GRASS CLUMPS

Grass clumps varying in size and number are ungrazed in most permanent pastures because of droppings. The usual practice, if anything at all is done, is to mow the clumps, the idea being that animals will graze the new grass when it comes on. Experience at Beltsville, however, indicated that if cows avoid the first growth because of the droppings they will also avoid the second growth, so an experiment was conducted to see if spraying the clumps with molasses would induce the cows to graze them. An application of molasses at the rate of 400 pounds per acre resulted in 65 percent or more of the herbage being eaten in 24 to 48 hours. Such a practice on a commercial scale may be practicable if the ungrazed clumps make up a considerable part of the total area and suitable implements are available for spraying.

SEASON OF FRESHENING INFLUENCES MILK PRODUCTION

Studies of the relationship between milk and butterfat production and season of year for freshening, based on the records of the Jersey herd at the Jeanerette, La., field station, indicate that dairymen in that region could increase milk production considerably by breeding more cows to freshen in the winter months, from November through April.

The records of 156 cows in the station herd were grouped according to the month in which they freshened. The average production was very uniform for cows calving from January to June, inclusive, ranging from 434 pounds to 437 pounds of butterfat per cow per year. The averages for cows freshening in July, August, September, and October were much lower, the September-freshening cows averaging only 325 pounds of butterfat. The cows freshening in July, August, and September produced 25 percent less than cows freshening from November to April. The lower production by summer-freshening cows is undoubtedly due to the combined effects of the higher temperatures and poorer pastures, which prevent cows from reaching a normal rate of production early in the lactation period. Cows freshening in the winter months do not experience this depressing effect in the early part of the lactation period, when the level of production is highest.

According to the latest estimates, the cows in Louisiana and four other States in the Gulf coast area have an average yearly production of 2,942 pounds of milk and 130 pounds of butterfat. This is only 62 percent as much milk and 70 percent as much butterfat as the average production for the United States. One way to increase milk production would be to have more cows freshen in the winter months.

MANY FACTORS AFFECT LABOR REQUIREMENTS FOR THE DAIRY HERD

Records kept of the man-hours of labor necessary to manage the dairy herds at the eight field experiment stations of the Bureau of Dairy Industry during the last 5 years show that many factors affect the labor requirements of a dairy herd.

The amount of labor for such operations as feeding; milking; caring for cows, calves, young stock, and bulls; hauling manure; washing and cleaning milking equipment, etc., was figured on the basis of milk-cow units, in which each dry cow, herd bull, or young animal was considered as requiring as much labor as one-fourth cow in milk. Size of herd, location and arrangement of buildings, type of milking employed (machine or hand), efficiency of labor management, climatic conditions, and other factors influenced the amount of labor required.

In 1938 the average labor requirement was 21.36 man-hours per milk-cow unit per month at all stations. This has been gradually reduced to an average of 18.94 man-hours per milk-cow unit. The range between stations has remained rather wide, however. The extremes are represented by a station in the South, where the cattle are outside most of the year, and one in the Middle West, where special-quality milk is produced. At the southern station only 11.35 man-hours per milk-cow unit were required as compared with 25.15 man-hours at the other.

At the average of 18.9 man-hours per milk-cow unit, 1.5 men working 8 hours a day would be required to handle a herd of 20 milk-cow units. More labor is required at the field stations, however, than on ordinary

dairy farms, according to surveys in several different States. The details of experimental work at the field stations slow up the work output, visitors tend to interfere with the routine work, attention must be given to the appearance of the cattle and buildings, and the cows on official test for records to be used for inheritance studies require more labor and attention than cows in commercial herds.

ROUGHAGES PRODUCE CHEAPER FEED NUTRIENTS THAN GRAIN CROPS

Records kept over a period of years at the Bureau's field experiment stations to show the comparative cost of producing feed nutrients in the various crops grown on the station farms all point to the important fact that nutrients can be produced much more cheaply in the form of roughages (hay, silage, and pasture) than in the form of grains, such as barley, oats, and corn.

The crops and costs vary somewhat with the region and yield, and in many cases it is difficult to make comparisons between stations. At the Mandan, N. Dak., station it cost 59 cents to produce 100 pounds of total digestible nutrients in barley and oats as compared with 48 cents in corn silage. At the Huntley, Mont., station it cost \$1.30 to produce 100 pounds of total digestible nutrients in small grains, 95 cents in corn silage, 70 cents in alfalfa hay, and 44 cents in irrigated pasture. At the Hannibal, Mo., station, the cost of producing 100 pounds of total digestible nutrients in alfalfa hay has averaged 35 cents. This low cost is due to the high yields, which have averaged approximately 4.9 tons per acre. One field averaged over 6 tons per acre for a period of 6 years.

Charges for use of land and equipment other than tractors, taxes, upkeep, and depreciation are not included.

KUDZU FURNISHES CHEAP GRAZING

At the Willard, N. C., field station, a 5.5-acre field was set to kudzu plants in the spring of 1940. The plants were set in 5-foot rows after an application of 2½ tons of manure per acre. The kudzu was allowed to grow undisturbed until 1941; in 1942, 5 tons of manure per acre was applied. In 1943 four milking cows grazed this field, but care was taken to see that the kudzu was not grazed close enough to injure the stand. The kudzu supplied grazing for 116 days or 62.6 cow-days per acre. The yield of total digestible nutrients was 1,002 pounds per acre, which compared favorably with the amount of nutrients furnished by pearl millet and was more than double the amount furnished by soybeans. The cost was \$7.60 per acre for the kudzu, as compared with \$12.87 for soybeans and \$13.42 for pearl millet.

LADINO CLOVER DOES WELL IN PASTURE MIXTURES

At the Lewisburg, Tenn., field station a series of 12 pasture plots were seeded to various combinations of grasses and clovers, including lespedeza, white clover, hop clover, crimson clover, orchard grass, bluegrass, and Ladino clover. In most cases seeding was done on prepared seedbeds, but in some plots the seed was sown on the sod. Check plots received no treatment other than mowing to control weeds and were not seeded.

A mixture of orchard grass and Ladino clover produced the most grazing and supplied 3,139 pounds of total digestible nutrients per acre, which was three times as much as native bluegrass sod. Seeding crimson clover on bluegrass sod which had been limed and manured increased the grazing by 19.2 percent over the untreated bluegrass sod. Bluegrass sod that was not mowed produced 15 percent less grazing than bluegrass sod that was mowed to control weeds.

At the Huntley, Mont., field station, alfalfa and Ladino clover were seeded separately in three $\frac{1}{2}$ -acre irrigated plots with canary grass, orchard grass, and meadow foxtail, respectively. The forage was cut and made into silage the first season, and the plots with the alfalfa combinations exceeded in yield the plots with the Ladino clover combination by approximately 20 percent. The next season the plots were grazed by milking cows. The computed yield of total digestible nutrients per acre was 5,488 pounds for the alfalfa-grass combination, as compared with 4,761 pounds for the Ladino clover and grass combinations, or an increase of 12 percent for the alfalfa and grass mixtures.

NUTRITION AND PHYSIOLOGY INVESTIGATIONS

HOLSTEIN HEIFER CALVES DO WELL WITHOUT WHOLE MILK

Farmers normally use about 3 billion pounds of whole milk annually in raising calves. With a view to saving some of this whole milk for human food, the Bureau of Dairy Industry is conducting an experiment to determine how well calves might do if they were fed no marketable whole milk at all.

In this experiment all the calves received the colostrum milk from their mothers for about 3 days. After that some of them were put on skim milk immediately (method 1), and the others were fed whole milk for about 1 month, and then skim milk (method 2). Both groups got the skim milk until they were about 6 months of age. All the calves received grain and hay from the time they were old enough to eat these feeds and a vitamin A supplement from the time they were put on the skim milk until they ate enough roughage to supply their vitamin A requirements.

The results with these two methods of feeding calves have varied somewhat with the breed. Fifteen Holstein heifer calves were reared according to method 1, with a grain mixture and U. S. No. 3 timothy hay. Their monthly weights during the first 3 months averaged only 9, 9, and 12 pounds less, respectively, than those of calves reared according to method 2 and otherwise similarly fed; and at 5 and 6 months of age they weighed practically the same as the calves reared according to method 2. Similar results were obtained with 7 Holstein heifer calves reared according to method 1 and fed grain and U. S. No. 1 alfalfa as compared with calves reared according to method 2 and fed the same ration of grain and hay.

With Jersey heifer calves the results were somewhat different. Seven of them, reared according to method 1, weighed at the end of the first month only 8 pounds less than the calves reared according to method 2 and fed a comparable ration of grain and hay, but this difference increased from month to month until it was 26 pounds at 6 months of age. When these Jersey heifer calves reared according to method 1 were compared with calves reared according to method 2 but fed grain and U. S. No. 1 alfalfa hay, the differences in weights at 1 and 6 months

of age were 12 and 36 pounds, respectively; but at 12 months of age the Jersey heifer calves reared according to method 1 were not significantly underweight.

Insofar as growth is concerned, method 1 apparently gave satisfactory results with Holstein heifer calves, but results were not so satisfactory with Jersey heifer calves. It is possible that the energy intake of the latter is not quite adequate for optimum growth. Methods of supplying more energy will be tried with both Holstein and Jersey calves.

VITAMIN A POTENCY OF COLOSTRUM VARIES WITH COW'S DIET

Cows that have been on rations of grain and either U. S. No. 3 alfalfa or U. S. No. 3 timothy hay for months invariably have defective calves, because these hays are poor sources of vitamin A. Even on diets which supply enough vitamin A to permit the cows to bear normal calves, some calves are born with practically no vitamin A reserves in their bodies and must depend on their mothers' colostrum for their immediate supply of this nutrient.

During the past year the Bureau of Dairy Industry determined the vitamin A potency in the colostrum and milk of four cows—one Holstein and one Jersey that had been on pasture (the pasture was not particularly good), and one Holstein and one Jersey that had been on a ration low in vitamin A potency but adequate to maintain the health of the cows and permit them to bear normal calves. The results are shown in table 2.

TABLE 2.—The vitamin A potency of colostrum and milk produced on rations varying in vitamin A potency (international units per quart)

Days after calving	Vitamin A in colostrum and milk of cows fed pasture—a good source of vitamin A		Vitamin A in colostrum and milk of cows fed rations low in vitamin A potency	
	Holstein	Jersey	Holstein	Jersey
1.....	20,150	19,714	3,292	4,473
2.....	12,716	11,011	1,042	0,239
3.....	3,997	5,426	1,338	1,352
4.....	4,282	4,827	969	809
5.....	3,554	4,743	928	868
6.....	2,104	.....	911	741
7.....	2,180	.....	909	626
8.....	2,696	3,487	.....	.....

It will be noted that the colostrum of the first 2 days was the most potent source of vitamin A, and that vitamin A potency declined rapidly after the second day to that of ordinary milk by the fifth or sixth day. These results agree with those reported by other laboratories. It will also be noted that, at comparable periods after calving, the colostrum from the cows on pasture was several times (2- to 12-fold) as potent as that from the cows on the low vitamin A ration; that the potency of the colostrum from the two cows on the low vitamin A ration was as low on the second or third day as that of ordinary winter milk; and that subsequently the milk from these two cows had only one-half to two-thirds the vitamin A potency of average winter market milk. The cows on the low vitamin A ration were receiving a

ration of grain and U. S. No. 3 timothy hay supplemented with enough cod-liver oil to maintain their health and permit them to bear normal calves. Such a ration obviously may not permit the production of colostrum or milk that is a good source of vitamin A.

With cows on rations low in vitamin A, it is obvious that the vitamin A intake of the calf could be considerably increased if some of the colostrum secreted on the first or second day were preserved and fed later. How feasible this practice would be depends on the changes that storage may bring about in other constituents, for the calf depends on its mother's colostrum not only for vitamin A but for numerous other factors which contribute to its welfare. A study of these questions is being continued.

U. S. NO. 3 TIMOTHY HAY NOT SUITABLE FEED FOR MILK COWS

Considerable quantities of poor-grade timothy hay are fed to dairy cows in certain parts of the United States, but evidence accumulating from intensive research in the Bureau of Dairy Industry indicates that the practice is unsound for a number of reasons, but particularly because such hay is a poor source of carotene, or vitamin A.

Various studies indicate that U. S. No. 3 timothy hay usually contains only 0.25 to 0.35 percent of calcium, and sometimes as little as 0.16 percent, whereas No. 1 alfalfa hay contains close to 1.5 percent; No. 3 timothy hay contains on an average about 5.3 milligrams of carotene per kilogram, whereas No. 1 alfalfa contains about 37.4 milligrams; and, according to Morrison's Feeds and Feeding, timothy hay contains on an average 2.9 percent of digestible protein, as compared with 10.6 percent in alfalfa. U. S. No. 3 timothy hay is therefore a very poor hay on a number of counts.

Although more work is necessary to determine whether or not U. S. No. 3 timothy hay may supply enough vitamin A to maintain the normal health and usefulness of the cow, the Bureau's research certainly indicates that this hay does not supply enough to permit her to bear a normal calf. Furthermore, although this difficulty could be overcome and the health of the cow maintained if a ration of grain and No. 3 timothy hay were supplemented with 10 or 20 milliliters daily of cod-liver oil (potency of 2,000 I. U. per milliliter), calves from cows on such a ration would be born with very little vitamin A stored in their bodies and would depend on their mothers' colostrum for their immediate supply of this vitamin. Cows fed in this way, however, would not produce a colostrum that would be a good source of vitamin A.

However, the most serious effect of using poor-grade timothy hay—and the most difficult one to overcome—is in connection with its effect on the vitamin A potency of the milk produced. The vitamin A potency of such milk is only one-half to two-thirds that of the average winter milk produced in this country. This was found to be true when this ration was supplemented with enough vitamin A to preserve the health of the cow and to permit her to bear her calf. Because of its effect on the vitamin A potency of the milk—and on that of the butter and cheese made from this milk—the use of No. 3 timothy hay for dairy cows should be discouraged.

NEW RESEARCH EXPLAINS HOW PLANT-JUICE EXTRACTS
INDUCE OVULATION IN RABBITS

Some plants contain a substance which, like the gonadotrophic hormone of the pituitary gland, brings about sexual activity when injected into a suitable test animal, such as the rabbit. Studies during the year to determine the physiological mechanism by which this substance causes a rabbit to ovulate (expel the egg from the ovary) indicate that the plant substance acts as a toxic agent and that it does not act directly on the ovary to produce ovulation.

The rabbit, like the ferret and the cat, is peculiar in that normally it ovulates only as a result of copulation. The nervous stimulation of the copulatory act in these animals results in a discharge of sufficient gonadotrophic hormone from the anterior lobe of the pituitary gland to induce the ovulation, the gonadotrophic hormone acting on the ovary to bring this about. This same nervous mechanism can be stimulated and ovulation can be produced in the rabbit by injecting copper acetate or by administering convulsive doses of metrazol or insulin.

The Bureau of Dairy Industry has now demonstrated that the plant-juice substance produces ovulation by a mechanism similar to that of copper salts. An assay of pituitaries from plant-juice-ovulated rabbits indicated that they had released enough gonadotrophic hormone to cause ovulation; it was shown also that when the plant-juice substance does not bring about the discharge of the hormone, it does not produce ovulation. As reported last year, the plant juices are toxic. It would appear that they do not contain a material which acts like the gonadotrophic hormone—i. e., that acts directly on the ovary—but, rather, a toxic material which brings about the discharge of the hormone from the pituitary gland into the blood so that the hormone can act on the ovary and bring about ovulation.

Moreover, these plant juices are active only in estrous rabbits or in anestrous rabbits that have been pretreated with estrogen. In other animals ovulation occurs without the nervous factor which is peculiar to the rabbit. In nearly all other animals (guinea pig, dog, cow, human being, etc.) when the ovarian follicle reaches a state of maturity comparable to that of the estrous rabbit, ovulation normally occurs automatically and independently of copulation and without the application of any nervous stimulation. It would, therefore, seem unlikely that a material which probably acts in the rabbit in lieu of the nervous stimulation due to copulation would be of practical advantage in bringing about ovulation with these other animals.

The condition of sterility in the female animals is usually associated with a failure in the early maturation phases of the follicle. Pituitary extracts and other gonadotrophic agents will stimulate the early maturation phases in the follicles of immature animals or adult animals with inactive ovaries. Copper salts and plant-juice extracts have failed consistently to show any effects comparable to those of pituitary extracts on immature or inactive ovaries.

The Bureau reported last year that plant-juice extracts given in conjunction with pituitary hormone failed to give any augmenting effects, when tested in the immature male and female rat. The immature female rat is very responsive to pituitary hormone and other gonadotrophic agents.

Stated briefly, then, the rabbit-ovulating factor that occurs in plant juices probably produces its effect through a nervous action (convulsive action due to its toxicity) which causes a discharge of hormone from the pituitary, which in turn causes ovulation in the estrous rabbit. (This effect cannot be demonstrated in other animals since they ovulate spontaneously.) There is no evidence indicating that this plant material is a gonadotrophic agent, i. e., that it has any direct effect on the ovary or testicle.

NEW STUDIES INDICATE PHYSIOLOGICAL IMPORTANCE OF THE UNIDENTIFIED-GROWTH FACTOR IN MILK

Results of research reported previously by the Bureau of Dairy Industry have indicated that milk contains some "growth promoting" substance that has not been identified and is not any of the known nutrients. The work showed also that various milk products (commercial skim-milk powders, cheeses, commercial casein), liver extracts, beef muscle, lettuce, hays, etc., possess this growth-promoting property, whereas yeast, white flour, reenforced white flour, whole wheat flour, and various grains do not. The liver extract that is used intramuscularly in the treatment of pernicious anemia is a particularly good source of it, being about 1,600 times as potent as whole milk.

During the past year a concentrated preparation of the unidentified growth-promoting factor was made, which, although impure, was active in doses as small as 2 micrograms daily. Also a preparation of crystalline folic acid, a recently isolated member of the vitamin B complex, was obtained, tested, and found not to have the growth-promoting properties of milk, milk products, or liver extracts. These results confirm the evidence presented a year ago, that the unidentified growth-promoting factor in these materials is none of the now known vitamins, but is a material that is active in doses of the magnitude of some of the known vitamins.

Two other studies by the Bureau during the year contributed further knowledge about the action of the unidentified growth factor and indicated its physiological importance. First, it was found that the rats that were on diets deficient in this factor always had larger kidneys per unit of body weight than those on diets adequate in this factor and that older animals that have been on the deficient diet for long periods practically always have a decided enlargement, or hypertrophy of the kidneys. This is true even though the food intake on the deficient diet is much less than that of the animals on diets containing adequate amounts of the unidentified factor, and the work of the kidneys might therefore be expected to be less.

Secondly, the effectiveness of the growth-promoting property of this unidentified factor varies with the level of protein in the diet. On diets containing 10, 15, or 25 percent of protein, groups of rats gained an average of 38, 78, and 84 grams, respectively, in 5 weeks when the diet was deficient in the growth factor, and 105, 162, and 179 grams, respectively, on the same diet supplemented with some source of the growth factor. When, in another experiment, the protein in the ration was increased from 25 to 45 percent, growth on the deficient diet was decidedly reduced. For the first 4 weeks it was 80 and 36

grams respectively, but with a supplement containing the unidentified factor it was 176 and 173 grams, respectively. These results were obtained with purified casein as the protein; similar results with these higher levels of protein are now being obtained with coagulated egg white as the source of protein.

The results demonstrate that the unidentified factor is very effective in determining the consumption of diets varying in their protein content and indicate very strongly that it may materially influence the utilization of such diets. They also indicate clearly that the failure of animals to grow normally on diets deficient in the unidentified factor is not due to an actual protein deficiency, although the material may be precipitated by certain protein precipitants and may occur—as in various casein preparations—closely associated with protein. The occurrence of enlarged kidneys in the stunted rats on diets deficient in the unidentified factor and the varying effect of this factor on the growth of rats on diets varying in protein content suggest that it may be well to investigate the relation of this factor to the metabolism of protein.

METHODS DEVELOPED FOR STUDYING THE COMPOSITION AND PROPERTIES OF MILK PROTEINS

Certain investigations in the Bureau of Dairy Industry have been concerned for several years with the properties and chemical composition of proteins—particularly the proteins in milk. A knowledge of the composition of these proteins would throw light on their nutritive value and on the relative value of the various feed proteins used in milk production.

Various other laboratories have shown that only certain of the amino acids that make up proteins are essential in the nutrition of the rat, dog, and human; and also that urea—a simple nitrogenous compound—can be used to replace some of the protein feeds in dairy rations, because certain amino acids are synthesized by the bacteria in the paunch of the cow.

But despite these facts, the biological value of a feed protein, even for the cow, depends on the kind and quantity of some of the amino acids in it. In an experiment by the Bureau of Dairy Industry some years ago, the milk yield of a cow dropped 25 percent in 10 days as a result of a change in only the kind of protein fed—the quantity remaining constant—and increased again during the next 10 days as a result of another such change. It is important, therefore, to know the content of essential amino acids in milk and feed proteins. Such knowledge is generally limited by the lack of chemical methods for determining the amino acids in these proteins.

The Bureau has now developed methods for the determination of threonine, an essential amino acid that was discovered first in casein; and of serine, the amino acid linked to phosphoric acid in casein and in vitellin of the egg. Threonine and serine are similar in composition, and the method developed for their determination made it possible to determine whether or not casein had any other similar amino acids in it. It had none.

These chemical methods also made possible the study of some of the chemical properties of proteins that had never before been studied. Serine and threonine are themselves quite stable; but it was found that

when they are combined in proteins they are chemically much more reactive. The serine group, for instance, can be made to lose water and combine with other groups. Thus serine, which itself is not an essential amino acid, can be converted while combined in the protein molecule into cystein or cystin, two varieties of an amino acid present in casein which under some circumstances are essential for optimum growth.

In proteins like casein and the vitellin of the egg, in which phosphorus is combined with some of the serine, not only is the serine chemically reactive, but the phosphorous combined with it also possesses biological properties which may make it very useful in the animal organism. Results obtained in connection with this work are consistent with the idea that certain enzymes can either destroy combined serine and set free phosphoric acid, or leave the serine intact and liberate a phosphoryl group capable of contributing to carbohydrate metabolism.

The Bureau investigators believe that further work may explain the specific functions of the two phosphoproteins, casein of milk and the vitellin of egg, especially as related to the nutrition of the nursing mammal and the chick.

PUTTING RESEARCH INFORMATION TO WORK

SPECIALISTS ASSIST IN MILK-PRODUCTION CAMPAIGN

How to bring about an increase in milk production sufficient to meet the wartime goal of 122 billion pounds was the big problem in the dairy industry early in 1944. Dairymen had failed to reach the same goal for the preceding year by approximately 4 billion pounds; and except for the fact that milk cow numbers had increased slightly, the prospect for more milk was little, if any, better in 1944, from the standpoint of feed, labor, and other facilities.

In a cooperative move to help dairymen reach the desired goal with the facilities at hand, the Bureau of Dairy Industry assisted the War Food Administration and the Dairy Industry Committee in formulating an eight-point program of approved feeding and management practices and helped carry the message to the dairy farmers in every part of the country. The greatest hope for the necessary increase centered around the smaller herds, which normally produce about 50 percent of the Nation's milk supply but whose owners do not as a rule follow the most advanced practices of feeding and farming for optimum production. Many owners of small herds are not ordinarily reached by the usual dairy extension program.

The message to every milk or cream producer stressed the following points: (1) Grow more legume hay, pasturage, and grain; (2) fertilize to increase quantity and quality of feed; (3) feed to avoid summer milk slump; (4) feed cows liberally during their dry period; (5) keep as many cows as feed and labor permit; (6) market more whole milk whenever possible; (7) produce good-quality milk and avoid waste; and (8) breed for better herd replacements.

The "What and Why" of the eight points were explained in a special leaflet issued by the Department to support the campaign, and most of the States through their extension services issued supplementary leaflets explaining the "How to do it" phase of each point. Suf-

cient copies of the Federal leaflet were distributed to the States and county agents for redistribution to every patron of every creamery, cheese factory, milk plant, receiving station, and condensery.

In addition, the Dairy Industry Committee, which represents nearly all buyers of milk and cream in the country, held schools for their field men, plant managers, and other representatives to acquaint them with the details of the program and to encourage them to carry the message to their patrons by direct personal contact or through the mail with the milk or cream check. The Federal and State extension dairymen and the county agents took an active part in the training activities of these schools, which were of 1- or 2-day duration, on a State or regional basis.

Reports reaching the Bureau of Dairy Industry at the end of the fiscal year indicated that total milk production in many States was greater for the first half of 1944 than in the same period the preceding year.

IMPROVED HERDS PRODUCE MILK CHEAPER

As a result of the production records and other information they obtain year after year, members of the dairy herd improvement associations continue to improve the average milk and butterfat production level of their herds by using intelligent culling practices and better breeding and feeding methods.

During 1943 the average association cow produced 8,323 pounds of milk and 338 pounds of butterfat, whereas the average for all the cows milked in the United States was 4,604 pounds of milk and 183 pounds of butterfat. Data tabulated by the Bureau of Dairy Industry indicate that the association cows, on an average, consumed approximately 99 cents' worth of feed for each 100 pounds of milk produced, whereas the cows with an average production similar to that of all the cows milked in the United States required \$1.32 worth of feed to produce 100 pounds of milk.

SHORTAGE OF TESTERS INTERFERES WITH ASSOCIATION PROGRAM

Organized testing and record keeping through the Nation-wide dairy herd improvement association program has diminished considerably in the last 2 years because of the manpower shortage. The problem of obtaining suitable testers was solved in part in some States by training women, older men, and a few conscientious objectors, but even with these sources it has not been possible to maintain the normal number of testers. Extension dairymen are now looking forward to the time when returned soldiers will be available for such work.

On January 1, 1944, there were only 954 associations in operation, compared with the 1,057 a year earlier and the peak number of 1,421 in 1942. The number of members at the beginning of this year was 20,825, as compared with 24,155 a year earlier and the peak number of 32,957 in 1942. The number of cows on test is 561,587, as compared with 616,972 in 1943 and the peak number of 816,117 in 1942.

TEN THOUSAND SIRES PROVED IN ASSOCIATION HERDS

The herds enrolled in the dairy herd improvement association program are an important source of desirable breeding stock for use in the Nation-wide effort of Federal and State extension workers to improve the dairy cattle outside the association herds. As a part

of the improvement program, the Bureau of Dairy Industry each year tabulates the dam-and-daughter production records for several thousand bulls that have been used in the association herds. The ultimate object of the sire-proving program is to single out the superior sires and their sons for more intensive service in other herds through the medium either of cooperative bull associations or of artificial-breeding organizations.

The eighth annual printed list of sires proved in the association herds has been prepared for publication and contains the proved-sire records of 3,101 sires whose records were tabulated in 1943. The average butterfat production of the daughters of these sires was 379 pounds, compared with an average of 375 for their dams.

Since the beginning of the sire-proving program, 10,000 association sires have been proved. The 92,000 daughters of these sires, for which production records were available, averaged 362 pounds of butterfat per cow per year. More than 99 percent of the 10,000 bulls had daughters whose average butterfat production was more than 200 pounds; 86 percent had daughters with an average of more than 300 pounds; and 25 percent had daughters with an average of more than 400 pounds.

Since the average butterfat production for the 25½ million cows milked in the United States last year was only 183 pounds, it seems obvious that practically all of these proved bulls and their sons could be used for the benefit of the dairy industry by placing them in herds in which their proved-sire records indicate they would be able to increase production.

The number of proved sires will continue to increase as more production records are obtained from the association herds and filed for future tabulation. To date the Bureau has filed the identification records of more than 1½ million association animals, both cows and bulls. Production records have been recorded for about 750,000 cows, and dam-and-daughter data are accumulating on some 90,000 bulls that have been used in the association herds and that are listed in the Bureau's files.

GOOD BULLS USED IN COOPERATIVE BREEDING PROGRAMS

In an effort to obtain a wider use of the outstanding sires found in the association herds, Federal and State extension workers are encouraging their use in cooperative bull associations and in artificial-breeding programs where their good inheritance may be spread over the largest possible number of dairy herds. The number of such breeding associations continues to increase each year, and more and more proved sires or their sons are being placed in service in these breeding organizations.

At the beginning of 1944 there were 293 cooperative bull associations, with a membership of 6,213 dairymen owning a total of 62,473 cows. In addition there were 96 artificial breeding associations, with a membership of 28,627 dairymen owning 218,070 cows. The artificial-breeding associations were using a total of 657 bulls, or approximately 1 bull for 331 cows, which is 10 or 11 times the number ordinarily served by a bull in individual herds.

Of the sires used in the cooperative bull associations, 89 had proved-sire records indicating an average production for their daughters of

408 pounds of butterfat per cow per year. Of the sires in service in artificial-breeding organizations, 127 had proved-sire records indicating an average production for their daughters of 420 pounds of butterfat per cow per year. The use of proved sires of such capacity is an indication of the progress being made in improving the dairy cattle of this country.

ORGANIZATION OF THE BUREAU'S WORK

The research, extension, information, and administrative work of the Bureau of Dairy Industry was carried out by the following organization:

Chief of Bureau.....	O. E. Reed
Assistant Chief.....	Ernest Kelly
Assistant to the Chief, Administration.....	J. M. Kemper
Chief, Section of Information.....	L. S. Richardson
Renovated Butter Inspection (Regulatory).....	C. S. Trimble
Extension (Cooperating with Extension Service):	
New England States.....	J. B. Parker
Middle Western States.....	A. B. Nystrom
Western States.....	R. C. Jones
Southern States.....	W. E. Wintermeyer
Head, Division of Dairy Cattle Breeding, Feeding, and Management Investigations.....	R. R. Graves
Head, Division of Dairy Research Laboratories.....	G. E. Holm
Head, Division of Nutrition and Physiology.....	C. A. Cary
Head, Division of Dairy Herd Improvement Investigations.....	J. F. Kendrick

**REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOL-
OGY AND PLANT QUARANTINE, AGRICULTURAL RE-
SEARCH ADMINISTRATION, 1944**

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1944.

Dr. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1944.

Sincerely yours,

P. N. ANNAND, *Chief.*

RESearch WHICH HAS FOR ITS OBJECTIVE more stable agricultural production was never more needed than it is today. A great part of the efforts of all the farmers on all available land can be frustrated by outbreaks of insect pests if they occur at critical times and places. No plans for victory in the war or for subsequent reconversion in this country and reconstruction abroad can be successful if they do not take into account the possibility of epidemics of insect-borne diseases and large-scale losses in yield or quality of growing crops or stored products resulting from the attacks of destructive insects. Research in the Bureau of Entomology and Plant Quarantine seeks to learn more about injurious insects—how to recognize them, their habits, and measures to control them at reasonable cost—and also how to make better use of beneficial insects.

Some of the information thus acquired is utilized directly in the Bureau's programs to suppress dangerous insects and to prevent their spread. Most of the results of research are made available as rapidly as possible. Many important contributions have been made, some of which are being employed to protect the health and comfort of civil and military populations and some to assist in stabilizing agricultural production by reducing losses and maintaining more consistent yields.

Measures for louse control developed by the Bureau and recommended to the Army and Navy were used to good purpose in stamping out a typhus epidemic in Naples, Italy, last winter, as recorded in accounts carried in periodicals of national circulation. As a result of this experience a high official in the War Department has stated that typhus fever has now become one of the easiest diseases of man to control.

Striking reductions in infestations by the Japanese beetle are following the continued distribution of the milky disease of the grubs. At the request of the War Department the distribution during the past

year has been concentrated largely in essential grass or turf areas in military establishments, particularly on airplane landing fields.

The development of an improved grasshopper bait spreader and advancement in the application of insecticides from the air also furnish gratifying evidence of progress in insect control. Not so satisfactory has been the situation with respect to the pink bollworm on cotton. The spread of this insect to Louisiana, where a noncotton zone is in effect in Cameron Parish, and the discovery of infestations in three additional Gulf coast counties give cause for concern.

In this report will be found numerous references to investigations on the insecticide 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane, the common name of which is DDT. The total output of this material in this country at present is being devoted to the needs of the armed forces, with the exception of a small amount that is being used for experimental purposes. Although results now available indicate that it will be an important agricultural insecticide, it is necessary to learn more about its effectiveness against various injurious insects and the quantities and concentrations needed for their control. Additional information will have to be obtained with respect to its effect on plants and beneficial insects and what, if any, hazard to human beings and animals may be associated with its use.

FRUIT INSECT INVESTIGATIONS

CONTROL OF THE CODLING MOTH WITH DDT INDICATED

The new organic insecticide DDT gave remarkable control of the codling moth in preliminary field tests carried on at Vincennes, Ind., beginning late in July 1943. Three applications of 3 pounds of a 50-50 DDT-pyrophyllite mixture per 100 gallons without supplements completely stopped a heavy worm attack for the remainder of the season. Where the DDT-pyrophyllite mixture was used at only 1.5 pounds per 100 gallons, the fruit averaged only 31 worms per 100 apples as compared with about 100 worms per 100 apples following the lead arsenate program. In some field experiments the DDT permitted large increases in the population of European red mites, apparently by killing or repelling certain ladybird beetles that prey on the mites. Considerable defoliation occurred on trees of the Grimes variety sprayed with DDT, but this may have been caused by the abundant mites. No defoliation occurred on trees of the Winesap variety.

OTHER INSECTICIDES TESTED ON THE CODLING MOTH

At Yakima, Wash., the method of using xanthone for controlling the codling moth in the Northwest was improved to the point where 2 pounds to 100 gallons gave better results than 3 pounds of lead arsenate. For the third season this insecticide greatly reduced the population of the Pacific mite. Field tests with a dinitro-*o*-cresol spray to destroy hibernating codling moth larvae, made on a larger scale than previously, killed 86 to 94 percent of the larvae and reduced the subsequent infestation in fruit 25 to 50 percent.

Although phenothiazine has given a high degree of kill of the codling moth in the Northwest, no way has yet been developed to prevent its adverse effect on the color of red apples, and work with it has been largely discontinued for the present.

At Vincennes, Ind., the repeated evening spraying of apple trees with small quantities of nicotine sulfate solution poisoned many of the moths and reduced the number of injuries by 42 percent.

PARLATORIA CHINENSIS CONTROLLABLE

Laboratory and field tests at St. Louis, Mo., indicated again that effective commercial control of the introduced scale insect *Parlatoria chinensis* (Marl.) can be obtained with oil emulsions. An emulsion containing 3 percent of a paraffin-base oil with a viscosity of 100 Saybolt seconds or higher or 4 percent of a similar naphthene-base oil should be applied during the late-dormant or delayed-dormant period, and an emulsion containing 2 percent of an 80-second or higher paraffin-base oil during the summer at times when most of the scales present are in the immature stages.

A continuation of the survey to determine the distribution of this scale insect has revealed for the first time a number of infestations in St. Louis County. The outermost infestation was about 5 miles from the St. Louis city limits. Several shipments of plants from infested properties to other States were followed up without bringing to light any new infestations.

ADVANCES IN CONTROL OF THE PLUM CURCULIO ON PEACH

Two applications of ground sprays consisting of dichloroethyl ether or dichloroethyl formal at Fort Valley, Ga., proved as effective against the plum curculio as the regular schedule of lead arsenate sprays.

An improved curculio-jarring sheet which holds the curculios in a bag in the center, developed at the Fort Valley laboratory, caught an average of 2.5 beetles per tree as compared with 1.3 beetles per tree caught with the old sheets.

NEW INFORMATION ON ORIENTAL FRUIT MOTH PARASITES

A big increase in the production of *Macrocentrus ancylivorus* Roh., the most important parasite of the oriental fruit moth, has resulted from rearing the parasites on the potato tuber worm. Use of this new host was made possible by the discovery of the tuber worm near Moorestown, N. J., where it had not formerly been believed to be present. This parasite was found to overwinter abundantly in strawberry leaf roller larvae infesting wild blackberries and related plants which occur in large numbers in the vicinity of peach orchards in southern New Jersey. This finding opens up the possibility of effective parasite colonization late in the season, and indicates that cage breeding of parasites on the strawberry leaf roller might be more successful with some of these newly found plant hosts than with the cultivated strawberry previously used.

CULTURAL METHODS CONTROL SHUCKWORMS ON PECAN

Further experiments at the Albany, Ga., laboratory in cultural control of the hickory shuckworm by destruction of the larvae in infested nut drops through the use of a disk tiller substantiated the favorable results obtained during the three previous seasons. For the

Schley and Stuart varieties the percentage of nuts infested was reduced about one-half, and the treatment more than doubled the yield of nuts.

CHERRY FRUITFLIES CONFORM TO LIFE ZONES

The cherry fruitflies, chiefly *Rhagoletis cingulata* (Loew) and to a lesser extent *R. fausta* (O. S.), have been found on the west coast in the Transition and Canadian Life Zones from the Sequoia National Forest north, wherever the preferred wild host, *Prunus emarginata* (Dougl.) Walpers, occurs. South of that point this host has not fruited for several years. In California these life zones occur at elevations mostly above 5,000 feet, where cultivated cherries are not grown. In Oregon cultivated cherries are grown in the Transition Zone, and in parts of that State they are extensively infested. This study was made by the Oregon Experiment Station in cooperation with the Bureau and the California Department of Agriculture.

GASTIGHT TENTS GIVE IMPROVED CONTROL OF CALIFORNIA RED SCALE

In studies of the California red scale carried on at Whittier, Calif., considerable work was done in the field with tent fabrics differing in gas-retention properties. Fabrics treated with certain plastic products were found to retain three to four times as much gas to the end of a 45-minute exposure period as the standard fumigation tents now in use. Correlated with the gas retention is a higher mortality of scales, or the possibility of an equal kill with lower initial dosages. With the blowers and gastight tents it has been possible to duplicate concentrations in successive exposures on different trees, and from night to night. By using scales of a known age and strain, it has also been possible to duplicate very closely the mortality obtained.

MILKY DISEASE CONTROLS JAPANESE BEETLE GRUBS

The milky disease of the Japanese beetle has continued to cause conspicuous reductions in infestation of the grubs wherever it has become well established in the soil. In the Mall section of Washington, D. C., for instance, where populations as high as 50 grubs per square foot of turf were recorded in 1941, and which received an intensive milky disease treatment, practically no grubs or beetles were in evidence during the spring and summer of 1944. The colonization of the organisms causing this disease is being continued.

At the request of the Office of Chief of Engineers, War Department, surveys of Japanese beetle grub infestation in maintained grass or essential turf areas were undertaken at military installations in the First, Second, and Third Service Commands during the dormant season of 1943-44. A program of milky disease treatment was started in March 1944 at installations where conditions called for treatment.

DDT EFFECTIVE AGAINST JAPANESE BEETLES

In field tests against adult Japanese beetles during the summer of 1943, $\frac{1}{4}$ pound of DDT per 100 gallons afforded the same protection to peaches as a single application of the recommended derris-rosin residue emulsion spray, protecting both fruit and foliage for 2 weeks.

A single application of a spray containing 1 pound of DDT per 100 gallons gave complete protection to the fruit and foliage throughout the entire beetle feeding season of more than 6 weeks. The spray left no visible residue on the fruit or foliage and caused no injury when used at a concentration of 1 pound in 100 gallons.

DDT has also been found effective at very low concentrations against the grubs of the Japanese beetle in the soil. In a number of soil types DDT, when freshly applied at rates of 5 to 27 pounds per acre, was as effective as lead arsenate at the rate of 500 pounds per acre. Studies in the greenhouse indicated that relatively large quantities of DDT could be applied to the soil without detrimental effect on certain crops, but that others, such as beans, spinach, and tomatoes, seem to be unfavorably affected with applications of 25 pounds of DDT per acre.

PEAR PSYLLA SUPPRESSION CONTINUES

Further progress has been made toward the suppression of the pear psylla in the Pacific Northwest. The number of infested properties found has continued to decline, 140 being found in 1943 as compared with more than 1,200 in 1941. Only minor extensions of the infested area have been brought to light. In the spring and early summer of 1944 one light infestation was found in lower Yakima County and several in Benton County, Wash. Three infestations were also found in Umatilla County, Oreg., within a few miles of the Washington State line.

The sticky-board trap, mentioned in last year's report, is proving a valuable aid in determining the distribution of the pear psylla. The board is about 6 by 10 inches, and is covered on both sides with a sticky tree-banding material. Yellow boards have captured more psyllas than any other color tested. The trap boards have revealed light infestations not found by the most careful visual scouting. One hundred thousand are being placed this summer at various points in the Northwest and elsewhere. Their use will give a much more complete picture of the infestation than has been possible thus far.

The spray program continues to reduce the psylla infestation. A special study of the effects of the program was made in Spokane County, where intensive spraying has been carried on since 1940. In 1943 spraying was discontinued in that county, except on properties that had been found infested in 1942 or 1943. Thorough scouting in the entire county resulted in the finding of only 70 infested properties, as compared with 889 in 1940 and 466 in 1941. Some spraying was done in British Columbia in 1943 and 1944 to protect the results obtained south of the border. In some areas co-operating growers assisted greatly in the program by applying much of the spray material themselves.

The removal of abandoned pear trees by the Washington State Department of Agriculture and the grubbing and treatment of pear regrowth by both agencies have eliminated many scattered properties from the spray program, and in some areas the time required for a given coverage has been cut by at least one-half. Considerable quantities of ammonium sulfamate are being used in the treatment of sprouting stumps and regrowth.

PROGRESS MADE TOWARD ERADICATION OF HALL SCALE

Marked progress is being made toward the eradication of the Hall scale from the area around Chico, Calif. Inspections have been made at several localities to which shipments from the United States Plant Introduction Garden were sent before fumigation was adopted, but no new infestations have been found. Further surveys of this kind are being made.

Spraying with oil, although not giving perfect kill, has reduced the infestation to a low point, thus minimizing the danger of spread. Test fumigations with hydrocyanic acid gas under tents have given complete kill of all scales present, and final eradication by means of fumigation seems entirely feasible.

FRUITFLY INVESTIGATIONS

In Mexico preliminary studies with DDT in dusts and oil preparations have shown promise in preventing fruit infestation.

In Mexico also sublethal quantities of tartar emetic ingested by the Mexican fruitfly were shown to inhibit egg development.

Infestation tests in Hawaii on tomato varieties developed by the agricultural experiment station there have shown three hybrids that are highly resistant to the melon fly.

At the Canal Zone station studies in addition to those on fruitflies are under way to determine the resistance to termites of different cable-insulating materials.

INVESTIGATIONS OF INSECTS AFFECTING FOREST AND SHADE TREES

ENGELMANN SPRUCE BEETLE OUTBREAK IN COLORADO

An extensive outbreak of the Engelmann spruce beetle has developed in Colorado during the last 2 years. The infestation was first reported on the White River National Forest in 1942, and it is now known to be present on the Grand Mesa, Routt, Uncompahgre, and Gunnison National Forests. An estimated 150 million board feet of Engelmann spruce has been killed on the White River and the Grand Mesa National Forests. The Forest Service is attempting to salvage as much of this dead timber as possible. About half of the timber resources of Colorado and Wyoming, or approximately 20 billion board feet, consists of Engelmann spruce. Much of this timber is mature or over-mature, and conditions are apparently favorable for continued widespread destruction by this beetle. On one small area on the White River National Forest where a recent survey was made, it was found that 35 million board feet, or 77.5 percent of the stand, on 2,227 acres, had been killed since February 1942. Since very little is known about this insect, it is impossible to make recommendations for control at the present time. A study is to be made of its life history as a basis for control work. Infested trees are difficult to detect because the foliage does not change color as does that of pines infested with bark beetles.

PINE BARK BEETLE SITUATION CONTINUES FAVORABLE

Bark beetles that attack the various species of western pines caused comparatively little damage during the past year. There were a few

localized areas where the insects appeared to be on the increase, and it is possible that the low point in the infestation cycle has been passed.

Assistance was given Federal and private agencies in the control of the western pine beetle through application of sanitation-salvage logging, and a close check was maintained of results on earlier projects in California. Other agencies are adopting this method of logging in stands of ponderosa pine where the beetle hazard is high. Beetle-control logging projects have been begun on the Warm Springs Indian Reservation and the Fremont National Forest in Oregon, and on the Yakima Indian Reservation and Snoqualmie National Forest in Washington. Other areas will be included when the supply of equipment and manpower permits lighter cuts over larger areas.

Two studies recently completed explain why certain trees and areas are more susceptible than others to pine beetle attack. One analysis demonstrates a relationship between ground cover and insect attack, and the other shows effects of root injury and soils on tree health. Both point to the importance of root development, soil, and competition. Federal and private agencies interested in these studies have given valuable assistance and are already putting to use some of the results.

SPRUCE BUDWORM OUTBREAKS CAUSE CONCERN

An extensive outbreak of the spruce budworm in the central Rocky Mountain region has killed or weakened tremendous quantities of Douglas fir, alpine fir, white fir, blue spruce, Engelmann spruce, and ponderosa pine. Much of the timber in this area is of value for watershed protection and recreational purposes. Previous attempts to control this insect by spraying with lead arsenate around camp grounds and other special use areas have been only partially successful. A series of spraying experiments conducted in the spring of 1944 in cooperation with the National Park Service and the Forest Service indicate that control can be obtained by the application of DDT at the rate of 1 pound per 100 gallons of water.

A widespread outbreak of the budworm has been in progress in parts of Ontario and Quebec for several years. The extreme destructiveness of this outbreak, together with the present critical shortage of pulpwood, has caused timber owners in the New England and Great Lakes States to become very much concerned about the possibility of similar losses in the United States. Plans have been made for an intensive study giving special attention to development of forest-management practices that will reduce the likelihood of an outbreak or aid in the salvage of infested timber.

IMPROVEMENTS IN AERIAL APPLICATION OF INSECTICIDES

The most important development in work being conducted in cooperation with the Division of Gypsy and Brown-Tail Moths Control has been the spectacular control of the gypsy moth obtained through the aerial application of DDT. A 20-acre tract of infested woodland located in Jefferson, Pa., was treated on May 3, 1944, with a concentrated spray mixture at the rate of 5 pounds of DDT per acre. The spray, released through a specially constructed distributor, settled through the forest as a fine mist, which gave good coverage of exposed surfaces of trees, undergrowth, and the forest floor. Foliage was just

beginning to appear, and no eggs of the gypsy moth had hatched. After the spray had dried, a fine crystalline deposit of DDT remained on all exposed parts of the forest. Observations indicated that the eggs hatched but that the small caterpillars were killed when they started crawling and came in contact with the DDT. No living larvae were found in the treated area. Furthermore, all black flies were eliminated from the area for at least a month after treatment.

The success of this experiment offers promise for extending the period over which infested areas may be treated. The residual effect of DDT may permit the beginning of spraying a month or more before gypsy moth eggs hatch. A study of small infested areas treated with DDT after foliage appeared and caterpillars were in different stages of development indicated that this insecticide also kills the larger larvae of the gypsy moth.

The same aerial equipment was used for applying a concentrated cryolite suspension to infested woodland. A fine, uniform deposit of cryolite, which adhered well after considerable rainfall, was obtained. The final results of this treatment cannot be accurately determined until late summer when egg deposition is over.

WAR FABRICS PROTECTED FROM TERMITE DAMAGE

Owing to the rapid deterioration of untreated fabrics in the tropical theaters of war as the result of attack by termites and micro-organisms, tests were made during 1943, both in the laboratory and in the field, to determine which chemical treatments offered most resistance to damage by these destructive agents. Such tests were conducted in cooperation with the War Department and with several other agricultural agencies. About 900 samples of fabrics, consisting of such materials as balloon cloth, canvas, twill, cotton Osnaburg, and light- and heavy-weight duck, were tested. A number of chemicals or mixtures were found to protect the fabrics from damage by termites.

PLANTATION INSECTS MAY INFLUENCE POSTWAR PLANTING PROGRAM

Studies of insects affecting young trees planted in the reforestation program under way in the Lake States have shown that much can be done to reduce the probability of serious damage by insects by using certain mixtures of tree species in all forest plantations. In many cases insects have caused extensive damage in plantations that were established in blocks of single species. Where mixed plantings were made or the trees were planted among natural stands of hardwoods, there has usually been less injury.

One of the most important plantation insects in the Lake States is the spittle bug *Aphrophora saratogensis* (Fitch), heretofore unknown as a pest of pine. It is widely distributed, and many thousands of acres of plantations and young natural growth of jack pine and red pine show serious damage and in some cases considerable tree mortality from it. The life history and habits of the insect have been studied, and in the spring of 1944 arrangements were completed for a cooperative study with the Bureau of Plant Industry, Soils, and Agricultural Engineering and Wisconsin State officials to determine the possibility of an interrelationship with some disease organism. The white pine weevil, the pine sawflies, the pine chafer, and the pine tortoise scale are also important pests in the extensive pine plantations

throughout the Lake States. The information gained from 3 years' study on permanent sample plots indicates that much of the damage by these insects can be prevented by good silvicultural practices.

CEREAL AND FORAGE INSECT INVESTIGATIONS

DDT SHOWS PROMISE AGAINST VARIOUS CEREAL INSECTS

Preliminary experiments indicate DDT to be a very promising insecticide for use against the European corn borer, the white-fringed beetle attacking a variety of staple crops, the chinch bug as a pest of corn, the velvetbean caterpillar, grasshoppers, the vetch bruchid, and insects attacking stored grains and packaged cereal products.

PROGRESS IN DEVELOPMENT OF INSECT-RESISTANT STAPLE CROPS

Intensive experiments to utilize varietal resistance to infestation by insects attacking a number of staple crops are being continued in cooperation with Department and State experiment station agronomists, with promising results.

Big Club 43, a variety of wheat being increased for release in 1944 to California wheat growers, showed high resistance to the hessian fly in two localities. This variety is also resistant to stem rust, bunt, and root rot. Thirteen promising advanced hybrids were included in eight adaptability test nurseries in Kansas. In Indiana high resistance to the hessian fly, mosaic, bunt, loose smut, leaf rust, and stem rust is being combined in advanced lines with good quality and yield. One of these fly-resistant hybrids outranked the standard varieties Fairfield and Trumbull in yield tests. Out of 201 varieties and hybrid selections tested in the greenhouse at the Beltsville Research Center, 16 showed high resistance to the fly.

In observations at Manhattan, Kans., 20 varieties of wheat and 9 of barley out of about 200 spring varieties of these crops tested were lightly infested by the chinch bug while other varieties were severely stunted.

Corn varieties tested in Illinois showed two types of resistance to the earworm—reduction in damage to infested ears and inability of the larvae to become established. Eleven families and three individual lines of corn were rated as highly resistant. Among hundreds of lines examined in test plots in Mississippi, several showed low infestation by the earworm and the rice weevil. Length and tightness of husk apparently were not the only factors responsible.

Several alfalfa plants showing marked resistance to the pea aphid, a serious pest of alfalfa, were selected from many thousands of seedlings tested at Manhattan, Kans., and passed on to the plant breeder for use in developing aphid-resistant strains of agronomic worth. Experiments in cooperation with the California Agricultural Experiment Station indicated that a synthetic variety having high resistance to aphids and increased vigor of growth might result from systematic crossing of two separate aphid-resistant families.

Progress has been made in methods of segregating the European corn borer and intensifying the resistance of field and sweet corn to this insect, and in utilizing this resistance on a commercial scale.

In the exploratory tests of inbred lines and open-pollinated varieties, 5 out of about 350 sweet-corn entries were promising as borer-resistant breeding material, and no additional resistant field lines were found among approximately 900 field-corn entries tested. It was decided that in determining the ability of a variety to resist borer attack the following factors should be considered: Type and rate of plant growth, pollen accumulations that serve temporarily as food for the larvae on different parts of the plants, and comparative abundance of the sucking bug *Orius insidiosus* Say, that preys on the eggs and larvae of the corn borer.

In testing over 4,000 varieties of sugarcane for resistance to the sugarcane borer, 2 were found promising for use as resistant parental material in breeding work. Forty-six classed as resistant in previous tests maintained this status in the 1943 trials. In the investigation of commercial varieties it was found that susceptible varieties produced 245 pounds less sugar per acre when heavily infested than when lightly infested, but that none of the resistant varieties produced less sugar per acre when heavily infested.

DEVELOPMENTS IN CORN EARWORM CONTROL

Tests of mineral-oil emulsions, with and without pyrethrins, atomized on the ear silks showed that there is a possibility of controlling the earworm by this method at less cost than when the oil-injection method is used. This might make their application to canning corn practicable. In preliminary tests an infusion of a bacterial disease of the earworm sprayed on the silks or injected into them did not interfere with pollination but did result in a fair degree of control. This method of control may have possibilities if a cheap method of culturing the bacterium in quantity can be devised.

WINTER GRAZING CONTROLS PEA APHID ON ALFALFA

Grazing of alfalfa in the Antelope Valley of California until March 1 prevented the development of severe early-spring pea aphid infestations except in some fields that were reinfested by migrants from ungrazed fields. In previous years late-winter or early-spring grazing of alfalfa in western Nevada satisfactorily disposed of spring aphid infestations.

GRASSHOPPER POPULATIONS AT A LOW EBB

Owing to the generally cold, wet springs of 1943 and 1944 and unfavorable conditions for fall egg laying in some areas, grasshopper infestations in the Great Plains and Rocky Mountain States have been considerably reduced and more local in character. Conditions were more favorable in Arizona and California, however, with attendant high populations in some localities.

LATE-SEASON BAITING OF ADULT GRASSHOPPERS A PROMISING LOCAL PREVENTIVE MEASURE

Large-scale poisoning of adult grasshoppers when they are congregated on their favorite egg-laying grounds late in the season was tried during 1943 in several California and Montana localities. The results indicate that this may prove to be an economical measure for prevent-

ing local infestations and may eliminate the need for more extensive and costly control operations in subsequent seasons.

REPLACEMENT OF BROADLEAFED WEEDS BY GRASSES ON ROADSIDES AND FIELD MARGINS GREATLY REDUCES GRASSHOPPER EGG LAYING

Observations during 1943 confirmed those of previous years that the numbers of grasshoppers and their eggs are greatly reduced in roadsides and field margins, important grasshopper breeding places, when broadleaved weeds are replaced by nearly solid stands of grass.

ADDITIONAL MORMON CRICKET OUTBREAK CENTERS LOCATED

In connection with field ecological studies new centers were located where Mormon crickets persist during periods of general scarcity, six of them in Nevada and one in Wyoming. The location of such areas and the control of this pest therein may result in prevention of general outbreaks at comparatively low cost. The studies indicated that hatching of crickets in such areas is delayed by continued cold until so late in the spring that there is little likelihood the crickets will be killed by adverse weather subsequent to hatching, as they often are in localities in which climatic conditions are less favorable.

NEMATODES PARASITIC ON WHITE-FRINGED BEETLE

An intensive investigation of certain nematodes known to be parasitic on the white-fringed beetle, a serious exotic pest of staple crops in the Gulf States, has shown these nematodes to be common both inside and outside the infested areas but apparently not a dominant factor in keeping down the numbers of the beetle.

INSECTS IMPORTANT FACTORS IN ALFALFA SEED PRODUCTION

Although *Lygus* spp. and other sucking bugs that attack alfalfa seed and hay crops in Arizona and Utah were much less abundant in 1943 than in the peak year 1941, their injury to the seed crop in Arizona was estimated to be over \$500,000. Observations in that State indicated that suitable cultural practices provided considerable protection when applied on individual farms as well as throughout a community. As much as 90 percent of the alfalfa blossoms of plants attacked by sucking bugs may fail to set seed. This failure is apparently due largely to the scarcity of the wild and domestic bees necessary to effect pollination. Studies are now in progress in cooperation with the Utah Agricultural Experiment Station on the utilization of bees to increase pollination.

NEW DEVELOPMENTS IN CONTROL OF INSECTS ATTACKING STORED GRAINS AND MILLED CEREALS

Six organic compounds showed considerable promise in preliminary tests as substitutes for the standard grain fumigants, the supplies of which are more or less limited by war conditions. Several materials, including white lead paint, whitewash, and a solution of nicotine sulfate, were highly effective in preventing the cadelle and the lesser grain borer from burrowing and persisting in the woodwork of wooden grain bins and infesting grain newly stored in these bins. Several organic and inorganic dusts, including DDT and magnesium oxide,

when added to wheat in extremely small percentages, were found to protect it from insect attack. One or more of these dusts may be found useful for preventing insect infestation of stored grain and other seeds for planting, if not for food.

Laboratory studies on the relation of temperature and moisture content of grain to the development and control of insect infestation therein showed that bran beetles do not lay eggs at 65° F. or below and that little insect activity occurs until the grain temperature exceeds 70° F. Bran and flour beetles bred in grain of almost any moisture content in which plenty of grain dust or broken kernels was present, but weevils did not breed in grain of less than 9-percent moisture content and bred only to a limited degree in grain of less than 11-percent moisture.

Serious injury to germination of wheat from normal dosages of grain fumigants occurred only when the moisture content was 14 percent or more. Baking tests in cooperation with the Kansas Agricultural Experiment Station indicated that loss of viability of wheat caused by fumigants apparently did not affect the baking quality of flour made therefrom, but that retention of fumigants in nonaerated wheat appeared to affect baking quality adversely.

Observations on stored soybeans indicated that insect infestation was of minor importance during the first year of storage.

OCURRENCE AND CONTROL OF THE EUROPEAN CORN BORER INCREASING IN IMPORTANCE

The general level of corn borer abundance in 1943 was the highest on record, the loss of field corn from this insect amounting to over \$28,000,000 and of sweet corn over \$5,500,000, and the infested area was extended half way across Iowa and Missouri and clear across central Kentucky. Early sweet corn from central Illinois to the Atlantic coast north of the Ohio River was heavily infested, and most of it was a complete loss owing to borer damage.

Commercial-scale trials resulted in gross returns of \$480 to \$600 per acre from spraying and \$54 to \$196 per acre from dusting early-market sweet corn with ground derris, as compared with practically total losses where no treatment was applied. A preliminary test of insecticide application by airplane in 1943 gave promising results, and this method is receiving further trial in 1944. Two out of 247 new insecticidal compounds used in laboratory tests gave favorable results and are being given field tests.

Thirty-two parasite releases, involving 39,418 parasites and 3 species, were made in 10 States during 1943. In cooperation with several State experiment stations this work has been much expanded. A total of 457,000 corn borer larvae were collected in the fall of 1943, from which it is expected that at least 450,000 parasites will be obtained for liberation in 1944. Parasitization of larvae collected from the field in the fall of 1942 ranged from 16 percent in a few Connecticut fields to 69 percent in a few New Jersey localities.

ANNUAL LOSSES CAUSED BY SUGARCANE BORER

Surveys have shown that the sugarcane borer causes an annual loss in cane sugar production amounting to over \$6,000,000. This insect reduced the 1943 yield in Louisiana alone by more than 200,000,000 pounds of sugar.

In commercial-scale dusting of cane for control of first-generation borers, applications of cryolite by airplane and ground equipment were about equally effective. Both gave a high degree of control, which in some instances amounted to as much as 50 percent reduction in numbers of borers present at harvesttime. In general, natural cryolite gave as good results as synthetic cryolite. Dilutions of these materials gave poorer control than the full-strength dusts.

The use of medium and heavily infested cane for seed resulted in estimated reductions in yield of 2.5 and 3.3 tons, respectively, of millable cane per acre, as compared with plantings of uninfested seed cane.

WEST INDIAN SUGARCANE MITE SURVIVES ERADICATION EFFORT

Although the eradication of the West Indian sugarcane mite attempted in 1941 appeared last year to have been successful, the mite was found to be again well established in two locations at Canal Point, Fla.

TRUCK CROP AND GARDEN INSECT INVESTIGATIONS

The control of insects that attack vegetables or transmit diseases to these crops has assumed an increasingly important role in the wartime food-production program. In addition to increased commercial plantings of such crops as beans, peas, potatoes, and tomatoes, the expansion of the Victory Garden campaign has created a further demand for information on insect control. Since some of the insecticides, such as pyrethrum and rotenone, are available only in limited quantities, it has been necessary to husband these supplies and to develop substitute materials or other control methods. A special effort has been made to disseminate information regarding insect control through the timely publication of bulletins and mimeographed material, as well as through the radio and the press and by personal contacts of Department workers with those interested in this information.

Special emergency surveys of insects and control requirements have been conducted, in cooperation with State workers, industry, and other agencies, in an effort to insure the distribution of insecticides to localities or districts where they are most needed.

ENCOURAGING RESULTS OBTAINED WITH NEW INSECTICIDES

In cooperation with commercial and State agencies a large number of new materials and combinations of materials have been tested for their insecticidal value. Among these materials the new synthetic organic chemical DDT was very effective, in preliminary field tests, against the following insects: Potato leafhopper, imported cabbage worm, cabbage looper, diamondback moth, cabbage webworm, pea aphid, Colorado potato beetle, flea beetles on potatoes, *Lygus* plant bugs, and the tomato fruitworm. Encouraging but not outstanding results were achieved with this material against the following insects: Pea weevil, onion thrips, gladiolus thrips, bean leaf beetle, stinkbugs of various species, and the beet leafhopper. Unsatisfactory or indifferent results were obtained against the Mexican bean beetle, the tobacco hornworm, the turnip aphid, and red spiders.

In tests directed against cabbage caterpillars, some insecticidal value justifying further tests was shown for yam bean flour, various nicotine combinations, a soap-water spray, scorodite, 2-chlorofluorene,

sodium fluosilicate, barium fluosilicate, potassium fluosilicate, and a low rotenone-containing product from the plant *Derris malaccensis* (Benth.) Prain. The fluorine compounds had a tendency to cause injury to cabbage, which limits their use as substitutes for the more desirable insecticides containing rotenone and pyrethrum.

In combating the pea aphid in 1943, dusts containing nicotine sulfate or rotenone combined with either nicotine or an organic thiocyanate proved less effective than dusts containing rotenone as the only active agent. Against the tomato fruitworm basic copper arsenate gave results superior to those obtained with calcium arsenate or cryolite, although DDT was the most effective insecticide tested against this important and widespread pest. In sprays for the Mexican bean beetle and the Colorado potato beetle good results were obtained with basic copper arsenate and micronized phenothiazine. Tests were made in Ohio to determine the relative efficiency against the Mexican bean beetle of two types of rotenone-containing dusts—ground derris or cube roots mixed with a diluent and impregnated dusts formed by depositing rotenone on the particles of the diluent. No differences in the results obtained could be detected, but since the dust mixtures are more easily prepared and less expensive than the impregnated materials, they would appear to be preferable for general use.

The new soil insecticide dichloropropane-dichloropropylene (DD) has given promising results against wireworms in southern California and in Washington, and has also proved of value in preliminary tests against larvae of the green June beetle infesting tobacco plant beds.

PROGRESS MADE IN ESTABLISHING RELATION BETWEEN INSECTICIDE DOSAGE AND INSECT CONTROL

As an aid in the conservation of insecticides, studies have been made on the most effective strengths and rates of application on several of the more important insects affecting vegetable crops. In field experiments directed against the pea aphid it was found that with dust mixtures containing from 0.25 to 1.5 percent of rotenone the quantity of rotenone applied per acre rather than the strength of the mixture governed the percentage of control. This relationship, however, did not prevail when the dust mixture was of lower rotenone content. For example, 60 pounds of a dust mixture containing 0.25 percent of rotenone gave approximately the same degree of control as 20 pounds of a dust containing 0.75 percent of rotenone; but 60 pounds of a 0.125 percent rotenone mixture was not so effective as 20 pounds of a mixture containing 0.375 percent of rotenone. The results demonstrated that when the recommended dosage of 0.33 pound of rotenone per acre was halved an appreciable reduction in control occurred. Moreover, a dosage one-fourth of that recommended was sometimes effective under favorable conditions for control, but the 0.33-pound dosage was required under unfavorable conditions.

MECHANICAL METHODS AID IN THE CONTROL OF INSECTS

In in experimental area in Tennessee traps and poison feeders baited with amyl salicylate reduced hornworm infestations by approximately 50 percent. However, the same methods tested in the flue-cured tobacco growing districts of North and South Carolina were less effective.

In Louisiana the use of vine-cutting machines combined with disking and plowing after harvest removed the crop remnants that serve as a winter food supply for the sweetpotato weevil in infested fields. The use of vine cutters prior to harvest facilitated the harvesting of the crop and the subsequent burying of crop remnants.

COMMODITY CREDIT CORPORATION ASSISTED IN PROTECTION OF LEND-LEASE TOBACCO

Throughout the year the Bureau's workers on stored-tobacco insects aided the Commodity Credit Corporation in protecting stocks of leaf tobacco purchased by the Government for lend-lease purposes. Surveys were conducted to find suitable warehouses, warehouses were inspected, a system of obtaining and recording infestation of tobacco with the cigarette beetle and the tobacco moth in each warehouse was developed, and recommendations were made as to control measures.

COTTON INSECT INVESTIGATIONS

Despite serious problems in manufacture and transportation due to the war, sufficient supplies of arsenical insecticides, sulfur, and cryolite were maintained and, although rotenone was not available for cotton and the nicotine supply was limited, essential insecticides were available for protection of the 1943 cotton crop. Through the cooperation of State and Federal agencies, growers, and many others, 25,741 examinations of cotton fields were made to determine current insect conditions and the local need for insecticides. This information will be of permanent value in determining the need for control and the time to apply insecticides.

Emphasis was given to research that aided the war effort by conservation of materials and manpower.

BOLL WEEVIL

The average reduction in cotton yield caused by the boll weevil in 1943 was estimated at 6.1 percent, as compared with 8 percent in 1942. In plots dusted with calcium arsenate at Tallulah, La., the average increase in yield over undusted plots was 278 pounds of seed cotton per acre, or 13.8 percent, as compared with the 24-year average of 309 pounds, or 22.2 percent.

Investigations were continued to determine how increases in cotton yields could best be attained from the use of reduced amounts of critical materials. Tests on high-yielding Louisiana soils confirmed previous findings to the effect that the recommended poundage per acre of calcium arsenate could not be materially reduced without sacrificing part of the potential gains, and that the largest increase in yield per pound of calcium arsenate resulted from delaying the first application until 20 to 25 percent of the squares were punctured. Over a 4-year period 5 applications beginning with square infestations of approximately 25 percent gave as large gains as 7 applications starting with infestations of 8 to 15 percent. Experiments have also been conducted during the last 5 years comparing control of weevil infestations that required 6 applications for complete protection of squares and bolls beginning before weevil migration, when 25 percent of the squares were infested, with only 3 late applications beginning after weevil migration had started. The former gave an average increase of 288

pounds of seed cotton per acre, or 48 pounds per application, and the latter a gain of 210 pounds per acre, or 70 pounds per application. However, on the lighter soils where cotton does not fruit so late in the season, control of the early weevil damage is more important.

Each year tests are conducted with various materials in the hope of finding an insecticide better than calcium arsenate for boll weevil control. Sodium fluosilicate, one of the most promising insecticides tested, prevented the proper development of the fiber and resulted in significant reduction in yield in one variety of cotton, though not in others. Barium fluosilicate, cryolite, DDT, and other materials tested were all inferior to calcium arsenate.

In tests to obtain additional information on mopping entire fields with molasses-calcium arsenate, 55 fields containing 276 acres were mopped at 6 localities in South Carolina, Georgia, Mississippi, Louisiana, and Texas. Half of the mopped area in 19 fields at 4 localities was also dusted with calcium arsenate when needed. The average gain for all 55 mopped fields was 83 pounds of seed cotton per acre; for the 19 most heavily infested fields, 142 pounds from mopping and 290 pounds from mopping and dusting. The gains from mopping were not significant at any locality, while dusting gave significant gains at 3 localities.

CHEMICAL DEFOLIATION FOR CONTROLLING COTTON INSECTS

Tests of chemical defoliation of cotton indicated that this treatment controls insects, improves the grade of fiber, increases the efficiency of mechanical cotton harvesting, and reduces the labor required for hand picking. In experiments in Mississippi, Texas, and Arizona dusting with 10 to 20 pounds per acre of calcium cyanamide, a commercial nitrogenous fertilizer, caused complete defoliation within a few days when moisture was abundant and the plants were succulent, but poor defoliation of water-stressed plants. Defoliation causes the small bolls and squares to shed and the mature bolls to open promptly and uniformly without a reduction in staple strength. This checks boll weevil breeding, prevents staining of lint by aphids or leafworms, permits all the crop to be picked at one time by hand or mechanical harvesters, reduces the trash, and improves the grade of lint.

COTTON APHIDS

The addition of nicotine to calcium arsenate to prevent the build-up of aphids increased the yields of seed cotton in 1943 by 137 to 435 pounds per acre in Mississippi, by 120 to 446 pounds in Louisiana, and by 0 to 132 pounds in Texas. The average gain in yield of seed cotton in 78 experiments at Tallulah, La., during 1939-43 was 128 pounds per acre when calcium arsenate dust was used against boll weevils and 393 pounds when calcium arsenate plus nicotine was used against both boll weevils and aphids. In other words, there was an increase in yield of 265 pounds when nicotine was added. In general, nicotine sulfate, free nicotine, and several fixed nicotines were about equally effective per pound of actual nicotine. Satisfactory aphid control was obtained in commercial dusting with airplanes or ground machinery at any time of day or night when atmospheric conditions were favorable for the dust to settle. None of the synthetic materials tested, including

DDT, thiocyanates, phenothioxin, and dinitro-*o*-cyclohexylphenol, have shown much promise.

The damage per aphid was found to be greater under dry than under moist conditions. In rainy years cotton on fertile Delta soils will tolerate a population of approximately 60 aphids per square inch of leaf surface before defoliation, whereas under the dry conditions of 1943 half this population caused premature leaf shed. In the drier areas of the West and on the soils with low water-holding capacity in the Southeast, cotton was defoliated by much lighter populations than in the Delta.

PINK BOLLWORM

During the last 2 years weather favorable for survival of hibernating bollworm larvae has aided in increasing the pink bollworm population in the lower Rio Grande Valley. Approximately twice as many worms were found in cotton squares and blooms in the spring of 1944 as in 1943. The average survival of pink bollworms in open bolls engaged on August 16, 1943, was 0.75 percent; on September 18, 7.93 percent; and on October 19, 32.05 percent. The average survival in bolls on standing stalks was 26.44 percent, in bolls on the soil surface 11.75 percent, and in bolls buried 4 to 6 inches 2.54 percent. The results of these experiments emphasize the importance of producing cotton early and plowing under the crop residue as soon as possible for control of the pink bollworm. Experiments indicate that the pink bollworm does not overwinter in free cocoons in the soil in this section.

In the Big Bend area high survivals during the winters of 1941-42 and 1942-43 and a prolonged planting period in 1943 following the removal of legal restrictions also aided in an increase of pink bollworms. However, the field clean-up, planting early maturing varieties, and early termination of irrigation have held the infestation below the levels recorded prior to 1938. As a result of late planting and late irrigation, some of the fields produced in 1943 large numbers of long-cycle larvae and the population entering hibernation was twice as large as in 1942.

The use of a special meter for indicating the percentage of moisture without disturbing the soil permitted a more accurate study of the effect of moisture on the mortality and time of emergence of pink bollworms. Apparently two or more irrigations with a drying-out period in between are necessary for complete pupation and emergence of adult bollworms. In the field a few moths emerge after the pre-planting irrigation, but others delay emergence until the first or second irrigation of the cotton, when squares and bolls are present.

Dichloropropane-dichloropropylene (DD) at the approximate rate of 50 gallons per acre killed 81 to 100 percent of larvae in buried cotton bolls when injected into the soil at 18-inch intervals and at the same depth as the larvae, or added to irrigation water, but was ineffective when sprayed on the soil surface after burial of the bolls.

The infestation in secondary host plants was correlated with their time of fruiting and the intensity of the pink bollworm population in cotton. It was definitely established for the first time that the pink bollworm overwinters in the seed pods of *Pseudabutilon lozani* (Rose) R. E. Fries.

BOLLWORM

Despite a high survival and heavy egg deposition early in the season, high temperatures and natural enemies greatly reduced bollworm damage. The most important predator was *Orius insidiosus* Say, though a number of other predators were factors in destroying over 20 percent of the eggs at Waco, Tex. Fewer bollworm eggs are destroyed when aphids are sufficiently numerous to provide an abundance of food for predators. This helps to explain why bollworms often increase following the use of arsenicals, which are known to cause a rapid increase in populations of aphids.

Cryolite diluted with 15 to 30 percent of sulfur gave as good bollworm control as the same poundage of undiluted cryolite, probably because the diluted cryolite has better dusting qualities and plant coverage. Greater dilutions were effective if the poundage of the mixture was increased so that 8 pounds of cryolite per acre was used. Cryolite-corn meal bait (1:9 dry mixed) applied at 40, 60, and 80 pounds per acre gave satisfactory bollworm control. Forty or more pounds of bait per acre, scattered by hand, gave good plant coverage and gains equal to those obtained with 8 pounds of cryolite dust.

Reduced dosages of insecticides have not proved satisfactory for the bollworm; in fact, the recommended dosages are too small for best control. In 2-year tests the usual dosage of 8 pounds of calcium arsenate per acre gave an average gain in yield of 173 pounds of seed cotton per acre, 12 pounds of calcium arsenate gave 187 pounds, and 16 pounds of calcium arsenate 195 pounds. A 1:2 and a 1:1 mixture of basic copper arsenate and sulfur at 16 pounds per acre gave average gains of 195 and 300 pounds of seed cotton, respectively. A spray of 8 pounds of basic copper arsenate per acre was as effective as a 1:1 dust mixture of basic copper arsenate and sulfur or calcium arsenate dust at 16 pounds per acre.

Calcium arsenite was found to be more toxic against the bollworm than calcium arsenate, but caused so much injury to the plants it is not safe to use. A 1:9 mixture of dinitro-*o*-cyclohexylphenol and sulfur was less effective than calcium arsenate, and a 1:1 mixture of phenoxathiin and bentonite gave very little control.

PLANT BUGS AND STINKBUGS

It was necessary to begin control of plant bugs and stinkbugs about 2 weeks earlier and to continue control measures for a longer period in 1943 than normally. Large quantities of arsenical-sulfur dust mixture used in Arizona gave good control when dusting was started early and sufficient applications were used. In plot tests gains of 220 to 371 pounds of seed cotton per acre were obtained with 5 commercial mixtures. A mixture containing 5 percent of calcium arsenite in sulfur caused plant injury and a loss of 22 pounds per acre.

In an airplane-dusting experiment six applications of a 1:2 mixture of calcium arsenate and sulfur at 15 pounds per acre produced a gain in yield of 271 pounds of seed cotton per acre, or 30 percent, as compared with a gain of 158 pounds, or 10 percent, last year.

EFFECTIVENESS OF DDT ON COTTON INSECTS

In preliminary experiments against several cotton insects in Louisiana, Texas, and Arizona, DDT was found to be less effective against

the boll weevil than calcium arsenate, less effective against the cotton aphid than nicotine, and less effective against the cotton leafworm than arsenical insecticides. Encouraging results were obtained in experiments with the bollworm, pink bollworm, thrips, plant bugs, and stinkbugs, all of which have been difficult to control.

BEE CULTURE

HONEYBEES POLLINATE MANY AGRICULTURAL CROPS

The benefits from research in bee culture are not confined alone to improvement in the production of honey and beeswax. Whatever advancements are made in the handling of bees, such as in the control of bee diseases, swarming, and other problems facing beekeepers, at the same time improve the pollination of important agricultural crops. In evaluating research in this field this fact should always be kept in mind, inasmuch as the profitable production of about 50 crops rests upon the beekeeping industry. Since beekeepers are dependent upon honey markets, the role of honey in our economic welfare assumes unusual importance. In planning research in the field of bee culture it is therefore imperative that consideration be given whenever possible to the use of bees in pollination.

HONEYBEES IMPROVE SET OF ALFALFA SEED

A survey of alfalfa fields in Utah in 1943 showed that honeybees outnumbered the wild bees in the ratio of 1,000 to 1. Pollen-gathering honeybees tripped practically all blossoms visited, and in some areas more pollen was gathered from alfalfa than from all other plants, indicating that a substantial amount of pollination is effected by honeybees. Nectar-gathering bees, on the other hand, tripped only about 2 percent of the blossoms visited, but because of their preponderant numbers they are unquestionably an important factor in the production of alfalfa seed. Methods of handling bees that stimulate them to gather maximum quantities of alfalfa pollen should improve seed production. The proximity to alfalfa fields of competing mustard, thistle, sweetclover, corn, and other plants has an important bearing on the distribution of pollinating insects in the alfalfa.

The yields of alfalfa seed in Utah declined from 6½ bushels per acre in 1925 to 1½ bushels in 1942. This decrease in productiveness may be attributed largely to the decimation of native pollinating insects and to an apathetic beekeeping industry caused by years of low honey prices.

INSECTICIDES VS. BEE LOSSES

Samples of bees from 115 dead colonies in Utah analyzed for arsenic showed that 95 contained sufficient arsenic to account for their death. Analyses of pollen stored in the hives in 63 dead colonies showed that 54 contained lethal amounts of arsenic. As little as 3 parts per million of arsenic trioxide in pollen was found to be harmful to the bees. Dusting operations on cotton and tomato crops in Arizona and California were responsible for the death of more than 10,000 colonies last year.

Although arsenic is the chief cause of bee poisoning, tests with DDT and with dinitro-*o*-cresol, both new spray materials the latter of

which is used for thinning fruit, indicate that they may become a menace both to pollination and to beekeeping. Neither of these materials was repellent to bees. A 0.05-percent concentration of DDT fed in syrup to honeybees acted as a stomach poison. Contact with a 10-percent DDT dust proved fatal to bees. Bees in contact with a surface sprayed with a 2-percent solution of DDT died within 6 hours. When brood and adult bees were sprayed with a 0.05-percent solution of DDT, the unsealed brood was killed within a few hours but the sealed brood and adults were unaffected.

All bees fed a 0.125-percent solution of dinitro-*o*-cresol in sugar syrup were dead within 24 hours. A 1.25-percent solution was neither repellent to bees nor effective as a contact poison.

HONEY YIELDS INCREASED BY SUPERIOR STOCK

Uniform testing methods were employed to compare the honey-producing capabilities of 9 lines of stock. In these tests 125 package-bee colonies which produced a total of 14,200 pounds of honey were used. The highest yielding colony, in spite of a poor to mediocre season, produced 250 pounds and the lowest 19 pounds. The average per-colony yield of the best line was 160 pounds, that of the poorest 52 pounds. The high-producing line was characterized by a narrow spread between the yields of the best and poorest colonies.

These tests indicate the need to develop superior lines of stock as a means not only of increasing profits in beekeeping but of improving pollination.

ADVANCES IN ARTIFICIAL INSEMINATION OF QUEEN BEES

Heretofore it has not been possible to use artificially inseminated queen bees in studies of practical beekeeping problems. Excessive losses of queens caused by long delays in the initiation of egg laying, as well as the abnormally short egg-laying period of inseminated queens, has precluded their use in field tests on honey production, resistance to disease, and other problems. By resorting to multiple inseminations, however, queens with the fecundity of naturally mated queens are now possible. The average number of sperms in drones ranged from 5.1 to 9.9 million, according to their age. In naturally mated queens the average sperm count was 5.7 million. Sperm counts from queens after one artificial insemination ranged from 2 to 3 million. An average of 5 million sperms per queen was obtained by using several drones. Multiple inseminations also advance the initiation of egg laying. Multiple-inseminated queens equaled or bettered naturally mated queens in egg-laying performance.

NEW TECHNIQUE FACILITATES WORK ON RESISTANCE TO DISEASE

Gradual increase in resistance to American foulbrood has been obtained through the F_6 generation with naturally mated queens. However, in the seventh and eighth generations, although resistance was maintained, it was not improved. Queens of the F_6 and F_7 generations artificially inseminated showed marked increase in resistance over the naturally mated ones.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

INSECTICIDES DEVELOPED AT ORLANDO ADOPTED BY ARMED FORCES

Three research projects undertaken at Orlando, Fla., on funds allocated by the Office of Scientific Research and Development sought to develop a satisfactory lousicide, an effective insect repellent against mosquitoes and other biting insects, and larvicides for malaria-carrying mosquitoes. By the middle of May 1943 the insecticide known as DDT was recommended for control of lice attacking man, and within a year it had proved its worth among troops and civilians in North Africa and Italy, especially in the control of a typhus epidemic in the Naples area. A mixture of three insect repellents was recommended during the year, and is in use by our military forces and their allies in different foreign lands. A new mosquito larvicide developed at Orlando is being used successfully by our armed forces.

NEW SPRAYS FOR CONTROL OF TICKS AFFECTING MAN

For killing ticks about the premises of camps, playgrounds, parks, kennels, and residences, a spray containing 5 percent of DDT was found to be very effective. An emulsion of this material caused no injury to the vegetation, and when applied at the rate of 1 pound of DDT per acre it gave control of the ticks for about 6 weeks.

For use about kennels and other locations where some temporary burning of foliage is not objectionable, a water spray containing 0.05 percent of nicotine and 1.5 percent of sodium fluoride applied at the rate of 75 gallons per acre killed all stages of *Ixodes ricinus scapularis* (Say) and *Dermacentor variabilis* (Say).

MOTHPROOFED FABRICS WITHSTAND LAUNDERING AND DRY CLEANING

The effect of laundering or dry cleaning on fabrics previously treated with mothproofing agents has been studied. Fabrics treated with such agents as Mitin SS concentrate (a sodium salt of tetrachlorodiphenyl ether phenylurea monosulfonic acid), Eulan CN (pentachlorotriphenylmethane sulfonic acid), and aqueous solutions containing sodium fluosilicate were washed in soap and water, or dry-cleaned from one to ten times, and then subjected to attacks of the black carpet beetle. The results indicated that moth resistance may be given by the manufacturers of suitings, overcoat materials, blankets, and other woolen fabrics. These tests have demonstrated also the practicability of treating woollens in the home with moth-resistant sprays.

NEW TREATMENTS SUCCESSFUL AGAINST SCREWORMS AND FLEECE WORMS

In limited field tests a new smear formula, known as P-55, afforded good protection in wounds of animals from infestations by screwworm flies, but it was slightly less efficient than Smear 62, which is now in use. Since the new smear contains ingredients that are not critically needed for war purposes, it seems promising as a substitute for Smear 62. Wounds of animals infested with screwworms healed as promptly after treatment with P-55 as those treated with Smear 62, but further tests of this kind are needed under ranch conditions.

Early in the spring screwworms moved into northern grazing areas along with shipments of animals, but the prompt use of Smear 62 prevented most of the losses that would ordinarily have occurred among the infested animals. The pest became established in many localities where stockmen were not familiar with it or with the use of this smear, and in such instances the losses were avoided only because of the timely surveys and the advice given by Bureau workers and by the early procurement of Smear 62.

Some outstanding results have been obtained in preventing infestations of fleece worms (*Phormia regina* Meig.) with a mixture of benzene and a wetting agent. Further tests are needed on a larger number of animals on ranches.

With another formula used on laboratory animals it has been possible to reduce the time required for healing wounds infested with fleece worms, and the average number of reinfestations has been reduced from approximately four per animal to less than one. When this treatment is applied to the infested wool of sheep, it penetrates the fleece and kills all fleece worm larvae upon contact.

Screwworm infestations occur in wounds caused by horn flies. Sprays with DDT for the control of horn flies attacking beef cattle under ranch conditions have greatly reduced the fly populations as well as the number of severe injuries caused by bites of large numbers of flies on small areas under the belly, about the rump, and at the base of the horns. A spray containing 1 percent of DDT killed all horn flies that alighted on the treated animals for 1 week. Range cattle sprayed with $\frac{2}{3}$ pint per animal of a 0.2-percent DDT emulsion remained almost entirely free of flies for 7 days.

ROTENONE EXTENDERS RECOMMENDED FOR CATTLE GRUB CONTROL

The practical use of rotenone-bearing powders when mixed with finely ground tripoli, volcanic ash, or pyrophyllite has been demonstrated under ranch conditions in the treatment of cattle for the control of cattle grubs. These diluents have been found to be much more effective than either sulfur or talc because they penetrate the hair better. Because of the good results obtained with them as diluents for ground cube or derris, they have been recommended for use in dusts for cattle grub control and as a means for extending the available rotenone. Sprays containing only finely ground cube or derris root in water also gave a high kill of cattle grubs. When applied at a nozzle pressure of 400 pounds or more, a suspension of cube or derris powder in water gave better results than when these powders were mixed with wettable sulfur or with a wetting agent in water. When the spray was applied at a low pressure, the addition of a small amount of sodium lauryl sulfate somewhat enhanced its effectiveness.

Dusts containing 10 percent of DDT were found to be almost entirely ineffective against cattle grubs.

NEW TREATMENTS FOR TICKS AFFECTING ANIMALS DEVELOPED

Investigations on control of the winter tick were concerned principally with washes that would kill all stages and protect horses against reinfestation. Considerable progress was made toward the development of a wash consisting of DDT and soluble pine oil in water.

With a nondrying adhesive containing an insecticide it was possible to protect the ears of cattle, sheep, and goats from the spinose ear

tick for 90 to 120 days. The spraying of salt troughs and the areas under them with equal parts of kerosene and used motor oil also destroyed many of these ticks. When both these treatments were used, marked reductions of tick populations in pastures were observed.

Tickicides containing 5 percent of DDT in nondrying adhesives were prepared and used in preliminary field tests against the Gulf Coast tick. The period of protection from reinfestation given by these formulas ranged from 3 to 5 weeks, whereas the materials now in use by ranchmen did not give protection for more than 8 days.

IMPROVEMENTS IN CONTROL OF LICE ON LIVESTOCK

In tests made in the interest of conserving rotenone, 2.5 pounds of cube powder (5 percent rotenone) in 1,000 gallons of water used as a dip killed all the motile stages of the short-nosed cattle louse. When 100 pounds of wettable sulfur was added to this dip, it was effective for a second dipping 2 weeks after the first. A dip containing 5 pounds of cube, without sulfur or with only 50 pounds of sulfur, did not kill all the lice when it was held for a second treatment. Other tests showed that wettable sulfur, without rotenone, used at the rate of 150 pounds per 1,000 gallons of water did not give satisfactory control of this pest.

DDT was found to be remarkably effective for controlling this and other less resistant species of cattle lice. As little as 0.06 percent of DDT in a water suspension gave complete mortality of the motile stages of all species of cattle lice.

Emulsions containing 0.1 percent of DDT killed the motile stages of all species of lice on Angora goats, and the material from a single dipping remained in the hair long enough to kill the young lice that hatched from the eggs.

INSECT IDENTIFICATION

More than 700,000 species of insects are already known, and a larger number still remain to be discovered and described. Many with significantly different habits, and consequently requiring different methods of control, are so similar that they readily pass for each other. Authoritative identifications by specialists are, therefore, prerequisite to the use of effective control measures. Moreover, specialized research in insect classification must be continued to provide an increasingly sounder basis for identification.

Identifications were reported for 59,956 insect samples contained in 33,668 lots. Of these 28 percent represented interceptions in imports from abroad and 29 percent collections made in the course of special surveys; 25 percent were from research and control activities of this Bureau and other Federal agencies; 9 percent from agricultural colleges and experiment stations of the various States and insular possessions; 5 percent from individuals, private agencies, and pest-control operators; and 4 percent from foreign governmental agencies and institutions, largely in the Western Hemisphere.

Research in insect classification and anatomy designed to improve the bases for exact identification in certain insect groups resulted in completion of 27 manuscripts, totaling 831 pages, for publication.

Direct assistance given the Army and Navy involved identification of approximately 2,000 samples of mosquitoes, mostly from the war

areas, and nearly as many samples of miscellaneous insects collected on Army transport planes operating abroad. It included also personal instruction to 122 officers in the identification of mosquitoes and other insects involved in the transmission of human diseases. In addition, the Medical Intelligence Branch of the Office of the Surgeon General of the Army has been furnished, upon request, pertinent detailed information on all insects of medical importance known to occur in specified foreign areas; and an annotated bibliography of the literature dealing with the yellow-fever mosquito, covering more than 1,200 published papers, has been prepared for the U. S. Public Health Service.

FOREIGN PARASITE INTRODUCTION

PARASITE IMPORTATIONS FROM SOUTH AMERICA

As an aid in the control of important insect pests of agricultural crops, a total of 16 consignments of parasites and predators were forwarded to the United States from Argentina, Uruguay, and Brazil, and 4 consignments were sent to Puerto Rico from Brazil.

Vegetable weevil parasites imported from Argentina and Uruguay consisted of 8,083 puparia of *Epiplagiops littoralis* Blanch., 4,370 cocoons of *Porizon* sp., and 195 cocoons of *Triaspis* sp. For use against various species of armyworms, 947 puparia of *Pseudoarchytopsis* sp. were forwarded from Uruguay and 271 *Phorocera* sp. and 248 *Calosoma argentinense* Csiki from Argentina. Importations of corn earworm parasites from Uruguay consisted of 169 puparia of *Actioplaga* sp. and 23 cocoons of *Paniscus* sp. A total of 2,195 puparia of *Paratheresia diatraeae* (Brèthes), a parasite of the sugarcane borer, were sent to Puerto Rico.

COOPERATION WITH STATE, TERRITORIAL, AND FOREIGN ORGANIZATIONS

Cooperative work with the Puerto Rico Agricultural Experiment Station included the foregoing shipments of sugarcane borer parasites from Brazil, and two consignments of 2,255 adults of *Hambletonia pseudococcina* Comp. received from that station for release against the pineapple mealybug in Florida. Two consignments totaling 600 adults of *Allotropa utilis* Mues. for test upon the Comstock mealybug and 200 cocoons of *Cryptus sexannulatus* Grav., a parasite of the codling moth, were received through the courtesy of the Canadian Department of Agriculture.

In furtherance of the cooperative work with the California Agricultural Experiment Station, 1,818 *Epiplagiops littoralis* Blanch., 4,370 *Porizon* sp., and 126 *Triaspis* sp. from South America were forwarded for rearing and release in that State. For the biological control of armyworms 481 adults of *Pseudoarchytopsis* sp., 133 *Phorocera* sp., and 169 *Calosoma argentinense* Csiki, also from South America, were forwarded to the Florida Agricultural Experiment Station for field release. Parasitized squash bugs were collected in Connecticut and New Jersey, and 1,175 puparia of *Trichopoda pennipes* (F.) were obtained from them for forwarding to the Washington Agricultural Experiment Station for rearing and release in that State. A total of 2,200 adults of the woolly apple aphid parasite *Aphelinus mali* Hald.,

were reared and forwarded to the Iowa Agricultural Experiment Station for field release.

The cooperative project for the biological control of the citrus blackfly on the west coast of Mexico was completed during the year. Twelve consignments of parasite material from the Panama Canal Zone yielded 8,767 adults of *Eretmocerus serius* Silv., a species known to be very effective in other sections of tropical America, and these were released in 60 infested plantings in the States of Sinaloa, Nayarit, and Colima. The parasite is now well established, and its effectiveness in control should be evident in the near future. Other shipments of parasites to Mexico included 1 consignment of *Lixophaga diatraeae* (Townsend), a parasite of the sugarcane borer, and 3 of *Aphelinus mali* Hald.

CONTROL INVESTIGATIONS

TOXICITY TESTS AID IN FURTHER IMPROVEMENT OF AEROSOLS AND SPRAYS

The great demand by the armed forces for insecticidal aerosols and the critical shortage of pyrethrum made it necessary to intensify the search for substitutes for part or all of pyrethrum used in the aerosol dispensers. One new material has proved to be very promising, and a large number of formulas containing it have been tested. A thorough investigation is being made, however, before a final formula is recommended.

A number of commercial aerosol dispensers have been tested. Most of these are 1-pound containers equipped with valves for releasing whatever quantity of aerosol is needed to kill the insects in the space being treated. They were effective in controlling flies and mosquitoes except when the aerosol solution was discharged at too rapid a rate. With the present aerosol formula a discharge rate of 0.5 to 1.0 gram per second is most satisfactory.

In tests comparing the effectiveness of pyrethrum in an aerosol and in a deodorized kerosene spray, the aerosol was found to be superior. In delayed-action tests the aerosol was found to be much better, since it remains suspended in the air for a much longer time. Approximately 885 tests were made on 65 aerosol formulas to test their effectiveness in controlling the housefly and malaria and yellow-fever mosquitoes.

Approximately 375 tests were made with a large number of spray formulas to control disease-carrying mosquitoes. Materials were tested in deodorized kerosene and in emulsion form. The oil-base sprays were more effective than the water-base sprays per unit of toxicant, although the toxicity of the water-base sprays varied markedly with the formula used.

Pyrethrum still remains the outstanding insecticide for the destruction of adult mosquitoes. Two materials that act as synergists slightly increased the effectiveness of pyrethrum against the yellow-fever mosquito, but to a much less extent than in tests on houseflies.

Of 123 new materials tested as synergists for pyrethrum in fly sprays, 13 increased its toxicity.

Of 171 samples of new materials, some in various concentrations, tested against the housefly, 1 plant material and 4 synthetic organic compounds showed high toxicity. Two of the latter are related to

DDT. In addition, 2 materials that had been developed elsewhere and were submitted for testing were found to be more toxic to houseflies than pyrethrum.

TESTS OF SUBSTITUTE MATERIALS CONTINUED

The search for noncritical insecticide materials for use on food plants was continued. In preliminary tests on 130 samples of new materials, 14 synthetics showed toxicity to 2 or more species of leaf-feeding insects. Of the plant materials tested, preparations containing extracts of yam bean and sabadilla seed exhibited considerable toxicity to leaf-feeding larvae.

In tests of powdered sodium fluoride for relative killing power against the American cockroach, a sample approximately 30 microns in average particle size killed 50 percent, a 10-micron sample 65 percent, and a 5-micron sample 75 percent. One new material has been tested that equals or exceeds sodium fluoride in toxicity to these roaches.

In cooperative work with the Eastern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry on better utilization of nicotine as an insecticide, 244 new samples were tested on plant-feeding insects. Most of these samples (220) were preparations containing nicotine compounds plus a material intended to act as a synergist. Seven of the materials added to the nicotine dust increased the effectiveness of the preparation against 2 species of plant pests.

In cooperative tests five samples of four species of rotenone-bearing roots from Puerto Rico were tested for insecticidal action. A striking difference in the toxicity of extractives other than rotenone was found.

NEW FUMIGATION SCHEDULES DEVELOPED

Wartime shipping regulations and conditions prevent the fumigation of carlots of vegetables to conform to Japanese beetle quarantine regulations, prior to icing for shipment. New dosage schedules for methyl bromide were therefore developed that permit treatment under various conditions of precooling and icing, under which procedure produce can be shipped without delay.

Further research in vacuum fumigation of nursery stock for elimination of white-fringed beetle larvae has shown that the previously approved dosage schedules can be substantially reduced, with consequent material reduction in the danger of injury to certain types of plants. Additional treatment schedules have been developed, and these now cover the temperature range of 40° to 80° F.

SMOKE AEROSOLS SHOW PROMISE AGAINST AGRICULTURAL PESTS

The production of insecticidal aerosols by means of heat rather than by liquefied gas is being studied to determine their usefulness against agricultural pests. Preliminary field tests against gypsy moth larvae showed a high mortality several hundred feet from the generator.

INSECTICIDE INVESTIGATIONS

Chemical investigations relating to insecticides and fungicides were concerned largely with the development and improvement of insecti-

cides to meet war needs. Many synthetic organic compounds have been prepared for testing as insect repellents, lousicides, and mosquito larvicides. Investigational work was reported in 88 published articles, and 30 United States patents covering new insecticides and methods of application were granted.

DDT INTENSIVELY INVESTIGATED

As indicated elsewhere in this report, DDT has proved amazingly effective against a number of agricultural insects and is being used by the armed forces in ever-increasing amounts for the control of body lice and as a partial replacement for pyrethrum in aerosols. The Division of Insecticide Investigations has been intimately associated with the development of DDT for these purposes and has taken an active part in furthering its manufacture in this country. Specifications have been developed for a satisfactory grade of DDT, and manufacturers were assisted in meeting these standards. An extensive research program on DDT for the armed forces is being carried on under a transfer of funds from the Office of Scientific Research and Development. Suitable preparations of DDT also are being developed for use against agricultural pests.

AEROSOL DEVELOPMENT CONTINUED

With the increasing demand by the Army and Navy for aerosol bombs for the control of malaria mosquitoes and houseflies, it has been necessary to develop substitutes for the limited supplies of pyrethrum and Freon-12 (dichlorodifluoromethane). A formula containing a considerably decreased amount of pyrethrins and another insecticide was worked out. A mixture of propane and butane was shown to be satisfactory and safe as a partial substitute for Freon-12. The aerosol method has also been found effective for applying other insecticides in greenhouse and field against certain agricultural pests, as well as for applying hormones to plants.

SUBSTITUTES AND EXTENDERS FOR WAR-SCARCE INSECTICIDES SOUGHT

Inasmuch as imports of rotenone-bearing roots and pyrethrum have been greatly curtailed and other insecticide supplies restricted, the development of substitutes or means of extending the supply has become of great importance. A number of synthetic organic compounds have been found effective as synergists for pyrethrum. It was shown that anethole can be substituted for geraniol and pimento-leaf oil for eugenol in Japanese beetle bait without adverse effect. Extracts of the plant *Erigeron affinis* DC. proved very toxic to houseflies and to some other insects. A mixture of soybean phosphatides and raw mineral oil was found to be a satisfactory substitute for soybean oil as a spreader and adhesive for lead arsenate and nicotine bentonite sprays.

PURE PYRETHRINS PREPARED

A method was devised for the preparation of practically pure pyrethrins from commercial pyrethrum extracts with very little loss of pyrethrins. This pure material is completely soluble in Freon-12 and

is well suited for use in aerosols. The pure pyrethrins also proved to be of use in the preparation of analytical standards for pyrethrum.

ANALYTICAL AND SERVICE WORK

Approximately 900 samples of miscellaneous insecticides were analyzed, most of them for other divisions of this Bureau and for the Foreign Economic Administration. Analytical methods were developed for DDT, for certain dinitro compounds, and for the determination of free lime in calcium arsenate and of sesamin in sesame oil.

MEXICAN FRUITFLY CONTROL

The area quarantined on account of the Mexican fruitfly now covers all the citrus-producing portion of Texas, but the infestation has not extended beyond the section adjacent to the Republic of Mexico. The citrus industry in Texas has had a phenomenal growth, and the inspection, sterilization, and certification of the approximately 50,000 cars of citrus fruit produced annually has become a problem of increasing importance. Although the possibility of permanently eradicating the Mexican fruitfly appears to be remote, the danger of its spread through the shipment of infested fruit has been drastically reduced by the requirement that all fruit from infested zones be sterilized before shipment. The amount of fruit treated during the season of 1943-44 increased almost 200 percent over the previous year. A total of 4,263 equivalent carlots of fruit were sterilized without injury to the fruit and at very little additional cost to the packer. Because of the general adoption of the fruit-sterilization process, which was developed by the Department in 1929, a lengthened harvesting season was made possible. The harvesting season for grapefruit produced in the regulated area was extended from April 30 to June 15, and that for Texas oranges was extended to include the entire year. The infestation in the regulated area developed somewhat later than in some previous seasons.

Tables 1 and 2 give data on the number of infestations and the amount of fruit sterilized in Texas since control of this insect was undertaken.

TABLE 1.—*Infestations of Mexican fruitfly in Texas, fiscal years 1935-1944*

Fiscal year	Flies trapped	Larval infestations	Date harvesting season closed †
	Number	Number	
1935.....	371	30	April 2.
1936.....	256	5	March 31.
1937.....	4,714	1,062	Do.
1938.....	712	218	April 30.
1939.....	13,087	2,141	May 15 (G). June 15 (O).
1940.....	6,157	1,582	April 30.
1941.....	979	532	May 31.
1942.....	244	259	Do.
1943.....	224	201	Do.
1944.....	1,796	576	June 15 (G). (No closing (O)).

† (G) Grapefruit, (O) oranges.

‡ Includes 4 infestations in 1939.

TABLE 2.—Tons of citrus fruit sterilized in Texas, fiscal years 1939-1944

Fiscal year	High-temperature method		Low-temperature method	
	Grapefruit	Oranges	Grapefruit	Oranges
1939.....	44, 150	2, 25	0	2. 1
1940.....	8, 927	. 75	208. 6	168. 8
1941.....	9, 937	0	53. 6	0
1942.....	3, 619	0	0	0
1943.....	23, 394	0	0	0
1944.....	62, 372	20	0	0

JAPANESE BEETLE QUARANTINE AND CONTROL

TRAP SCOUTING IN NONREGULATED TERRITORY

Trapping to determine the spread of the Japanese beetle in 1943 largely paralleled that of the previous year. With the necessity for conservation of traps and labor, most of the activities were confined to localities in which combined trapping and soil-treating work had been carried on in previous years, or in which incipient or apparently negligible infestations had been discovered. This left a few traps for setting in localities not previously trapped. From the 55,354 inexpensive scout traps used in 1942 it was possible to salvage 41,993 for the current year's activities. As in 1942, trapping was performed in 17 States, but the number of localities was reduced from 242 to 161. Beetles were captured in 107 communities, in 12 of them for the first time.

An important development of the year was the discovery of a heavy infestation at Blowing Rock, N. C., in the mountains in the northwestern section of the State. Over 17,000 beetles were trapped at this point, which is remote from any other known infestation. At Hendersonville, N. C., where 1,718 beetles were trapped in 1942, only 785 beetles were collected this season. Beetles were collected in 17 other North Carolina localities where they had been trapped in previous years.

Cooperative Federal-State trapping in Maryland showed relatively heavy infestations in Hancock, Hughesville, and Siebert, in addition to four other negligible infestations in the nonregulated area.

In New York State trap captures in Canandaigua, Dunkirk, Lyons, Medina, Newark, North Tonawanda, and Plattsburg were of a few beetles each. Infestations persisted in Avon, Jamestown, Silver Creek, and Waterloo. In Newark and Niagara Falls, where treatments had been applied in previous years, the captures were reduced to 1 and 71 beetles, respectively, compared with 65 and 216 beetles in 1942. Beetles collected at Geneva and Ogdensburg indicate increased infestation there. Trapping in Westfield disclosed 27 beetles.

In Ohio negligible first-record collections were made at Fostoria, Fowlers Mill, Lima, and Willard. In Bellevue, East Conneaut, Gallipolis, Rockbridge, and South Zanesville fewer beetles were turned up than in 1942. Increases were noted in Ashtabula and Marietta. The remaining infestations persisted at about the 1942 level.

In Pennsylvania trapping was limited to a group of traps in Greenville, where 14 beetles were caught.

In Virginia 25 beetles were trapped at Lynchburg, the largest number taken at any point in the nonregulated area. Approximately the same number were collected in Bristol, Harrisonburg, Lexington (first-record), and Woodstock, with lesser numbers at Luray, Staunton, Waynesboro, and Williamsburg.

In West Virginia half of the 6 localities where beetles were trapped this year were first records. The only captures of consequence were 21 beetles at Princeton and 19 at Williamstown.

All trapping in three cities each in Florida and Wisconsin was with negative results.

Trapping in Georgia showed that infestations had persisted in Atlanta, Augusta, East Point, and Toccoa.

Collections in Illinois indicate a reduction in the infestation at Highland Park, but increases at both Chicago and East St. Louis. Solitary beetles were trapped in Cicero and Oak Park.

In Indiana the capture of only 17 beetles at Richmond where 556 had been trapped in 1942 indicates a substantial reduction in the infestation there. Infestations in 4 other localities remained at about the same level.

In Michigan beetles were caught in five localities in which infestations had been found in previous years.

In Missouri 14 beetles were collected at St. Louis, as compared with 6 caught there last year.

In South Carolina beetles were again trapped in Florence and Greenville.

Trapping in Tennessee resulted in the capture of five beetles each in Kingsport and in the Tennessee portion of the city of Bristol.

SUPPRESSIVE MEASURES

The combined trapping and soil-treatment programs in infested localities outside the regulated area and in nonquarantined States, together with State quarantine action as to certain outlying areas, assured protection from spread comparable to that that would have been obtained if the Federal quarantine had been extended.

Applications of lead arsenate were made with State cooperation at 53 isolated infestations in 10 States. Fall treatments comprised 796 acres, with an additional 95 acres covered in the spring. The total acreage was less than had been necessary to suppress the isolated infestations treated during the previous year's cooperative State-Federal soil-treating program. Spores of the milky disease of the Japanese beetle grub were distributed at Asheville, Blowing Rock, and Henderson, N. C., in cooperation with the Division of Fruit Insect Investigations.

Largest of the soil-treating programs were those in Ohio, Illinois, Michigan, and North Carolina, where 233, 177, 149, and 143 acres, respectively, were treated.

Additional acreages treated were New York 73, Indiana 68, Virginia 22, Missouri 13, Tennessee 8, and Georgia 6.

MODIFICATION OF QUARANTINE REGULATIONS

A revision of the Japanese beetle quarantine and regulations was issued effective March 30, 1944. Provisions were made for more flexi-

bility in the handling of seasonal and local problems through the issuance of administrative instructions by the Chief of the Bureau. Only small additions were made to the regulated area, and the heavily infested area remains the same except for the inclusion of the township of West Leesport, Berks County, Pa.

HIGHWAY INSPECTION SERVICE

The road-patrol work for 1943 continued on the same basis as in the previous year, the inspection being confined to examination of motor trucks. By July 6 eight road stations were set up. One of these operated until July 24, and the remainder until the first week in September. Thirty inspectors were assigned to this work. During the season 94,748 trucks were inspected. Of these, 703 were found to be transporting uncertified produce, but 504 lots of produce were certified at inspection centers located near the highway stations. Inspectors at the road stations examined and certified 143 shipments and issued permits for the movement of 55 truckloads to isolated regulated areas. Only one violation of the regulations was recorded during the season. Inspectors intercepted 596 southbound empty trucks, from which 3,823 live Japanese beetles were removed. An additional 46 beetles were taken from the small lots of farm products examined at the stations.

CERTIFICATION AND TREATMENT OF NURSERY STOCK

Nurseries entitled to a noninfested status under modified regulations numbered 669 at the end of the fiscal year. The classification system previously used was discontinued owing to the revision of the regulations. Authorization of new methods of chemical treatments that may be utilized for plants with soil about the roots has removed the necessity for screening greenhouses or treating potting soil or field plots.

New administrative instructions to inspectors on treatments used as a basis of certification under the Japanese beetle quarantine, issued on September 10, 1943, provide the freest possible use of the various treatments and utilization of new facts as they are developed.

Use of the ethylene dichloride dip increased in popularity from month to month. A total of 708,515 plants were treated in this manner during the year. Many small nurseries adopted this treatment as a means of qualifying their plants for certification. These establishments had previously refused orders going outside the regulated area because of the labor and expense entailed in existing methods of certification. The dip treatment is cheap and easy, and its use permits acceptance of all outside orders, no matter how small. The temperature requirement for the dip has been brought down to 35° F. By this method a carload of 152 *Taxus* plants with 21- to 24-inch soil balls was dip-treated by 5 men in less than 4 hours. The soil balls absorbed 370 gallons of the emulsion. By placing his tank of emulsion in a box car another nurseryman was able to dip his stock as it was being loaded.

For the information of nurserymen and greenhouse men a list of plants treated commercially with ethylene dichloride during October, November, and December was distributed on December 30, 1943.

In cooperation with the Division of Fruit Insect Investigations, tests were made of the ethylene dichloride dip treatment of nursery stock with soil balls up to 30 inches in diameter.

Chloropicrin was approved as a fumigant for bulk soil in the absence of plants. Methyl bromide fumigation of nursery stock after loading in tight box cars was authorized and was utilized by nurserymen during the year.

During the adult beetle flight in the summer of 1943 from 2 to 4 scoutings were made of 861 nurseries and greenhouses in which infestations had not previously been determined. Infestations were found in approximately 100 establishments.

CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

Inspection and certification of fruits and vegetables during the 1943 period of flight of adult Japanese beetles was concentrated at 27 inspection centers scattered throughout the heavily infested area. During the fiscal year inspectors removed 1,087 beetles from 2,339,196 packages of commodities certified for distant movement. Certification of this produce involved the methyl bromide fumigation of 5,692 loaded refrigerator cars and 61 loaded trucks, and the hydrocyanic acid fumigation of 252 empty refrigerator cars. Ninety-five beetles were taken also from 7,887 packages of cut flowers inspected during the summer.

Experimental work was completed on which to base methyl bromide fumigation of refrigerator cars at temperatures as low as 40° F., thereby permitting their fumigation while iced. Previously cars to be fumigated had to be uniced. These low temperatures were authorized for use during the summer of 1944.

ARTICLES CERTIFIED AND VIOLATIONS INVESTIGATED

Nursery stock moved under certification in lesser quantity than last year. From infested establishments 26,637,568 plants and 648 tons of soil and manure were certified. In addition, 15,902,721 plants were shipped under certification from noninfested premises. Moreover, 29,811,009 plants and 1,669 tons of soil and manure were certified for movement between dealers within the regulated zone.

To cover quarantined products moving to nonregulated territory, 199,053 certificates of all types were issued.

Investigations were made of 481 apparent violations of the quarantine regulations.

PHONY PEACH AND PEACH MOSAIC DISEASE CONTROL CONTINUED IN 16 STATES

Federal-State surveys and inspections for the phony peach and peach mosaic diseases were conducted in the summer of 1943 in 16 infested States from South Carolina to California. These inspections were made in commercial orchards and other peach plantings. Growers gave more assistance than for many years despite the manpower shortage. The lifting of the standard State phony-peach quarantines from 18 additional counties—1 in Illinois; 3 each in Arkansas, South Carolina, and Tennessee; and 8 in Texas—having a 3-year disease-free status, reflects continued progress in controlling this disease. No additional counties were found infected with the phony disease. The standard peach-mosaic quarantine was modified to remove Salt

Lake County, Utah, from the regulated area. Mosaic was found in Alfalfa and Woods Counties in Oklahoma. In the spring of 1944 the annual inspection was made in infected areas of all nurseries and their 1-mile environs. The number of nurseries ineligible for certification has decreased annually, and there has been no record of spread of these diseases through nursery-stock shipments in the last 6 years.

The apparent eradication, since 1936, of the phony disease from 6 entire States and a 98-percent reduction in 8 others made it possible in 1943 to direct greater attention to the heavily infected States of Alabama and Georgia, where 48,790 phony trees (68 percent less than in 1936) were found and destroyed.

With the cooperation of Mexican pest-control officials, inspection was made in the Juarez Valley, Chihuahua, and 947 mosaic trees were found on 170 of the 192 properties inspected.

SURVEY FOR ORIENTAL FRUIT MOTH IN NINE WESTERN STATES

The survey in the spring and summer of 1943 for the oriental fruit moth resulted in the discovery of infestations in parts of 62 counties extending from northeastern Texas through parts of Oklahoma, eastern and east-central Kansas, southeastern Nebraska, and southern Iowa. Following the twig inspections, trapping operations for adult moths resulted in locating an infestation in an additional county in west-central Kansas in September. In the spring of 1944 a more intensive inspection and trapping program was instituted, and was under way, at the close of the year, in the more important fruit areas of Arizona, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, Washington, and the El Paso Valley of Texas. The moth has not previously been found in these areas. The States have rendered assistance in both years.

NO TRACE OF CITRUS CANCKER FOUND

Federal-State inspection for citrus canker was conducted from October 1943 to March 1944 in 35 Texas counties, including vicinities of 44 nurseries, without finding the disease. Formerly infected areas in Brazoria, Galveston, and Harris Counties and the town of Hamshire in Jefferson County were intensively inspected for any vestige of this highly infectious bacterial disease. Particular attention was given to old hedges of trifoliolate-orange at Navasota, where citrus canker was last found in this country in 1943. As no Federal funds were made available for the work in 1945, Bureau participation in this activity was discontinued June 30, 1944.

GYPSY AND BROWN-TAIL MOTHS CONTROL

Gypsy moths are known to be present only in a relatively small part of the Northeastern States. The object of control is to protect our forests by eradicating this destructive insect from the isolated area of infestation in northeastern Pennsylvania and by preventing its spread from the infested area in eastern New York and in New England. The program is sufficiently flexible to allow prompt modification whenever developments of research or control procedure in-

dicating need for change, or to provide for expansion at the termination of the war.

NEW AND VERY EFFECTIVE METHOD OF CONTROL INDICATED

During the year DDT was tested on an experimental control basis against gypsy moths. A 20-acre woodland tract in Pennsylvania and a 5-acre wood lot in New York, in which rather heavy infestation existed, were treated with DDT in concentrated spray form at the rate of 5 pounds per acre. The spray was applied by a specially constructed spinner-disk apparatus attached to a biplane. Application was made in the Pennsylvania tract early in May before leaves had developed and prior to hatch of gypsy moths. In New York treatment was applied after leaves had fully developed and when gypsy moths were in the second larval stage. From a relatively few hours after the treatment to the close of the fiscal year no living gypsy moths were found in either tract.

Other small-scale demonstrations with DDT as an emulsion, in aerosol form, and in a dilute spray mixture were conducted. All methods proved to be spectacularly effective against gypsy moths in all stages of larval development. As a final check all treated areas will be carefully observed through the egg-laying season.

It is believed that, when available for the purpose, application of DDT by aircraft will afford a cheaper and much more effective method of control and eradication of gypsy moths than any method previously used.

These experiments with DDT in spray form were carried out cooperatively with the Division of Forest Insect Investigations, and those with the material in aerosol form with the Division of Control Investigations.

PROGRESS IN PENNSYLVANIA

The effectiveness of gypsy moth control is evidenced by the fact that at the close of the year the size of the infested area in Pennsylvania had been reduced to 556 square miles. This is in comparison with an area of 1,040 square miles in 1938. As a result the State quarantine was revised to remove from regulation more than 400 square miles where infestation had previously existed.

SPECIAL EMPHASIS PLACED ON SURVEYS

During the year surveys were conducted on more than 4 million acres within and beyond the limits of spread of the gypsy moth, by using a sex attractant. While no additional infestations were found beyond the area of general distribution in Pennsylvania, the gypsy moth was detected in New York State in several townships north and northeast of Albany and Schenectady Counties, where infestation had been discovered by the same type of survey during the previous year. This spread increases the extent of areas needing treatment, but since the wood lots in these areas are small compared with the acreage in pastures and under cultivation, the application of extensive control and eradication methods when manpower and materials are available should result in elimination of this westward extension of infestation.

NEW DEVICE FOR DISTRIBUTING CONCENTRATED SPRAYS FROM AIRPLANES

In previous seasons insecticides to control gypsy moths from aircraft have been applied only in dust form. Satisfactory adherence of the dust to foliage could not be secured. This season lead arsenate and cryolite in concentrated spray form were distributed from a specially devised spinner-disk apparatus attached to a biplane. The mortality of gypsy moths approximated 100 percent in all areas treated with lead arsenate, and reasonably satisfactory control was obtained in the areas treated with cryolite. The aerial method of application of insecticides for gypsy moth control is now considered to have passed the experimental stage; its effectiveness and economy of operation have been demonstrated.

COOPERATION WITH OTHER AGENCIES

As a result of the cooperation of State agencies, Bureau research units, and the public, surveys were conducted on a larger acreage than was covered in any previous year; the adhesiveness, and consequently the effectiveness, of the insecticides was increased; and other project activities were performed with a considerably reduced personnel.

Cooperative control on an experimental basis was conducted with the Dominion of Canada against the spruce budworm and with New York State against a destructive species of sawfly, to determine the effectiveness of distributing new insecticide formulas with the spinner-disk type of apparatus attached to aircraft. Preliminary observations indicate that very effective control was obtained.

INCREASE IN INTENSITY OF INFESTATION

A decided increase in intensity of gypsy moth infestation has been noted in a small area in Pennsylvania and in the north-central portion of Massachusetts. From observations made at the close of the year, it is estimated that more than 200,000 acres of forest land were severely damaged by heavy to complete defoliation, compared with 35,000 acres during the previous year. During the last 3 years gypsy moth populations, except in the Cape Cod area of Massachusetts, have been at the lowest ebb since 1924.

BROWN-TAIL MOTH CONTROLLED BY STATES

Brown-tail moths are present only in the four northern New England States, and all work on control during the year was conducted by the affected States. Very little defoliation or heavy feeding was noted, except in a few areas along the coast near the Maine-New Hampshire State line.

CERTIFICATION OF PRODUCTS UNDER THE GYPSY AND BROWN-TAIL MOTHS QUARANTINE

Gypsy moth infestation resulted in little defoliation in the summer of 1943, according to reports of district inspectors stationed throughout New England. This was not the situation in June 1944, however. Enormous damage to woodlands by gypsy moth larvae was reported in sections of Massachusetts, Maine, and New Hampshire, particularly in the Cape Cod and Northampton-Belchertown areas of Massachu-

setts. Caterpillars bunched in a layer 6 inches deep were observed in June at Florence, Mass.

Owing to the lighter infestation during most of the year, there was a further reduction in the number of infestations removed from inspected products. In the inspection of 90,056 shipments, 349 egg clusters, 230 larvae, and 18 pupae of the gypsy moth were removed.

Improvisations and substitutions in the lumbering industry required more than usual vigilance on the part of inspectors supervising shipments of wood products. Many items that under normal conditions are considered undersized or waste were utilized in the effort to meet the extraordinary demand for lumber and other wood products for war uses. In some cases lumber has been inspected on the day that the trees from which it was cut were felled. Some of this unseasoned material is shipped "round edge," so that inspection of each board is required. Many egg clusters have been discovered during inspection of this green material. The last of the pond storage sites for 1938 hurricane lumber was emptied during the year, and the logs were processed. White pine of small diameter and poor quality was also felled and shipped under inspection for use in blocking and crating such war materials as jeeps, coastal targets, light and heavy trucks, guns of all sizes, and tanks.

The use of edgings, formerly a waste product of lumber mills, as crating material added another item to the inspection list. Used railroad ties by the thousands were ripped up from abandoned rail lines in infested sections and shipped to distant points. Inspection of one lot of 2,708 ties destined to nonregulated territory resulted in the removal of 84 egg clusters.

An Army officer moving from Falmouth, Mass., to Chevy Chase, Md., presented a child's collapsible play pen for inspection. Fifty-six gypsy moth egg clusters were removed from the pen before it was certified.

Movement of pulpwood to paper mills in northeastern New York was facilitated by scouting of lots from which most of the wood is cut. Certification is granted for all wood from uninfested lots. A limited permit agreement was signed by one of the largest paper mills in New York, under which permits are issued for the rail movement of uninspected wood to that mill for immediate grinding into pulp.

A survey of all junk yards, a total of 101, within the infested area was made from February to April. Gypsy moth infestation was found on or near the premises of 13 of these. In 4 yards egg clusters were found on the stored junk. Arrangements were made for the inspection of any of this material that was intended for shipment outside the infested zone.

On two occasions inspectors were stationed on certain highways leading from the infested area. While heavy movements of Christmas trees were in progress in December, 8 inspectors formed a roving patrol on the principal exit highways. They intercepted 23 truckloads of uncertified Christmas trees and in most cases induced the drivers to return to the regulated area for disposal or inspection of their load. One consignment of trees was destroyed at the point of interception. For 10 days during June one of the regular inspectors was assigned to road-patrol work in western Vermont. Three uncertified truckloads, one each of lumber, pulpwood, and granite, were intercepted,

and not permitted to proceed until they had complied with certification requirements.

Inability to hire temporary inspectors greatly curtailed the force engaged in Christmas-tree inspection. Whereas normally 30 inspectors are used, this year only 3 temporary men were employed. This situation was alleviated by the shift from piece-by-piece, visual inspection to fumigation of the trees after loading in box cars. Three times as many Christmas trees were moved under certification from the regulated area during November and December as were shipped the preceding season. In all, 419,133 Christmas trees were certified. Of these, 262,818 trees were shipped in 136 box cars after fumigation with methyl bromide. Last season only 34 carloads were fumigated. Further to facilitate Christmas-tree fumigation, tests were made in February of methyl bromide applied at low temperatures.

Among the products shipped in large quantities that were inspected and certified during the year were the following:

Lumber.....	board feet..	190,358,725
Logs, piles, poles, ship knees, and ties.....	pieces..	818,479
Shavings.....	bales..	98,237
Pulpwood.....	cords..	51,428
Cable reels.....	number..	46,087
Miscellaneous forest products.....	pieces..	118,454
Shrubs.....	number..	2,778,203
Young trees.....	do.....	208,084
Specimen evergreens.....	do.....	643,001
Young evergreens.....	do.....	2,224,424
Seedlings and small plants.....	do.....	502,092
Boughs, balsam twigs, and mixed greens.....	boxes or bales..	26,680
Christmas trees.....	number..	419,133
Granite.....	pieces..	2,718
Paving blocks.....	number..	25,500

DUTCH ELM DISEASE ERADICATION

In February all federally-financed tree removal in connection with the Dutch elm disease control program was discontinued to conform with a proviso in the current Agricultural Appropriation Act leaving to States and property owners the responsibility for removing trees in which the causal agent of the disease has been found. In this revised program the emphasis has been shifted from eradication of known sources of the disease to the maintenance of a constant watch on its spread so that quarantine measures may be enforced. Large-scale field experiments were undertaken to determine what action, if any, may be taken by individuals, municipalities, or other political units to protect valuable elms from this disease when it occurs generally in the area.

SCOUTING FOR DISEASED OR BEETLE-INFESTED ELMS

Scouting during the summer of 1943 included a band of territory approximately 15 miles wide along the perimeter of the major disease area, the outlying disease centers of Indianapolis, Ind., Cumberland, Md., and Athens, Ohio, as well as exploratory scouting in the Mississippi and Ohio River valleys, and near Boston, Mass., and Baltimore, Md. A small amount of work was also done at Norfolk and Portsmouth, Va., and Brunswick, Md., where the disease occurred in pre-

vious years. Summer scouting was terminated early in October, and the winter scouting program, which was to continue through the remainder of the fiscal year, was begun in December.

Supplementing the scouting on foot and in automobiles during the summer of 1943, extensive trapping of elm bark beetles was undertaken by piling elm logs or other attractive elm material at selected points in the work area for the purpose of supplying beetle specimens for laboratory culturing. About one-third of the trap logs became infested with bark beetles. A few of the samples of wood and bark cut from the infested material disclosed the presence of the disease in the locality.

First-record infections were reported from 120 towns, townships, and boroughs—15 in Connecticut, 3 in New Jersey, 32 in New York, 8 in Maryland, 3 in Massachusetts, 31 in Pennsylvania, and 28 in Ohio.

Spread of the disease, as evidenced by both summer and winter scouting, was rather extensive in New York, with more moderate increases of territory in Pennsylvania and Connecticut. Only a few scattered new infections were reported from New Jersey and Massachusetts. Westward progress of the disease in all the main infested areas appears to have been greatly retarded this year. At Indianapolis no additional territory was found invaded. There was a somewhat uniform and large expansion of territory in the vicinity of Athens, Ohio.

First-record infections discovered in New York extended the isolated area at Binghamton roughly one tier of towns northward and two tiers eastward. The principal additions to the main New York area were eastward in Columbia and Rensselaer Counties.

Extensions of the disease in Pennsylvania were largely southward in Delaware and Chester Counties plus infections discovered in intervening towns in Montgomery County that had previously been surrounded by disease areas. This filling in of sections already surrounded by disease areas also caused increases in infection in the Wilkes-Barre isolated zone.

Eastward extensions of the disease in Connecticut were confined largely to confirmations of one or a few trees each in towns near known disease territory, several instances of infection being found in intervening territory.

The three first records discovered in New Jersey connect what had previously been an isolated infection with the main disease area in Burlington County.

The first-record confirmations in Massachusetts were in Berkshire County in the town of Mount Washington, already surrounded by towns in which the disease had been found; in West Stockbridge, adjacent to the known disease area; and in Pittsfield, one town removed from the nearest known disease case. All of the 13 diseased trees found in the State during the year were eradicated with State cooperation.

In Maryland early-winter scouting in the vicinity of the former Brunswick disease area disclosed 8 diseased trees, 6 in the Monocacy River valley north of Frederick, and 2 trees 2 miles north of the Potomac River and 3 miles west of the Monocacy. The outermost of these were slightly more than 20 miles apart. Additional men were assigned to this territory for exploratory scouting. During March ten addi-

tional confirmations were reported, and late in May and early in June 4 more were discovered, giving a total of 22 in this general area. These trees, plus some associated beetle material, were eradicated by the State. The total area involved is a strip 30 miles wide running northeast through central Frederick County. This is the first reappearance of the disease in Maryland since 1941, and in Frederick County since 1935, when 3 diseased trees were found in Brunswick.

The exploratory scouting indicated that the *Scolytus multistriatus* (Marsh.) infestation near Boston is continuous through Massachusetts to the main disease area in New York, where these bark beetles are the principal carriers of the fungus causing the disease. A scout crew traced an infestation of this species down both sides of the Mississippi River as far as northern Mississippi and west of the river in Arkansas. *S. multistriatus* was also found well established in the Indianapolis area.

In the effort to develop means whereby individuals or municipalities may protect their own trees from the Dutch elm disease, experimental plots have been established at Morristown, Princeton, and Ridgewood, N. J. At Morristown a circular area having a radius of 3 miles is being intensively scouted as in former years. In the inner 2 miles trees showing symptoms of the disease are removed as promptly as possible, the outer mile serving as a buffer zone. In this inner area confirmations from 1939 to 1942 numbered 72, 13, 7, and 22, and increased to 140 in 1943.

As a check on disease incidence within the heavily infected territory where organized control work has been abandoned, scouting was continued in plots each 5 miles in radius at Princeton and Ridgewood, N. J. Here also pronounced increases in the number of diseased trees were found this year. The Ridgewood plot in 1943 yielded 292 confirmations, as contrasted with 115, 85, and 71 in the 3 preceding years. Confirmations at Princeton increased from 75, 93, and 16 to 208 confirmations in 1943.

Scouts submitted 14,213 samples to the laboratory for culturing; 1,736 of these were infected. Connecticut had 122 confirmations, Massachusetts 13, New Jersey 845, New York 386, Pennsylvania 252, and in the isolated infected areas Maryland 22, Ohio 92, and Indiana 4. Of the New Jersey confirmations, 809 occurred in experimental check plots inside the disease area. Since area-wide, systematic eradication work was discontinued in 1941, total confirmations for this year or either of the previous 2 years are not indicative of intensification or diminution of the disease in the main area.

Cumulative totals since discovery of the disease in 1930 show 67,374 known cases of the disease. Of these 2,026 have been found in Connecticut, 20 in Massachusetts, 50,847 in New Jersey, 12,843 in New York, 1,265 in Pennsylvania, and 373 in the isolated areas.

ERADICATION AND SANITATION ACTIVITIES

Prior to abandonment of tree-removal work in February, crews had destroyed 510 confirmed trees and 1,157 elms or other elm material containing bark beetle infestation. During the remainder of the year, through State and municipal cooperation, an additional 43 diseased trees and 60 beetle-infested items were eradicated. In addition, 198 elms were pruned of bark beetle material.

There were 1,645 known diseased trees standing at the end of the fiscal year, plus 71 trees that had been pruned over a period of years and kept under observation.

A revision of the quarantine embargo that prohibits the interstate movement of elms and elm material from the infected zone to outside points was under consideration at the end of the fiscal year. Some movement of nursery elms was authorized during the year under precautionary restrictions and on an experimental basis.

WHITE PINE BLISTER RUST CONTROL

Control of the blister rust disease is essential to the maintenance of the white pine forests of the United States. The accomplishments of the last 25 years are reflected in the amount of lumber available for war purposes and in the young growth for the next forest crop. Stands of white pine initially protected from blister rust in the earlier years of the control program are being harvested, and the young growth now receiving protection by eradication of ribes, alternate host plant for blister rust, will provide lumber for the future. Over 2 billion board feet of white pine lumber were used during each of the last 3 years in connection with the war program. Accelerated cutting of white pine caused by war demands continued during 1943, and the need for adequately protecting the young growth, which is soon killed by blister rust, becomes of increased importance in providing for future crops of this valuable wood.

EFFECT OF WAR ON CONTROL PROGRAM

Conditions resulting from the war emergency continued to handicap the control program and to increase the difficulties of field operations, although some regions experienced less trouble than others. There were varying degrees of labor shortages in different areas, and a scarcity of many items of supply and equipment. The unavoidable restrictive orders and regulations resulting from these shortages, such as priority ratings, wage and labor stabilization policies, food and gasoline rationing, and restricted travel, greatly increased the problems and difficulties of carrying on field work. In some regions the general scarcity of labor in forest areas, or its employment on urgent war projects, resulted in greater use of blister rust crews on emergency fire-suppression work. Also, some of the permanent field personnel were temporarily detailed to aid the timber-production war project, and other urgent war activities were given assistance, when this could be done by employees without serious detriment to their regular work.

Field work was adjusted to meet war conditions by using labor outside draft age, mostly young men from 16 to 17 years of age, by temporarily releasing men for farm work, by restricting travel and the use of equipment and supplies to bare essentials, by adopting a holding program for the duration of the war, by revising work schedules to maintain control on protected areas, by giving priority to areas requiring rework, and by assisting other war projects wherever practicable.

PROGRESS OF CONTROL WORK

There are about 28 million acres of white pine control area in the United States. This area fluctuates from year to year, being decreased by logging, fire and other causes and increased by natural

reproduction and planting. The initial eradication of ribes has been completed on over 22 million acres of the net control area, and of this acreage about 7 million have been reworked.

Control work during 1943 was carried on in cooperation with Federal, State, and private agencies under the over-all leadership and technical direction of the Bureau. The eradication of ribes by all cooperating agencies resulted in the removal of 16,116,886 ribes bushes from 1,141,914 acres of control area, of which 467,270 were initial eradication and 674,644 rework. The details of this work by regions are shown in table 3.

TABLE 3.—*Ribes* eradication work of all cooperating Federal, State, and private agencies for the calendar year 1943

Region	Initial eradication	Reeradication	Total	Effective labor	Ribes bushes destroyed
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Man-days</i>	<i>Number</i>
Northeastern.....	92, 928	275, 709	368, 727	23, 287	2, 574, 503
Southern Appalachian.....	294, 578	278, 049	562, 627	10, 191	817, 615
North Central.....	50, 573	58, 646	109, 219	15, 490	2, 061, 192
Northwestern (Idaho, Montana, and Washington).....	8, 927	27, 820	36, 747	47, 098	3, 790, 528
Pacific Coast (California and Oregon).....	30, 264	24, 330	64, 594	50, 115	6, 873, 048
Total.....	467, 270	674, 644	1, 141, 914	151, 181	16, 116, 886

SPREAD OF BLISTER RUST

White pine blister rust has been reported from 27 States. In California infection on ribes was found this year for the first time on the Tahoe National Forest, which extends the known distribution of the disease a few miles southward in the commercial sugar pine belt. Rust on ribes also was found in Marin County along the California coast, bringing the disease close to the San Francisco Bay district. Within the sugar pine area of California and Oregon, where rust has been found, a careful search was made for centers of pine infection in all control units. In these centers the cankers on the pines and the ribes in the vicinity were removed. This action temporarily retards the intensification and spread of rust, thus allowing more time for eradicating ribes in additional sugar pine stands in advance of the disease.

In the western white pine type of eastern Washington, northern Idaho, and western Montana the rust is well established and increasing on those portions of the control area where ribes is still prevalent. In 1943 cankers resulting from pine infection in 1941 began to appear. The amount of this infection, particularly in areas where the disease became established in 1937 and on which ribes eradication had not been performed in the meantime, is comparable to the heavy infection wave of 1937. Since 1923, when the rust first reached the western white pine region, more than the average amount of annual pine infection occurred in 1927, 1933, 1937, and 1941.

In the southern Appalachian region there was an increase in the number of infected counties, and continued intensification of the disease in unprotected white pine areas. Blister rust was found for the first time on ribes in Bedford, Botetourt, and Washington Counties in Virginia, and on white pine in Giles, Nelson, and Rockbridge Counties. The rust has now been found on ribes in 29 of the 34 counties in Virginia making up the control area and on pine in 18 counties. Also

the disease was found for the first time on pine in Greenbrier County, W. Va., and was again observed on ribes in Avery County, N. C.

Weather conditions in the North Central States continued to be favorable for the spread of the rust, particularly in the northern part of Michigan, Wisconsin, and Minnesota, where the disease is increasing on pine. In northeastern Minnesota blister rust is developing so rapidly that millions of young white pines will be killed before they can be protected. In some localities the unprotected pines are so severely diseased that they have been abandoned to the rust. One such stand in Sawyer County, Wis., had 70 percent of the trees infected, while another stand in the same county that had been protected by ribes eradication showed less than 5 percent infection.

In the Northeastern States ribes was generally infected, although evidence of pine infection of recent origin is rather meager even in some unprotected areas, which is the reverse of the situation in the North Central States. Some of this is due to weather conditions adverse to rust development, but the chief factor in checking the spread of the disease has been the eradication of ribes on more than 85 percent of the control area.

DEVELOPMENT AND IMPROVEMENT OF CONTROL METHODS

In California dosage tests with aqueous ammonium sulfamate sprays on *Ribes roezlii* Regel confirmed preliminary data showing favorable killing action on this species, which has been markedly resistant to other well-known herbicides. Similar tests with ammonium sulfamate were applied to *R. lacustre* (Pers.) Poir. in northern Idaho, where this species is a troublesome eradication problem on some areas.

Experimental work in extracting ribes seeds from samples of forest duff and soil resulted in the development of a successful method consisting of a combination of mechanical screening and blowing, and subsequent flotation in a saturated solution of calcium chloride. This method will be used in making direct measurements of the potential ribes-regeneration hazard in parts of control areas where these bushes are exceptionally persistent.

Studies were continued on tests of new herbicides for ribes eradication, on sampling methods used to determine pine stocking and disease prevalence, and on the ecology of ribes and white pines. Additional data were obtained on the germination of ribes and white pine seeds; on the effects of logging, burning, and grazing on ribes regeneration; and on the correlation of ribes ecology and pine-management practices.

WHITE-FRINGED BEETLE CONTROL

Inspections for white-fringed beetles were conducted in the Southeastern States and at maritime ports of entry from Brownsville, Tex., to Maryland. Infestations totaling 20,000 acres, including localities at Foley, Ala., and Mendenhall, Waveland, and Collins, Miss., were discovered late in the summer of 1943, and the Federal quarantine was extended to include these areas. An incipient isolated infestation was also found at Vander, N. C. By inspection for larvae in the spring of 1944 infestations were located at Mount Olive and Fayetteville, N. C.

Control operations in all areas reduced beetle populations, lessened damage to vital food, feed, and fiber crops, and minimized possi-

bilities of spread of the pest. Many farmers in infested areas on the Gulf coast adopted recommended planting and cultural practices, including crop rotation, that tend to reduce beetle populations. The planting of small-grain and winter cover crops was increased several fold. Other Department as well as State agencies participated in bringing these practices to the attention of the farmers.

Methods of handling nursery stock were improved, in cooperation with State pest-control agencies. The number of fumigated, barricaded areas and of protected plunging beds has been more than doubled. The percentage of certifiable nursery stock was correspondingly increased. An incipient infestation at Avery Island, La., 125 miles west of any other known infestation, is believed to have been eradicated by methyl bromide fumigation.

Improvement was made in machinery used for applying insecticides. A machine for applying concentrated spray was developed so as to eliminate belt drives, reduce the gross weight, and apply the spray more evenly and uniformly. Field tests have indicated that the concentrated-spray method of applying insecticides is more effective than others against white-fringed beetles.

GRASSHOPPER AND MORMON CRICKET CONTROL

Grasshoppers were somewhat more abundant in the spring of 1944 than in 1943, from Texas north to Montana and North Dakota. Although the infestation was spotted, destructive populations developed locally in 8 to 10 counties in south-central Texas and in western Kansas, central and western Nebraska, and northeastern Colorado, and particularly damaging outbreaks threatened in 10 or 12 counties in central South Dakota. In Wyoming, Montana, and North Dakota the outlook for the 1944 crop season is not particularly alarming, but considerable baiting may be needed in some localities to protect late crops.

Mormon cricket infestations developed in 1944 very much as indicated by the fall egg surveys. Control operations were conducted during May and June in Washington, Oregon, Idaho, Nevada, and Wyoming. More extensive outbreaks occurred in Idaho and Nevada. Wet, cool weather during the spring and early summer retarded both grasshopper and Mormon cricket development and greatly promoted growth of crops and natural vegetation. Early crops that normally would have been susceptible to grasshopper attack had a good growing start, and the natural vegetation provided sufficient attractive cover so that early-season damage was restricted to localized areas.

The grasshopper-control program in 1944 presented several important aspects. Relatively low populations generally offered possibilities for holding infestations at a low ebb with a small amount of timely and effective control work. If a repetition of unfavorable past experiences in the more heavily populated areas was to be avoided, it was necessary to supplement farmer control in such areas with federally-financed spreading of poisoned bait on roadsides and rights-of-way.

To implement this program a new type of blower spreader was designed, and 275 of these spreaders were constructed. This spreader, with a throw of approximately 35 feet to either or both sides, will

give adequate coverage at speeds up to 25 miles per hour. To furnish the amount of bait needed for this purpose, a new type of batch mixer was also designed, which eliminated the need for large mixing-station crews and provided ample quantities of bait at less expense. By July 1 approximately 2,400 tons of bait had been spread by farmers, and 500 tons by States and counties with Federal assistance.

As the result of control operations and natural factors the area infested with the Mormon cricket has been reduced from approximately 19,000,000 acres in 1939 to 940,000 acres in 1944. By July 1 about 550 tons of bait had been spread by plane and 300 tons by power baiting units. A much smaller, though highly important, portion of the area, embracing country inaccessible to mechanical spreaders, was baited by hand. In the combined operation 150,000 acres were covered in 1944, and important savings of range forage and adjacent crops were effected.

CONTROL OF CHINCH BUGS

A moderate infestation of chinch bugs developed in parts of 40 counties across the central part of Illinois. Nearly 800,000 pounds of dinitro-*o*-cresol dust and approximately 250,000 gallons of creosote were supplied to farmers in this State for construction of barriers. More than 100,000 acres of corn were saved. Only limited amounts of barrier were constructed in other States.

BARBERRY ERADICATION

Eradication of rust-spreading barberry bushes in important grain-growing areas is essential to the control of stem rust of wheat, oats, barley, and rye. As a result of organized effort on the part of grain growers, and with the assistance of county, State, and Federal agencies, nearly 70 percent of the approximately 1 million square miles in the 17 States comprising the barberry-eradication area has been protected from local sources of stem rust since control work was undertaken 25 years ago. The remaining 310,500 square miles must be given further attention to eliminate bushes that have grown from seed that were in the ground at the time of the initial survey. Of immediate concern at this time are areas approximating 10,000 square miles last inspected about 6 years ago. Since the new bushes may produce seed when 5 to 6 years old, the proper timing of clean-up work is important if it is to be done most economically and effectively.

ACCOMPLISHMENTS IN 1943

During 1943 difficulties arising from war conditions combined to reduce accomplishments in barberry eradication to somewhat below those of the previous year. Nevertheless, 1,715,933 bushes were destroyed in 252 important grain-producing counties. During the season systematic surveys were applied to 5,456 square miles. Of 11,117 previously infested properties that were reinspected, 4,000 will require no further work. Barberry bushes were located and destroyed on 2,132 properties, 544 representing new locations. The program was confined largely to rework in areas where there was immediate danger of reseedling, and where bushes growing in close proximity to grain fields constituted a serious stem-rust menace.

A summary of the eradication work by States is shown in table 4.

TABLE 4.—Results of barberry eradication work, calendar year 1943

State	Area surveyed	Properties cleared		Bushes destroyed		
		New	Old	<i>Berberis vulgaris</i>	Native species †	Total
	<i>Square miles</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Colorado.....	124	46	186	11,360	273,110	284,470
Illinois.....	493	32	53	816	.....	816
Indiana.....	682	9	36	796	317	1,113
Iowa.....	592	56	123	2,714	125	2,839
Michigan.....	906	194	239	5,623	.....	5,623
Minnesota.....	168	35	97	742	.....	742
Missouri.....	73	8	26	197	.....	197
Montana.....	863	2	5	148	.....	148
Nebraska.....	297	1	8	35	.....	36
North Dakota.....	641	0	1	27	.....	27
Ohio.....	177	37	178	6,122	.....	6,122
Pennsylvania.....	27	25	121	207,656	.....	207,656
South Dakota.....	113	1	1	5	.....	5
Virginia.....	18	17	34	16	1,185,875	1,185,891
West Virginia.....	49	0	141	41	42,444	42,485
Wisconsin.....	203	81	339	7,764	.....	7,764
Wyoming.....	0	0	0	0	0	0
Total.....	5,456	544	1,588	244,062	1,471,871	1,715,933

† *B. fendleri* A. Gray and *B. canadensis* Mill.

STEM RUST DAMAGE LIMITED TO LOCAL AREAS

In general wheat west of the Mississippi River escaped serious damage from stem rust in 1943. Barberry bushes rusted later than usual, and less than the normal amount of inoculum of wheat stem rust developed in Mexico and Texas. Only slight damage resulted from the northward spread of the rust. Both in the South and in the western part of the Mississippi Valley there was more stem rust of oats than of wheat.

In the Eastern States the situation was the reverse. There was more abundant development of stem rust of wheat, especially in Virginia, West Virginia, North Carolina, Kentucky, and southern Ohio, while stem rust of oats was light. In Virginia and West Virginia heavy infection also developed early on barberry bushes, and local outbreaks of the disease caused severe damage to wheat in barberry-infested areas.

Stem rust was severe in the vicinity of Palouse, Wash., where losses were estimated to total 150,000 or more bushels of wheat. Observations indicate that it originated on barberry bushes within this area and that very little, if any, was from outside sources.

The rust situation in 1943 in the Virginias and Washington provides additional evidence of the importance of barberry bushes in starting damaging epidemics of stem rust.

DISTRIBUTION OF PHYSIOLOGIC RACES OF STEM RUST

Studies of the distribution of physiologic races indicate that stem rust in the Plains States had a separate origin from the rust in the more eastern States. In the eastern area race 38 predominated on wheat, while west of the Mississippi River race 56 was most prevalent, with race 17 in second place and race 38 rarely found. For the country as a whole only these three races of wheat stem rust were sufficiently prevalent to be of practical importance. The 982 collections of wheat

stem rust yielded 1,455 isolates. Of these, 49 percent were race 56, 24 percent race 38, and 23 percent race 17. Compared with the previous year, there was an increase in prevalence of race 56 and a decrease in races 38 and 17, but no conspicuous change in trends.

Race 8 of the oat stem rust was sufficiently prevalent in 1943 to cause concern regarding its future effect on the performance of Boone and several other resistant varieties of oats, most of which were derived from Victoria \times Richland crosses. More than 20 percent of the total isolates of oat stem rust were of races 8 and 10, both of which attack the new varieties. Although there have been indications during the last 5 years that race 8 might become more abundant, the sharp increase in prevalence in 1943 was unexpected since the previous high was about 6 percent in 1940.

The identification of physiologic races of wheat stem rust from 55 viable collections obtained from barberries, grains, and grasses in the Palouse area of Washington and Idaho resulted in 65 isolates comprising 14 races. These were all identified as previously described races, although some of them could have been considered as new ones on the basis of minor but apparently consistent differences. These differences indicate that a great deal of recombination between races had taken place on the barberry bushes. Of these 14 races, the only ones found commonly elsewhere are 56, 17, and 38. These were by far the most prevalent in the Mississippi Valley, but each was isolated only once in the material from the Palouse area. It appears, therefore, that there was relatively little, if any, interchange of rust between this area and other wheat-growing areas in which the prevalence of physiologic races is known.

NURSERY INSPECTION

Applications for permits to ship *Berberis* and *Mahonia* plants under the provisions of Federal Quarantine 38 were received from 42 nurseries during 1943, and 37 were granted. It was necessary to refuse 2 applications because the nurseries were growing susceptible varieties and did not wish to remove them, and the approval of 3 applications was delayed pending the eradication of susceptible plants. Few susceptible barberry plants are now found in nurseries in the States participating in control work, and many nurseries outside the control area are restricting their stock to immune or resistant varieties and species. During the year 17 nursery operators voluntarily destroyed 700 susceptible barberry plants.

INFORMATIONAL ACTIVITIES

Informational activities during 1943 were planned to supplement the survey and eradication program, particularly in territory where work could not be accomplished as scheduled. In Minnesota 55 counties authorized bounties ranging from 2 to 5 dollars for reporting the location of barberry bushes. Numerous news items were written for publication, and 9 papers of a popular or technical nature were issued.

PROGRESS IN SWEETPOTATO WEEVIL CONTROL

The wartime demand for increased food supplies has greatly stimulated sweetpotato production beyond the normal 70 million bushels annually, and has stressed the importance of protecting this valuable

crop against its most destructive insect enemy, the sweetpotato weevil, which thrives in commercial areas of the Gulf Coast States. During 1944, 1,181 farms in Alabama, Georgia, Louisiana, Mississippi, and Texas were cleared of this pest by the cooperation of the Bureau, the States, and the growers. Inspection was then extended into other commercial sections of Louisiana and Texas, where 1,280 additional farms were found infested, and control activities are going forward. The clean-up of fields after harvest and of seedbeds and storage places is effective in combating the weevil.

MOLE CRICKETS CONTROLLED

Populations of mole crickets apparently were reduced in the 15 Florida counties in which a control program was conducted in the summer and fall of 1943. Nearly 33,600 acres of truck-crop plants were spread with sodium fluosilicate bait supplied to 3,096 farmers. By baiting in the seedbeds and planted fields, farmers were able to control the burrowing crickets until the young vegetable plants were well rooted. As has been done in the past, the Bureau supplied the bait, supervision, and technical assistance, and the State plant board transported and distributed the bait to the growers.

SURVEY BEING MADE FOR GOLDEN NEMATODE OF POTATOES

The golden nematode of potatoes, *Heterodera rostochiensis* Wollenweber, was found in a small area on Long Island in 1941. The New York State Department of Agriculture and Markets, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture, conducted a survey to delimit the infestation, and the former agency established a quarantine on the area, effective March 13, 1944. The source of the infestation is not known. The Bureau of Entomology and Plant Quarantine, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and with appropriate State agencies, in June 1944 began a survey of the more important northern potato districts east of the Mississippi River to determine as far as possible their status with respect to this potato root parasite.

PINK BOLLWORM CONTROL AND QUARANTINE ENFORCEMENT

INSPECTION

The pink bollworm situation appeared critical because of an increase in intensity of infestation in Cameron County, Tex., and spread into new areas in Texas and Louisiana. Inspection showed initial infestations in Schleicher, Calhoun, Matagorda, and Brazoria Counties in Texas, and in Cameron, Calcasieu, and Jefferson Davis Parishes in Louisiana. There was also a marked increase in infestation in Hidalgo and Maverick Counties, Tex. In northwestern Texas results were negative in all previously known infested counties except Tom Green. There was an increase in infestation in the Big Bend of Texas over the previous season, although it was substantially lower than during the years of heaviest infestation. The regulated areas of New Mexico and Arizona showed no material changes. Negative findings for a number of years made it possible to release from quarantine four

counties in northwestern Texas and one in eastern New Mexico. The Glendale area in Maricopa County, Ariz., appeared free of infestation, but four specimens, the first since 1939, were taken in the eastern part of the county.

In all regulated areas a total of 60,294 bushels of trash were inspected and 26,986 pink bollworms were found. Outside of regulated areas a total of 31,596 bushels of trash were inspected in Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas. Inspections were negative with the exception of those previously mentioned. Inspection of sea-island cotton fields in north-central Florida was negative. Summaries of the amounts and the results of the various kinds of inspection are given in tables 5 and 6.

TABLE 5.—Results of inspections for pink bollworm in regulated areas, crop season of 1943

State	Gin trash		Field			Laboratory	
	Quantity	Pink bollworms	Blooms	Bolls	Pink bollworms	Green bolls ¹	Pink bollworms
	Bushels	Number	Number	Number	Number	Number	Number
Arizona.....	31,132	213	0	18,255	26	0	0
New Mexico.....	591	93	0	2,250	0	4,000	0
Texas.....	28,571	26,880	1,112,460	12,366	124	5,592	111
Total.....	60,294	26,986	1,112,460	32,871	130	9,682	111

¹ Collected from 1942 cotton crop.

² Distributed in counties as follows: Graham 3, Greenlee 4, Maricopa 4, Pinal 2.

³ From Graham County, although most of the bolls inspected were in Maricopa and Pinal Counties.

⁴ Southern Texas.

⁵ 112 from blooms and 3 from bolls in Cameron County, 9 from bolls in Hidalgo County.

⁶ 100 specimens in El Paso County and 11 in Hudspeeth County.

TABLE 6.—Results of inspections for pink bollworm outside regulated areas, crop season of 1943

State	Gin Trash		Field				Laboratory ¹	
	Quantity	Pink bollworms	Squares	Blooms	Bolls	Pink bollworms	Green bolls	Pink bollworms
	Bushels	Number	Number	Number	Number	Number	Number	Number
Alabama.....	1,370	0	0	0	0	0	0	0
California.....	0	0	0	0	37,443	0	0	0
Florida.....	186	0	1,874	574	48,711	48	12,010	1
Georgia.....	2,037	0	0	0	351	0	0	0
Louisiana.....	4,048	11	0	0	91,127	214	0	0
Mississippi.....	146	0	0	0	1,748	0	0	0
Texas.....	23,758	13	0	0	204,031	18	46,594	0
Total.....	31,596	24	1,874	574	383,411	280	58,604	1
Mexico:								
Chihuahua.....	1,068	809,304	0	0	0	0	0	0
Coahuila and Durango.....	780	892,886	0	0	0	0	0	0
Nuevo Leon.....	523	0	0	0	0	0	0	0
Tamaulipas.....	665	15,787	0	438,282	0	61	0	0
Total.....	2,936	1,717,947	0	438,282	0	61	0	0
Grand total.....	34,531	1,717,971	1,874	438,856	383,411	341	58,604	1

¹ Bolls collected from 1942 crop.

² Work done by port and border survey personnel.

³ 27,385 bolls from sea-island cotton and the remainder from wild cotton. The 48 specimens were from wild cotton.

COOPERATIVE PROGRAM IN MEXICO UNDER WAY

Control operations against the pink bollworm in the United States have been affected by natural spread from heavily infested areas in Mexico. To offset this condition increased funds were provided for the cooperative control work in Mexico, and during the past year Bureau personnel have been working with Mexican agricultural officials, agricultural agencies, and individual farmers to effect improvements in administration of control procedure, particularly in interior areas. Emphasis continues to be placed on efficient regulatory and control practices in border areas, which it is believed compare favorably with those in adjacent areas in the United States.

Farmers in the lower Rio Grande Valley of Mexico destroyed stalks on 125,000 acres promptly after harvest.

PROGRAMS IN THE VARIOUS REGULATED AREAS

For the second consecutive season rains prevented completion of field clean-up in the lower Rio Grande Valley and permitted considerable carry-over of pink bollworms. This resulted in a substantial increase in infestation in 1943. Farmers destroyed stalks on 218,618 acres, and Bureau funds were used to pile and burn stalks in heavily infested fields. The Bureau, in cooperation with Texas authorities, grubbed cotton sprouts from 46,764 acres, in order to establish and maintain a starvation period for the pink bollworm subsequent to destruction of stalks by farmers. To reduce the number of overwintering larvae, the State of Texas has set September 15 as the date for the completion of stalk destruction. This is 15 days earlier than in previous years.

In 1943 no effort was made in the Big Bend of Texas to shorten the growing season through regulation of the planting date, but in 1944 the Texas State Department of Agriculture sought to reduce the number of generations of the bollworm through regulations involving delayed planting.

In Louisiana an intensive clean-up program was carried out with Bureau funds on 2,115 heavily infested acres in Cameron Parish, and the area then was designated as a noncotton zone by State authorities. The State required farmers in two additional parishes to destroy stalks at their own expense.

A total of 876,166 bales of cotton were ginned at 555 gins in the regulated areas of Texas, New Mexico, and Arizona. In all, 352,934 tons of seed were sterilized, 327,980 tons of seed were processed at the 49 designated oil mills, and 484,076 bales of lint and 8,252 bales of linters were compressed at 11 plants. A total of 11,022 bales of Mexican linters were fumigated. The supervision of these treatments required 2,360 inspections of processing plants.

In southern Texas about 2,100 small lots of quarantined products were intercepted through examination of trucks and 24,600 pick sacks that were being carried out of the regulated area by transient workers.

ERADICATION OF WILD COTTON

Eradication of wild cotton from southern Florida was handicapped in some sections because of labor shortages. Infestation continues to be held at a low level in the greatly reduced number of plants, thus

minimizing the likelihood of spread of the pink bollworm to domestic plantings in the Cotton Belt. All west-coast locations and many keys were covered three times. The Cape Sable area, in which many plants occur, and the other keys were covered twice. In all, 29,425 plants with mature bolls and 297,519 current year seedlings, a total of 326,944 plants, were destroyed. This was a reduction of nearly 11,000 in the number of plants maturing bolls, as compared with the 1943 season. Since the inception of wild-cotton eradication in Florida, a total of 16,429,671 plants have been removed.

DOG FLIES CONTROLLED AT ARMY AIR FORCES BASES

To prevent serious interruptions of military training programs along the Gulf coast of northern Florida, the United States Army Air Forces for the third consecutive season provided funds for the control of outbreaks of dog flies (stableflies) in this area in the summer and fall of 1943. By spraying the breeding places of the flies—beach deposits of marine grasses—with 25 percent of creosote in bay water along 562 miles of shore line, the fly populations were greatly reduced and military operations were permitted to function normally. The United States Public Health Service cooperated in the work. A similar program was being conducted in the summer of 1944.

TRANSIT INSPECTION

Because of citrus sterilization requirements in the Rio Grande Valley of Texas during the spring of 1944, additional transit inspectors were assigned at gateways from the valley for several months. Intensive inspection of shipments of restricted fruit leaving the valley resulted in interception of 339 apparently unsterilized shipments. Throughout the year inspection was conducted at 18 transfer points strategically located with respect to movement of restricted articles by common carrier from areas regulated by Federal domestic plant quarantines. There were examined 1,234,471 mail, express, and freight shipments; 2,226 apparent violations of 7 of the 9 Federal domestic plant quarantines and 38 violations of the District of Columbia plant-shipping regulations were reported. Six hundred and eight apparent violations of State quarantines, including those pertaining to phony peach and peach mosaic diseases and the sweetpotato weevil, were reported to State officials.

TERMINAL INSPECTION OF MAIL SHIPMENTS

The States maintaining terminal inspection of mail shipments of plants and plant products under the procedure carried out in cooperation with the Post Office Department, which provides for turning back or disinfecting shipments if found infected, are Arizona, California, Florida, Idaho, Louisiana, Minnesota, Mississippi, Montana, Oklahoma, Oregon, Utah, and Washington. The District of Columbia, Hawaii, and Puerto Rico also maintain this procedure. The States that have availed themselves of the provisions of the terminal-inspection procedure for the enforcement of their plant quarantines are Arizona, Arkansas, California, Florida, Minnesota, Mississippi, Montana, and Oregon.

FOREIGN PLANT QUARANTINES

MARITIME PORT INSPECTION

Many of the effects of war that were noted in previous reports marked foreign-plant-quarantine enforcement in 1944 at maritime ports. Success in the antisubmarine warfare, together with ship construction, resulted in a 39-percent increase in ship arrivals over 1943, and consequently in cargoes subject to inspection; but there was a marked reduction in the need for emergency safeguards for cargoes discharged from ships under distress conditions. Wartime controls over commerce, such as the convoy system, continued to place heavy loads on inspection staffs in peak periods. The use of dry ballast again necessitated large expenditures of inspector-hours in protection against pest risk when the ballast contained top soil.

The record of ship inspections appears in table 7. The data given in this table do not include those for ships engaged only in Great Lakes trade.

TABLE 7.—Number of ships arriving, inspected, and bearing prohibited plant material, fiscal year 1944

Origin	Arriving	Inspected	Bearing prohibited material
Foreign ports, direct.....	21,832	21,749	4,813
Foreign ports, via United States ports.....	3,442	2,210	191
Foreign ports, via Hawaii.....	94	94	13
Foreign ports, via Puerto Rico.....	33	33	12
Hawaii, direct.....	1,166	1,166	190
Hawaii, via United States continental ports.....	50	50	3
Puerto Rico, direct.....	456	455	38
Puerto Rico, via United States continental ports.....	30	30	1
United States ports, via Panama Canal.....	184	184	58
Total.....	27,297	26,981	5,316

CARGO INSPECTION

Importations of plants and plant products showed an increase for the year, notably in fruits and vegetables, with a falling off in nursery stock. The totals were as follows: Fruits and vegetables, 10,299,785 containers, 80,316,596 bunches of bananas, 17,387,327 pounds, and 86,436 units; nursery stock and seeds, 6,926 containers, 1,661,489 pounds, and 1,700,607 units; cotton lint, bagging, and cotton products, 166,133 bales, 1,155,762 containers, and 37,580,202 pounds; fibers and cereals, 166,059 bushels, 123,462 containers, 6,141,238 pounds, 53,592 dozen, and 17 units. In addition 205 lots of restricted plant material were admitted in accordance with governing regulations at Canadian border ports where no plant-quarantine inspectors are stationed, through the cooperation of the customs officers and the Canadian Department of Agriculture.

Not included in the foregoing totals were several thousand importations of fruits and vegetables over the Mexican border, in such small quantities that no entries are required by customs and no plant-quarantine record of them is made. Each of these small lots was inspected before release, and a large outlay of inspector-hours was required to handle them, especially at the larger ports.

DISINFECTION

The amount and type of plant material treated under supervision of inspectors and collaborators of this Bureau reflect the wartime character of commerce in restricted plant products. The number of bales of cotton, linters, and bagging treated was 195,971, an increase of 12 percent. The total of 30,576,074 pounds of cottonseed cake and meal treated was more than twice the 1943 volume. Weevil-infested vetch contaminating straw jackets around liquor and wine bottles presented a difficult problem in pest protection. Effective steps were taken to bring about the use of unobjectionable packing materials, but 239,148 cases of these products were fumigated in the meantime. Only 39,905 plants, cuttings, bulbs, roots, and other plant-propagating materials were treated; in addition, 19,051 pounds of seeds were safeguarded by treatment. A total of 4,214 samples of cotton lint, linters, etc., and 18,943 containers of other restricted plant products were fumigated or otherwise treated.

AIRPLANE INSPECTION

The rapid expansion of air-borne commerce presented a major plant-quarantine problem during 1944. The inspection of airplanes now arriving in a continuous flow, after only a few hours on the way from many different foreign countries, has become an activity of first importance. As this type of commerce developed, studies were made to appraise the pest risk involved in it and to determine the means available to meet the situation. During the year 21,557 airplanes were inspected at 27 ports of entry, including 2 airports previously without plant-quarantine protection that were temporarily staffed for the last part of the period. There were 8,464 more inspections than in 1943, an increase of 65 percent. Prohibited plant material was found in 3,031 of the airplanes inspected.

In connection with airplane inspection 1,281 interceptions of insects and plant diseases were made. While many of these pests, including mosquitoes, were stowaways that might menace public health, plant pests of economic importance were found in plant material carried in baggage, cargo, mail, and stores. Among the insects found were the Mediterranean fruitfly, the Mexican fruitfly and two other species of *Anastrepha*, one of them probably *serpentina* Wied., the citrus blackfly, and the East Indian bean pod borer (*Maruca testulalis* (Geyer)). Over half of the 44 interceptions of 26 plant-disease organisms were found on orchids, including 1 undescribed rust. The gravity of the pest risk associated with air commerce is emphasized by the speed with which a plant pest can be transported by this means.

FOREIGN PARCEL-POST INSPECTION

The inspection of parcel post from foreign countries developed in 1944 into a plant-quarantine problem of materially increased importance, which will continue until after the return of the armed forces now overseas. The millions of American men and women in uniform who are stationed abroad enjoy customs and postal privileges that place their mail in a class apart from peacetime international mail. Because of its volume and of the customs and postal procedures involved in handling it, this foreign parcel-post traffic creates difficult problems in providing plant-quarantine protection against pest entry. A total of 147,007 foreign parcel-post packages were inspected, an increase of 97 percent over 1943. Of these, 717 were refused entry, in whole or in

part, because they contained prohibited material, 1,664 were diverted to another port for disposition, and 1,361 were released under permit.

MEXICAN BORDER SERVICE

In 1944 a total of 67,755 freight cars from Mexico were inspected, a decrease of 1,429, or 2 percent, from the 1943 total. It was necessary to fumigate 12,985 as a condition of entry into the United States. This represents an increase of 813, or 7 percent, over 1943. Coupons valid for the fumigation of a freight car were sold, at \$4 each, in the amount of \$52,196. During the year search continued for possible ways to expedite railroad traffic from Mexico by eliminating fumigations when possible to do so without increasing the risk of introducing foreign plant pests. By using certain railroad records, which were carefully compared with other sources of information and confirmed by actual inspections of the cars themselves, it was possible, during the last half of the year, to reduce materially the number of cars requiring fumigation at Nogales, Ariz., without additional risk of pest entry.

In addition, 4,620 Pullman and passenger coaches were inspected upon entry into this country. A total of 4,569,545 other vehicles and 806,809 pieces of baggage were examined in cooperation with customs officials, a decrease of 3.5 percent in the number of other vehicles examined and an increase of 44 percent in baggage examinations.

INSPECTION IN HAWAII AND PUERTO RICO

The predominant activities carried on in the enforcement of Federal plant quarantines governing the movement of plants and plant products from Hawaii to the mainland were preflight inspection of aircraft and the inspection of mail, baggage, and express. The local demand for all fresh fruits and vegetables left little for shipment to the mainland. Inspections and certifications decreased accordingly. Preflight aircraft inspections and the examination of express increased approximately 600 percent over 1943, and necessitated the assignment of additional personnel from the mainland. Mail and baggage inspections continued in volumes approximating 1943 figures; however, conditions surrounding the handling of mail from the armed forces in Hawaii were such that it could not all be made available for inspection prior to dispatch to the mainland. By the close of the year over 60,000 parcel-post packages were being inspected monthly at mainland ports, thus adding materially to the work load of maritime inspectors at Pacific coast ports. The inspectors continued to cooperate with the censors in the examination of mail and express in Hawaii.

In Puerto Rico also the demands for local consumption resulted in very little call for the inspection and certification of fruits and vegetables for shipment to the mainland. Emphasis there is on the inspection of surface vessels and aircraft to prevent both the introduction of foreign plant pests and the spread of injurious pests of Puerto Rico to the mainland. The insular inspectors, acting as collaborators, assist in these activities, all of which have been adjusted to meet the needs of wartime commerce.

DEPARTMENTAL PLANT MATERIAL AND DISTRICT OF COLUMBIA INSPECTION

A total of 411 shipments of incoming domestic material (51,163 plants, cuttings, bulbs, etc., and 2,237 lots of seeds) and 1,793 shipments of outgoing domestic material (200,947 plants, cuttings, bulbs, etc., and 10,730 lots of seeds), including material shipped by the United

States Department of Agriculture, were inspected in the enforcement of the regulations governing the movement of plant material into and out of the District of Columbia. Some form of treatment for the elimination of pests in these shipments was given to 175,517 plants, 1,509 lots of seeds, and 141 parcels containing plant material not for propagation. In addition 25,978 containers were examined at the post offices, express offices, and freight stations, and 19 truckloads containing 68,922 plants consigned to retail merchants in the District of Columbia were checked on arrival for proper certification.

INSPECTION OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

Plant material that is being propagated at plant-introduction and propagating gardens maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering is inspected regularly for the presence of plant pests. Such material distributed from the gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau. The inspections at Chico, Calif., were handled jointly by an inspector from this Bureau and an entomologist from the California Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., stations was examined by Bureau inspectors. The following were examined prior to distribution from these stations during 1944: 448,178 plants, 1,264 bud sticks and cuttings, 43,388 roots and tubers, and 136 shipments of seeds.

INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The interceptions of prohibited and restricted plants and plant products in 1944 are as follows: In baggage, 46,534; in cargo, 199; in mail, 1,484; in quarters, 6,176; in stores, 3,558; total, 57,951. In addition, interceptions were made in baggage by customs officers at Mexican border ports where no plant-quarantine inspectors are stationed. Customs officers at Canadian border ports without plant-quarantine inspectors made 210 interceptions.

The Bureau is fortunate in having the interested, intelligent cooperation of the customs personnel in the enforcement of foreign plant quarantines, particularly at ports where traffic conditions do not now warrant the services of a plant-quarantine inspector. This is an important factor in maintaining the safeguards against pest entry.

PESTS INTERCEPTED

During the inspection of foreign plants and plant products, and of such products received on the mainland from Hawaii and Puerto Rico, inspectors and collaborators of the Bureau collected insects belonging to 897 recognized species and others distributed among 590 genera and families, as well as fungi, bacteria, nematodes, and viruses belonging to 238 recognized species, and large numbers of other pathogens that could be referred to genus, family, or general group only. Many of these interceptions were of important plant pests; others were of scientific interest, including a number of undescribed species.

The combined total of 43,001 interceptions of insects and diseases made were taken as follows (figures refer to number of interceptions): In material offered for entry for consumption, 23,711 insects, 13,654 diseases; in material offered for entry for propagation, 1,508 insects, 491 diseases; in material not offered for entry, such as in-transit shipments

and materials in ships' stores, quarters, etc., 2,358 insects, 1,279 diseases; total, 27,577 insects, 15,424 diseases. In addition, inspectors stationed in Puerto Rico in connection with the enforcement of the fruit and vegetable quarantine made 60 collections of insects and 8 of diseases during their field and packing-house inspections.

PEST SURVEY IN VICINITY OF PORTS OF ENTRY

During the year 42,879 man-hours were expended in making an insect and plant-disease survey of the more important food crops growing in the environs of the ports of entry and international airports on the Atlantic, Gulf, and Pacific coasts and at the Mexican border, for possible introduced plant pests. A total of 19,698 lots of insect material and 4,450 plant pathological specimens collected in the course of the survey were submitted to specialists for determination.

As a result of the survey samples of several insects and plant diseases known to be of economic importance in foreign areas were collected in the United States for the first time. The most important insects found include two bean pod borers, *Maruca testulalis* (Geyer) and *Fundella cistipennis* Dyar, found in Texas and Florida, respectively; a lepidopterous insect, *Gnorimoschema gudmannella* (Wism.), whose larvae attack the flowers and fruits of bell peppers, found in Florida; and the European rose maggot, *Rhagoletis alternata* (Fall.), found in rose hips in the States of Rhode Island and Washington.

Plant diseases found include *Phomopsis tuberivora* Gussow and Foster, which causes a hard stem end rot of potatoes in British Columbia, and *Elsinoe piri* (Wor.) Jenkins, a fungus known to disfigure apple and pear leaves and fruit in Europe, both found in the State of Washington; and the European fungus *Phomopsis juglandina* (Fckl.) Hoehn., found on *Juglans regia* L. in California.

Several insect pests, not widely distributed within the United States, were found in areas where they had not been known previously to occur. New locality records that are of importance include the following: The California red scale, a major pest of citrus, was found in Arizona on lemon and grapefruit trees; two mirids, *Pilophorus perplexus* D. and S. and *Heterotoma meriopterum* (Scop.), known to occur in the Northeastern States, were found in Washington State, the former on plum and the latter on apple and potato; the gelechiid *Gnorimoschema plaesiosema* (Turner), an important pest of potatoes and tomatoes in New Zealand and Australia, and heretofore recorded only in this country from California, where the larvae attack nightshade, was found infesting the same host in Louisiana.

CERTIFICATION FOR EXPORT

A total of 1,716 export certificates covering 594,306 containers were issued to meet the sanitary requirements of foreign countries. Certificates were issued at 29 ports covering 40 commodities which were exported to 58 foreign countries.

INSECT PEST SURVEY AND INFORMATION

Owing to war conditions, no reviewing of literature for survey data was carried on during the year, except what was necessary to meet specific requests for information. Approximately 5,000 current notes were added to the Insect Pest Survey record, increasing the number

of species now on record by about 200. The Survey files now contain records on more than 53,000 species of insects and 5,000 host plants. During the year 125 requests for specific information on survey matters were filed, exclusive of inquiries from the divisions of the Bureau. Four monthly summaries and an annual summary of insect conditions were issued. Ninety-nine press and radio releases were issued.

A total of 404,050 printed publications and 131,390 copies of regulatory material were distributed. The series of circulars on Insects in Relation to National Defense was exhausted and had to be reprinted.

EDITORIAL WORK AND PUBLICATIONS

At the beginning of the year 170 manuscripts were on hand, and during the year 404 were received, making a total of 574. Of these, 32 were withdrawn, 41 were published by the Department, 36 were issued in processed form by the Bureau, and 332 were approved for outside publication. On hand at the end of the year were 134 manuscripts, 111 of which were in the Bureau, 15 in the Office of Information, and 8 in the Government Printing Office. Of the 111 in the Bureau, 44 were being reviewed or edited for departmental publication and 67 for publication outside.

The Bureau's 41 Department publications included, in addition to the annual report of the Chief of the Bureau, 6 Circulars, 4 Farmers' Bulletins, 4 Leaflets, 3 Miscellaneous Publications, 5 Service and Regulatory Announcements, 11 Technical Bulletins, and 7 articles for the Journal of Agricultural Research.

ORGANIZATION OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Chief of Bureau.....	P. N. Annand.
Associate Chief.....	A. S. Hoyt.
Assistant Chief (regulatory).....	S. A. Rohwer.
Assistant Chief (research).....	F. C. Bishopp.
Assistant Chief (control).....	W. L. Popham.
Assistant Chief (administration).....	F. H. Spencer.
Division of Finance and Business Services.....	B. Connor.
Division of Personnel.....	William F. Leffler.
Editorial Office.....	Rolla P. Currie.
Division of Insect Pest Survey and Information.....	G. J. Haessler.
Division of Fruit Insect Investigations.....	D. L. Van Dine.
Division of Fruitfly Investigations.....	A. C. Baker.
Division of Mexican Fruitfly Control.....	P. A. Holdale.
Division of Japanese Beetle Control.....	E. G. Brewer.
Division of Forest Insect Investigations.....	F. C. Craighead.
Division of Gypsy and Brown-tail Moth Control.....	R. A. Sheals.
Division of Plant Disease Control.....	J. F. Martin.
Division of Cereal and Forage Insect Investigations.....	C. M. Packard.
Division of Truck Crop and Garden Insect Investigations.....	W. H. White.
Division of Cotton Insect Investigations.....	R. W. Harned.
Division of Pink Bollworm and <i>Thurberia</i> Weevil Control.....	L. F. Curl.
Division of Bee Culture.....	J. I. Hambleton.
Division of Insects Affecting Man and Animals.....	W. E. Dove.
Division of Insect Identification.....	C. F. W. Muesebeck.
Division of Foreign Parasite Introduction.....	C. P. Clausen.
Division of Control Investigations.....	C. P. Clausen.
Division of Insecticide Investigations.....	R. C. Roark.
Division of Foreign Plant Quarantines.....	E. R. Sasser.
Division of Domestic Plant Quarantines.....	B. M. Gaddis.
Division of Grasshopper Control.....	Claude Wakeland.

REPORT OF THE CHIEF OF THE BUREAU OF HUMAN NUTRITION AND HOME ECONOMICS, AGRICULTURAL RESEARCH ADMINISTRATION, 1944 .

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1944.

DR. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I submit herewith the report of the Bureau of Human Nutrition and Home Economics for the fiscal year ended June 30, 1944.

Sincerely,

HAZEL K. STIEBELING,
Chief.

FOOD TO EAT, CLOTHING TO WEAR, A HOUSE TO LIVE IN—these are necessities of everyday living whether the Nation is at peace or war. To furnish facts that will help American families select and use these essentials so as to promote health and well-being is the long-time objective of the research of the Bureau of Human Nutrition and Home Economics. War, however, brings its own immediate and pressing problems.

During the critical year just past, research has been directed toward furnishing families with a steady stream of timely information, designed to help with day-to-day problems.

For agencies responsible for policy and programs affecting civilian welfare there has been an equally constant supply of basic facts and figures on a wide variety of topics touching the home.

At the request of military services some research activities were focused on their specialized needs.

At the same time fundamental contributions were made to science, and plans were laid for attacking some of the problems the home will face in the postwar world.

NUTRITION RESEARCH APPLIED

Since the onset of the war the Nation's families have met their food problems in a remarkably forthright way.

Increased purchasing power has, of course, helped raise dietary levels by enabling many families to buy more of needed "protective" foods. Rationing has given every family its chance at the scarcer foods. Enrichment has put within reach of the household buyer white bread and refined flour with certain vitamins and iron added.

But when this war's food history is written, much credit for improved diets will justly go to the families in town and country for the

hard work, good grace, and firm determination with which they turned to and produced more of their own food, especially vegetables, preserved more fresh food for later use, and conserved food values through better care and cooking. Thus they helped change what might have been a serious drop in the nutritive quality of family meals into an upward trend.

Many of these wartime achievements would have been impossible had not research been quietly building up a backlog of facts, which could quickly be put to practical use when the emergency developed. Indeed, our wartime food program is a demonstration on a vast scale of the importance of research in human nutrition and the nutritive values of food. Because of its work in this field this Bureau has been able to contribute to the solution of many current and pressing problems, as the following examples of the year's accomplishments show.

LIGHT ON THE PROTEIN PROBLEM

To help solve the protein problem, which continues to be a major issue in war and postwar plans for food supply, the Bureau conducts studies from both the long-range and the immediate points of view.

One accomplishment last year in the field of protein chemistry was the development of a method for determining two amino acids, tryptophane and cystine, directly in foods. This marks a milestone in nutrition research. For, when traced to its roots, the protein problem is one of finding how much everyday foods furnish of each of the many amino acids making up the hundreds of proteins and how such foods can best be combined for economical and efficient growth and repair of body tissue. Meat, milk, eggs, and other such foods of animal origin have long been recognized as good sources of "efficient" protein. But whenever in time of war or economic pressure their supply becomes restricted, we need to know how far we can go in supplementing them with proteins of plant origin. The new method of determining certain essential amino acids directly in foods makes possible much more rapid advance in supplying precise information on the protein value of our common foods.

Throwing light on the protein problem from another direction are studies completed this year on the relative value of the proteins of soybeans, peanuts, and cottonseed. Results show conclusively that these plant proteins have high nutritive value and can serve to "extend" or "spare" the proteins of meat, milk, and eggs when circumstances require.

Important in this connection were tests showing that cooking in the presence of moisture for 15 to 30 minutes increases the nutritional value of the protein in soya flour and grits as now produced; whereas overcooking deteriorates both protein and thiamine (vitamin B₁) values. During the past 18 months, 130 recipes for the use of soya flour and grits in both home and school-lunch cooking have been developed in the Bureau's laboratories and given Nation-wide distribution by the War Food Administration. Preliminary work was also done on recipes using peanut flour, looking toward the time when this product may become another high-protein, low-cost food widely available on the retail market.

CANNING—MOST POPULAR HOME FOOD-PRESERVATION METHOD

In 1943 for the second consecutive year millions of families canned, dried, brined, and otherwise preserved food at home. According to national surveys, canning was by far the most popular method. An estimated 25 million families canned for their own use over 4 billion containers of food. That this great volume of home-canned food contributed materially to maintaining nutrition standards is acknowledged by all.

Spoilage, however, took an undue toll of this home-canned food. A midwestern State estimated that by December 1943 over 2 million quarts of home-canned food from the 1943 pack had spoiled in that State alone. While some of this spoilage was traceable to defective equipment or to the home canner's failure to follow directions accurately, much of it pointed to the urgent need for additional controlled experimentation on which to base improved home-canning practices.

Recognizing that 1944 would again be a year of extensive home canning, the Bureau revised and reissued its home-canning bulletin. To make the directions readily understandable by every person doing home canning, this bulletin was copiously illustrated with step-by-step picture sequences showing exactly how to can fruits and tomatoes in the boiling-water bath, and string beans, a typical low-acid vegetable, in the steam-pressure canner. Many of the procedures recommended are adaptations of commercial practices, since industry has long been an important source of scientific facts on canning methods. But because equipment for commercial canning differs in many ways from that used in the home, wide margins of safety had to be allowed in adapting the data from industry's research to the home situation. In some cases, the margin may be so wide as to result in overprocessed food. But in a matter as directly connected with public health as the possible contamination of home-canned food with botulinus, it was felt wiser to err, if erring it was, on the side of processing times and temperatures with a generous factor of safety.

Strong warning was also included against oven canning, in line with the recommendations of the National Home Food Preservation Conference held in Chicago, Ill., in January 1944.

Nearly a third of the States used this Federal canning bulletin instead of issuing one of their own, and many magazines and commercial companies bought and distributed it widely. It thus served to bring greater uniformity in home-canning procedures in the 1944 season. Distribution of the Bureau's home-canning instructions during this fiscal year totaled nearly 3½ million copies.

With the increased support for research in home food preservation recently granted by Congress, this Bureau has developed plans for acquiring the additional information needed to put home canning practices on a scientific basis, taking due cognizance of the great diversity of soil and climatic conditions affecting the raw food and the keeping quality of the canned product when stored. The work was started in the Bureau's own laboratories this past year and will be augmented in the years ahead by extensive cooperative work with State research agencies. One result of the Bureau's research during

this year is that the temperature for the canning of meats in quart glass containers is being changed from 250° to 240° F. and the processing period shortened as much as possible, in order to ensure a product of superior nutritive value. Exploratory work has also been carried out looking toward revising or verifying present methods of canning tomatoes and spinach. Later, the research will be extended to include other important hard-to-can products, such as peas, beans, and corn.

Throughout all the studies the aim is to develop methods that will reduce the amount of spoilage in home-canned food and yield safe products retaining food quality and nutritive value to the highest possible degree.

LOOKING TOWARD HOME FREEZING OF FOOD

A beginning has been made on studies designed to supply basic information about home freezing of food. These studies will be made by the Bureau's laboratories in cooperation with State agencies.

Polls of rural and urban families made by several agencies indicate that quick freezing is the method of home food preservation most likely to expand after the war. Unquestionably, as soon as factories can be reconverted to supply the necessary equipment, the public will be offered many types of freezer cabinets and greatly increased facilities at community freezer-locker plants. Commercial food-freezing companies are also planning new methods of merchandising frozen foods, such as house-to-house delivery of pies and other "made" dishes all ready to cook. These call for new-type storage facilities in the home refrigerator.

These developments in commercial and home freezing of foods pose new problems from the home standpoint if this method of preserving food is to yield products high in eating quality and nutritive value. Many questions are pending as to the best treatment of food before freezing. For example, while the Bureau's preliminary work with vegetables this past year confirms the previous finding that steam scalding may be preferable to water scalding as a pretreatment, its studies also show that equipment now found in homes is not well adapted to the purpose. Work is therefore under way to design simple, efficient, steam-scalding equipment for the home.

NEW FORMS OF FOOD

The needs of the armed services and civilians in war areas for nutritious food in compact forms resistant to adverse storage conditions over long periods is obvious. Studies leading to the improvement of dehydrated foods and their packaging, including compression into bulk-reducing forms, have been carried out cooperatively with other research groups—the Bureaus of Animal Industry, of Plant Industry, Soils, and Agricultural Engineering, and of Agricultural and Industrial Chemistry. The contribution of the Bureau of Human Nutrition and Home Economics has chiefly been to measure the effect on palatability and nutritive value of different methods of processing and packaging, and of different conditions of storage of various dehydrated products—beef, pork, eggs, soup mixes, and vegetables. Work has also been done to find the methods of preparation that will make these products most appetizing.

Efforts have also been directed toward correlating general acceptability scores, as well as special judgments regarding flavor, texture, and other points in palatability, as made by trained judging panels, with objective chemical or physical tests of the properties of various food products. As yet, no substitute has been found for the human palate, and the tests with men and women eating the food appear to be the more delicate, valid, and reliable indices of the acceptability of a product.

WARTIME RECIPES TO MATCH FOOD SUPPLIES.

On the home front as well as on the military front, food plays a leading part in keeping up morale as well as nourishing the body. To do this, food must be cooked and served in such a way that the eater wants to eat. But how to adjust customary cooking methods to changing food supplies is a major problem with the wartime cook. To help her make the most of temporary abundances as well as scarcer rationed foods, the Bureau maintains a food preparation service. As fast as they are tested, recipes and suggestions for wise food use are channeled to the public in printed leaflets for distribution through nutrition committees and other field agencies, and by radio and press release.

Noteworthy examples of this service are series of recipes that have two-way use, such as those issued for potatoes and eggs. In times of abundant supply they show how to serve these familiar foods in a variety of ways to avoid monotony. When supplies are short, by demonstrating how to conserve nutritive value, they help a family to get full good from the limited quantity available.

TRENDS IN NATIONAL DIET

Is our national diet improving, and if so in what respects?

The Bureau provided answers to this important question in two ways this past year. One was by continuing its periodic checks of the nutritive quality of total civilian food supplies, in cooperation with the Bureau of Agricultural Economics and the War Food Administration. These estimates show that for 1943 our civilian food supply on a per capita basis provided more of every nutrient than in 1935-39. For most nutrients the situation was even better than in 1941, a prewar year of high food production and one when our food consumption here at home was little affected by shipments abroad. Preliminary estimates also indicate that in nutritive value, civilian food supplies in 1944 will measure up to the 1943 level.

To agencies planning wartime food production, such periodic checks of the nutritive quality of civilian food supplies are invaluable as a basis for setting national goals and making needed changes in policy. Of more importance to agencies concerned with marketing and to our long-time nutrition program are the studies of diets that show how the national food supply is divided up among families at different income levels.

Another chapter of such documentary evidence is the report, *Family Food Consumption in the United States* (Misc. Pub. 550). It gives a comprehensive picture of the kind and quantity of foods used in the spring of 1942 by urban and rural families, grouped according to their cash income. The national average for the nutritive value of the food as brought into the kitchen appeared to equal or exceed the dietary

allowances recommended by the National Research Council. Yet the food actually eaten probably failed to meet these allowances in several respects because of wasteful ways of storing, cooking, and serving food. The outstanding danger spots were in the B vitamins, and vitamin C was probably uncomfortably near the margin. As would be expected, the diets of the families in the low-income groups were most unsatisfactory in these nutrients. In addition, city families with little money to spend on food also tended to be on the short side in food energy and calcium. The diets of farm families were less affected by money income because they were able to raise such a large part of their food supply.

On the whole, the study shows that families were faring better in the spring of 1942 than at the time of the last Nation-wide dietary study. For example, comparison of diets in the year 1936 with those in the spring of 1942 indicates that increased incomes, improved marketing methods, and widespread nutrition education have markedly improved food-consumption patterns in the United States. But recent surveys also show that a large proportion of families are still unaware of, or indifferent to, the newer knowledge of nutrition. All of which points to the need for periodic studies of our dietary habits and redoubled efforts in popularizing research findings in such simple terms and arresting ways that the hitherto unreached public will be moved to adopt good food practices.

As a contribution toward spreading authoritative facts about human nutrition and diet, the Bureau prepared a bulletin entitled "Principles of Nutrition and Nutritive Value of Food." It was written by Dr. Henry C. Sherman, Chief of this Bureau from April 1943 to June 1944, while on leave from Columbia University. This 40-page statement about the functions of food in nourishing our bodies and the contribution various food groups make to the diet as a whole, is a brief of our nutritional knowledge today, but it bears the same title as one of the first popular publications on nutrition printed by the United States Department of Agriculture. The early bulletin was the work of Dr. W. O. Atwater, one of the founders of research in human nutrition in this country. This year is the one-hundredth anniversary of Atwater's birth, and the issuance in 1944 of a bulletin bearing the same title as his, is a tribute to his great achievements in this field. It serves also to show how the research he started in Federal and State laboratories has led to the discovery of more and more facts about a subject which has tremendous possibilities for advancing human welfare, not only by increasing the life span, but by making the adult years healthier, happier, and more efficient.

NUTRITION GUIDES TO FOOD PRODUCTION

Striking deep at our food and nutrition problem, the Bureau's nutrition experts are cooperating with agricultural economists to find what are the nutritional returns in important crops and livestock products from a given amount of land, labor, and other facilities. Such studies show in quantitative terms what has generally been recognized in principle—that many of the food crops are relatively more economical forms of food than are animal products, particularly if the feed is composed to any large extent of products that can serve directly as

human food. Taking one food as an illustration, corn, used directly by humans as corn meal, can provide about three times as many calories as the resultant pork and lard if the corn were used to fatten hogs. Hogs excessively fattened by grain and grain-fed cattle become a luxury in the face of world food shortages.

As compared with animals that can yield food only upon slaughter, the cow, providing milk as well as meat, has long been known to be an economical converter of feed into calories and protein. Milk is also an outstanding source of calcium and riboflavin, nutritive factors often relatively low in American diets. Nutritionists have, therefore, not only urged families to consume more milk but have also advised increased milk production and the use of an increasing proportion of what is produced for human consumption. The civilian demand for milk has stepped up considerably in recent years, and per capita consumption of milk and milk products (other than butter) is now almost 20 percent higher than it was in the 1935-39 period.

Among food crops, too, there are differences in the yield per acre or per unit of labor of calories, protein, minerals, and vitamins. Studies have been made, for example, of the relative economy, nutritionwise, in the production of different vegetables and fruits. As a result, recommendation was made to truck farmers to grow in wartime more of some and less of others—for example, more carrots, cabbage, beans, tomatoes, and onions, and less celery, cucumbers, and watermelons. Victory gardeners, likewise, were urged to grow crops that, for the space occupied, give the greatest returns in terms of minerals and vitamins—crops like tomatoes, carrots, beans, and leafy vegetables.

Paralleling these economic studies are feeding experiments with laboratory animals to find how we can best combine foods of plant and animal origin in diets that will promote growth, health, and general well-being.

For example, studies are under way on diets made up largely of cereals combined with small amounts of green leafy and root vegetables and varying amounts of meat, milk, or eggs. These, too, will provide information needed in the planning of both family and large-scale programs for the production and use of food.

HELPS TO BUDGET PLANNING

Though food is the number one item in the family budget, the war has brought inescapable proof of our need for better medical care also, particularly in rural areas. Spurred by the situation highlighted by the war, groups throughout the Nation are discussing post-war plans for improving rural health facilities.

The same study of family spending and saving that yielded invaluable material on dietary levels also furnished the basis for answering some of the current questions on expenditures for medical care. An analysis of what farm and city families spend for such services, issued by the Bureau this year in preliminary form, has already attracted wide attention. It will be amplified and printed during the coming year.

One of the important findings is that farm families spend about as much as city families for medical care, when money incomes are the

same. Most farm families, however, have lower incomes than city families, which is one reason why farm families have not been able to avail themselves of as good medical care as their city cousins. Other obvious reasons are that it takes a concentration of wealth and population to support the hospitals, doctors, highly trained specialists, and nurses found in cities. And even cities where hospitals and clinics are used to capacity have found endowment necessary in order to maintain up-to-date services and modern equipment.

Another outstanding difference in the practice of rural and urban families in obtaining medical care, disclosed by this study, is their use of prepayment plans. In farm communities, membership in prepayment plans has been confined almost exclusively to families in the lowest income groups. In urban areas, on the other hand, the proportion of families with membership in prepayment plans is small among low-income groups; most of the subscribers are in moderate or comfortable circumstances.

An estimate of the cost of adequate medical care in a rural community is now being made by the Bureau in consultation with the United States Public Health Service and other health agencies. This is being done in connection with developing rural family budgets for the study of real income on the farm as compared with urban communities.

Also as part of its continuing function of formulating budgets for various population groups, the Bureau has contributed to the setting up of minimum physical standards for the operation of war relocation camps and this past year published a guide to the preparation of minimum-wage budgets for women. Done at the request and with the cooperation of the United States Department of Labor, this publication provides State wage boards with an itemized list of the goods and services a wage-earning woman must have for healthful living, together with suggestions for pricing these. The Bureau's leadership is being sought in the preparation of such material because of its knowledge of requirements, based on laboratory research in food and clothing and Nation-wide studies of consumption habits. State wage boards report that by having this scientifically compiled list of items priced locally, they can arrive at a cost-of-living figure free from personal bias. This they find of invaluable help when setting the minimum wage for women required by State law.

COPING WITH THE CLOTHING SHORTAGE

Scarcities in supply of essential items of civilian clothing grow more acute as war continues. Clothing needs for the armed forces naturally have to come first. In this global war they include great quantities and varieties of clothing and textile articles for use in every climate from the subzero temperatures of the Arctic to the humid heat of the Tropics. In consequence, there has been neither manpower nor raw materials to produce the volume, variety, and quality of civilian goods to which we are accustomed. The resulting deterioration in fabric quality and the shortage of articles, particularly in the low-price ranges, have brought serious problems to homemakers.

To relieve the situation in some measure, the Bureau has furnished detailed information on conserving supplies now on hand. For example, so that women can develop professional skill in remodeling and

repairing both clothing and household articles, Bureau experts prepared manual-type publications as guides. These deal with making a standard type dress at home, cleaning and adjusting sewing machines, mending carpets and rugs, and making over coats, suits, dresses, and even knitted garments. Traveling exhibits of remodeled clothing supplement the printed material in a number of cases. Extension workers report that this material has helped to return to use thousands of articles that would otherwise have been wasted and has to that extent relieved buying pressure on new goods at the stores.

FUNCTIONAL CLOTHING

Wartime necessity has greatly accelerated the demand for functional clothing, not merely for wear at work, but for dress and street use. Although some of the present vogue may pass with the war, there are certain basic types of garments that can be greatly improved in comfort, convenience, and economy of making and laundering, by applying the principles of functional design.

Bureau clothing specialists contributed to this development with original designs for 17 women's work garments for use in field and factory. These have been widely reproduced in both patterns and ready-to-wear garments. This past year designs for 14 dresses and aprons for wear in the home have been completed and are now being released to the public through Government and trade channels. Attention will be turned next to the designing of infants' and children's garments with functional ideas as the basis.

That a more rational approach, based on scientific data, is needed for the sizing of clothing is widely recognized by industry as well as by the almost universal experience of men and women who attempt to buy clothes. Shoes probably cause the most trouble and have the greatest effect on health. Millions of American men and women are limping their way through life on feet deformed by ill-fitting shoes.

Before the shoe-sizing situation can be improved, a representative sample of American feet must be measured and these data used in building modern lasts for shoe manufacture. Industry recognizes this need and is giving informal cooperation to the work initiated by this Bureau, particularly through helping to select the foot contours to be measured.

For some time the method for measuring the contours of the human foot presented a difficult technological problem. This has now been solved on a laboratory scale, as has the method of transferring these data to paper where they can be subjected to statistical analysis. A pilot-scale study is now being made with groups of soldiers at one of the Army's reconditioning camps. After further perfecting the methods, the Bureau will be ready to train measurers and conduct a large-scale foot-measuring study to help solve one of the most fundamental problems in clothing hygiene.

COTTON-HOSIERY STUDIES

Five years ago at the request of the Congress, the Bureau began a series of laboratory and service tests on women's cotton hosiery, and since that date has issued 44 progress reports and technical publications on this study.

Accomplishments of this research on cotton hosiery proved of timely value in the wartime clothing situation. First, when the silk crisis came, the Bureau was able to make available to the trade over 200 designs for women's full-fashioned cotton hose. These included sheer, medium, and heavy weights in plain and fancy weave for street, work, and dress wear. Some of these designs were reproduced exactly and placed on the market. All furnished manufacturers with ideas for developing their own exclusive designs.

Other phases of this research provided information on yarns, finishes, and hosiery construction at a time when this was especially needed. These studies also served to show how the medium staple lengths of cotton fiber can be used acceptably in hosiery manufacture. Wearing qualities were determined by actually putting into service hose made of different varieties of cotton and with different yarn and fabric constructions.

These studies have unquestionably had an important influence on making cotton hosiery once again an accepted article in the well-dressed woman's wardrobe. They have shown cotton growers and hosiery manufacturers the possibilities of American-grown cotton in high-grade hosiery manufacture. And they have contributed important methodology to the scientific study of a standard article of clothing. Since the main objectives have been accomplished, this project is being redirected to a study of other types of knitwear.

AIDS TO MICROBE CONTROL IN FABRICS

Two series of investigations, undertaken at the request of the armed services, are yielding promising results for the better control of disease-spreading organisms in clothing. The objective of one series is to find a fungicide which, when added to the dubbing used in shoe dressing, will prevent reinfection with athlete's foot and keep shoes from mildewing, without, at the same time, producing toxic effects on the wearer of the shoes or harming the leather itself.

Of the large number of fungicidal chemicals now tested for this purpose in the Bureau's laboratories, several have been found to have good inhibiting action against the two harmful fungi. Results remain, however, to be further checked by storage experiments. The National Bureau of Standards is cooperating in this project by furnishing leather and dubbing, as well as making available equipment for physical tests on the leather.

As with shoes, great quantities of wool clothing and equipment have had to be discarded because the methods used to free them from dangerous micro-organisms have ruined their usefulness. How to sterilize wool in such a way as not to render the cloth harsh and boardy and the fibers weak is a problem of tremendous economic importance to the armed forces.

Previous research on wool sterilization by this Bureau afforded a good foundation for attack on this problem. As a result of studies undertaken at the request of the military services, methods have been found for sterilizing wool fabrics that leave them soft and pliable and with loss in breaking strength of less than one-sixth. In contrast, other commonly used sterilizing processes leave the fabrics harsh and stiff, with losses in breaking strength sometimes of more than one-third.

Closely allied to this work on ridding fabrics of bacteria injurious to health is the research on treatments of fabrics to make them resistant to mildew and insect damage. To be practical, such treatments must hold through sun and rain. Bureau studies had shown that certain natural dyes and some chemical compounds, such as copper naphthenate and copper sulfate combined with 8-hydroxy quinoline, are especially valuable for rendering outdoor fabrics mildew resistant. In cooperation with the Bureau of Entomology and Plant Quarantine, some of these same treatments applied to fabrics were subjected to attack by termites. Five of the sixteen treatments that were so tried have been found to be resistant to the insects.

A new method (the soil-suspension method) for determining mildew resistance of treated fabrics has been published and is included in Proposed Federal Specification of Test Methods for Mildew Resistance, for the evaluation of chemicals and treated fabrics offered for Government purchase.

COOPERATIVE FUR STUDIES

To meet the need for facts on the properties of fur for use in clothing and bedding by troops in Arctic climates, research was conducted on 17 furs and shearlings by this Bureau in cooperation with the Bureau of Animal Industry, United States Department of Agriculture, and the Fish and Wildlife Service, United States Department of Interior. For comparative purposes, 19 selected fabrics were also given similar study. The data developed covered such points in furs and fabrics as air permeability, weight per square yard, compressibility, resilience, and the amount of water they could absorb, as well as how much water vapor could permeate them. The two latter properties are closely related to the comfort of clothing and sleeping bags used by troops exposed to driving rain, sleet, and snow. Since the basic information desired by the armed services has now been furnished to the Quartermaster General's Office, the project is being closed.

INFORMATION FOR THE HOME FRONT

Supplying information to the home front by printed bulletin, press, radio, and picture continues to be the *modus operandi* of the information services. As fast as results become available from the Bureau's research, or authoritative compilations of scientific findings can be made, these facts are put into layman's language for use in the wartime programs. Much of this information feeds directly into home-front programs organized by the Office of War Information. These programs coordinate the efforts of Government agencies, educational organizations, and advertising and commercial interests, and provide the public with well-rounded, authentic information on subjects vital to civilian welfare.

During the last year this Bureau participated actively in three such programs—nutrition, food conservation, and use of temporary food abundances—and served as manager for still another, home food preservation. Besides preparing special materials on these subjects for distribution through State and local nutrition committees, schools, and extension groups, the Bureau furnished a steady stream of factual material to radio, magazine, and advertising-copy writers.

Wartime Family Living, the monthly digest started in January 1943, has been continued. This is a service to aid Extension workers and other field agencies in interpreting to farm families the economic factors and Government regulations affecting family living, such as price controls, regulation of quality, limitations on production, and direction of distribution.

The Bureau also maintained its flow of technical papers and interpretative articles to research and professional journals.

Totals for the year April 1, 1943, to March 30, 1944, are as follows: 30 bulletins printed or in press; 20 processed publications; 12 issues of Wartime Family Living; 37 scientific papers; 110 articles for magazines and press; 4 sets of educational charts (40 in all); 205 radio broadcasts on national networks.

That American families have adjusted as well as they have to conditions this past critical year of the war is due in no small measure to the eagerness with which they have sought and applied the findings of science to their everyday living.

REPORT OF THE CHIEF OF THE BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, AGRICULTURAL RESEARCH ADMINISTRATION, 1944

UNITED STATES DEPARTMENT OF AGRICULTURE,
Plant Industry Station, Beltsville, Md.,
September 15, 1944.

DR. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I submit herewith a report of the work of the Bureau of Plant Industry, Soils, and Agricultural Engineering for the fiscal year ended June 30, 1944.

Sincerely yours,

ROBERT M. SALTER, *Chief.*

RESEARCH FOR BETTER CROP PRODUCTION in the United States has resulted in benefits not only for those in agriculture and related fields but also for the general public and the Nation as a whole. Specific examples of these benefits, whenever they are assembled for such summary purposes as those served by an annual report, are surprisingly numerous, even to those most closely associated with the investigations.

Such summaries repeatedly reveal many accomplishments in reducing the costs and increasing the efficiency of farm operations: in making more certain an assurance of ample supplies of food, feeds, and fiber; in improving crop- and soil-management systems for a more readily sustained profitable production without the loss of basic resources; and in promoting the prospects for a future of human welfare and national security. These accomplishments, especially those noted during a period of great emergency, are further significant as indicating the facility with which research can be adapted to varied conditions and itself serve the constant purpose of adapting agriculture to changing circumstances.

COOPERATION CHARACTERIZES RESEARCH PROGRAM

It seems apparent on reflection that this success is due not only to the enterprise of agricultural scientists but also in large measure to the mechanisms for coordinated cooperative research that have been developed in this country and to the facility with which it has been possible to use these mechanisms.

The Bureau of Plant Industry, Soils, and Agricultural Engineering, for example—one of seven agencies whose programs are coordinated in the Agricultural Research Administration—is peculiarly concerned with national problems in administering the work at its central headquarters, at Federal field stations throughout the Nation, and at four regional laboratories. There are many accomplishments to be reported as a year's results in this work, and all but a very few of them are joint accomplishments of the Bureau and some State agricultural experiment station. A major part of the Bureau's work is, in fact,

carried on in cooperation with the States at 92 State experiment stations and substations.

Many of the accomplishments are likewise the results of cooperation with private agencies. So few have been the national problems without some major aspects which are also State problems that one of the most important services performed by this Federal agency for the entire Nation has thus been the coordinating help given to State, local, and private research enterprises.

It is not merely that these particular problems have in this way been solved more quickly. It is not merely that the waste in duplicated efforts has been avoided. It is rather that in the long run, considering all the possible benefits and beneficiaries, the farmers throughout the Nation, and the Nation itself, have been best served through cooperation. With the sort of program that has been developed, benefits to different groups are more nearly simultaneous, rather than serial. Growers throughout the country, in other words, can the more quickly apply benefits that might otherwise for years be enjoyed only in limited areas.

An outstanding recent accomplishment in plant breeding, for example, was the development of the means for producing hybrid onions. This is a finding of as great importance to onion growers as the earlier development of hybrid corn was to corn growers—a development that in 1943 added more than 650 million bushels to the national corn harvest. Yet, but for the means of cooperation that are available, it would be years before the benefits of hybrid onions could be enjoyed throughout the Nation.

It was, in fact, the discovery at a California experiment station of a male-sterile onion plant some years ago that suggested the possibility of a feasible hybrid onion seed industry. By 1944 it had been found that the genetic factor which made this plant male sterile could be introduced into other varieties, and intensive research at the Bureau's Plant Industry Station had demonstrated that such male-sterile parents when pollinated by another variety would yield seed capable of producing crops 20 to 50 percent greater than those produced by normal seeds. By introducing male sterility into a variety it had been proved possible to accomplish through genetics the same thing that is done more simply when the tassels of one hybrid corn parent are removed by hand.

Yet by 1944 only one actual hybrid onion variety—California Red Hybrid No. 1—had been released; only in the Southwest could onion growers realize the 20- to 50-percent increases that hybrid onion seed makes possible. Thus it was that in the spring of 1944 the hybrid onion greenhouses at the Plant Industry Station were operated on a 7-day-a-week basis, not for the creation of particular varieties, but for the production of foundation breeding stock that could be distributed to cooperators who simultaneously would develop many hybrid varieties, each adapted to a particular region. In this way, agricultural research gives its most effective service to the Nation.

COOPERATIVE RESEARCH PREPARED FOR WAR

How great such a service can be is evident in the difference that cereal breeding, for instance, has made in the Nation's situation since World War I—when disease-resistant cereal varieties were al-

most unknown, when stem rust took an enormous toll of a critical wheat harvest, and when, as a result, the Nation knew wheatless days and wheatless meals. Progress in cereal breeding has now not only removed hazards to an adequate production for domestic needs but also has helped greatly in making it possible for the United States to become the granary as well as the arsenal of democracy. Essential to this progress has been the cooperative nature of the cereal-breeding program, for as a result, the new varieties have included those specifically adapted to various regions. On some 65 million acres used for wheat, to cite one example, new varieties have supplanted or are supplanting the old in nearly all areas, and in each case the new varieties have resulted from cooperative programs. Similar developments have taken place with reference to oats, barley, flax, sorghum, and rice, and the now familiar development of hybrid corn has been one of the most revolutionary agricultural accomplishments of our time.

Also typical of the success with which the Nation's cooperative research facilities have been used in solving problems of producing war crops are the contributions made in connection with peanut production, to cite another specific example—contributions made not only through cooperation between State and Federal agencies but also through coordinated efforts of agricultural engineers, soil scientists, and crop specialists. Peanuts have been needed in much greater quantities than ever before—as a source of vegetable oil, for peanut butter and other food products, and for forage. As with other particularly war crops, many of which might be similarly discussed, research has been of great value in helping farmers make the needed expansion in production and make it in the wisest way possible. It has been found, for example, that if either Spanish or Runner peanuts are planted at twice the currently practiced rate of seeding the increased yields much more than pay for the extra seed. Three superior strains of the Spanish-type peanut have been developed and tested cooperatively at the Georgia Agricultural Experiment Station—strains that outyield current standard kinds by 15 to 20 percent and produce 50 to 100 pounds more oil per acre on good land.

What is good land—or the best land—for peanuts is a question that soil scientists have helped answer. During the war these scientists have given special emphasis to the soil requirements of hemp, guayule, and other critical war crops, as well as peanuts and food crops in general. Schematic soil maps have been prepared that show where such crops can be grown most effectively, and interpretive groupings of soil types have been shown on many existing maps. An outstanding example is the contribution to Georgia's cooperative publication on Peanut Production Possibilities in Georgia, and to a similar South Carolina cooperative publication, in which it was possible to include maps showing the excellent, good, fair, and unsuitable areas, which in many sections are intermingled.

Agricultural engineers likewise have contributed to the solution of peanut-production problems. A harvester, for example, has been built that will dig, shake, and windrow two rows of vines at a speed of 4 miles per hour. This machine, which has been thoroughly tried out, reduces the labor requirement to half a man-hour per acre, whereas 20 to 25 man-hours an acre were required with the one-mule equipment

and the hand methods commonly used. A farm-size sheller for hulling seed has also been developed, which is simple, effective, low in cost, and capable of shelling as many peanuts in an hour as a man can shell by hand in 300 hours.

Thus the advantages of State and Federal cooperation and the coordinated contributions of crop and soil scientists and agricultural engineers are apparent in a single example of recent accomplishments.

Fertilizer technologists also are involved in a broad program of integrated research; and a recent achievement in fertilizer technology, the development of granular ammonium nitrate, exemplifies still another aspect of cooperative agricultural research—cooperation with industry.

In the spring of 1943 surplus nitrogen as ammonium nitrate began to be released from munitions plants, offering a most fortunate solution to the nitrogen shortage except for the fact that ammonium nitrate, in the form available, absorbed so much moisture that its use was not practical. In cooperation with producers and with the fertilizer industry, investigators studied this problem in every conceivable way, and as a result in less than a year a suitable treatment had been devised. A new product—granular ammonium nitrate with a moisture-resistant coating on each granule—was perfected and made available.

FUTURE DEVELOPMENTS FORESEEN

Thus instances of achievement during only 1 year point clearly to the advantages of cooperative research, and the full annual report of the Bureau shows that such instances are numerous in all fields of activity—in cotton and fiber, forage, rubber, sugar, tobacco, and drug and related crops; in forest pathology; dry-land and irrigation agriculture; mycology and nematology; and plant exploration and introduction, as well as in the fields from which specific examples have been chosen. Just as clearly would a survey of the present needs point to the importance of further progress along the same lines, particularly in the post-war years immediately ahead; for American agriculture, so largely exploitive in the past, can most effectively through research make an efficient and profitable use of soil and other resources on a sustained and permanent basis.

There is not yet an adequate knowledge of all our soils. Adapted crops resistant to diseases are available for only a relatively small part of our crops and crop areas. Very little has yet been accomplished in developing insect-resistant varieties, and they can be developed. Suitable pasture grasses and legumes are still unrealized needs for sound land use programs in large areas of the country. Knowledge of human and animal nutrition in relation to soils and the crops grown on them is still in its infancy. Much can still be done to increase efficiency in handling, storing, and transporting products and in developing labor-saving devices. The mechanisms now available for cooperative research must thus be developed further and used even more effectively than they have been in the past.

ORGANIZATION OF THE BUREAU'S WORK

Conducted with these basic objectives, the work of the Bureau of Plant Industry, Soils, and Agricultural Engineering comprises investigations of soils, fertilizers, plants, farm machines and structures, and methods of growing, harvesting, storing, and doing certain primary processing of crops.

Soils are studied from the standpoint of their distribution, adaptation to use, and management. By means of surveys and maps—combined with experiments in the field, greenhouse, and laboratory—systems of management for efficient crop production and soil improvement are determined. Problems of soil fertility, fertilizers, soil tilth and tillage, drainage and irrigation, salinity, and soil-borne plant diseases are all involved.

Fertilizer investigations include the development of improved materials and more efficient methods of manufacture and use.

Research with plants is concerned with reducing production hazards and improving the quality of crops. One of the principal ways of doing this is by breeding new strains or varieties that are resistant to disease, heat, drought, and cold.¹ Many of these result from plant exploration and introduction from other countries. Other studies are concerned with weed control and methods of planting, harvesting, transportation, and storage of crop plants.

Agricultural engineering research includes the design of new machines or the improvement of old ones; development of new methods of carrying out farm operations, including seedbed preparation, planting, cultivation, harvesting, storing, and primary processing; and the design of farm buildings and equipment.

The Bureau maintains experimental farms, greenhouses, and laboratories at its national headquarters at the Plant Industry Station, Beltsville, Md., and conducts research in cooperation with the State agricultural experiment stations, at various field stations and laboratories throughout the country, and at four regional laboratories—the United States Regional Vegetable Breeding Laboratory, Charleston, S. C.; the United States Regional Pasture Research Laboratory, State College, Pa.; the United States Regional Soybean Laboratory, Urbana, Ill.; and the United States Regional Salinity Laboratory, Riverside, Calif. It also administers the National Arboretum at Washington, D. C.

The Bureau is organized in 17 units, as follows:

Chief of Bureau.....	Robert M. Salter.
Assistant Chief.....	F. P. Cullinan.
Assistant Chief.....	M. A. McCall.
Agricultural Engineering.....	George R. Boyd.
Cereal Crops and Diseases.....	M. A. McCall.
Cotton and Other Fiber Crops and Diseases.....	H. W. Barre.
Drug and Related Plants.....	D. M. Crooks.
Dry Land Agriculture.....	C. E. Leighty.
Forage Crops and Diseases.....	Olaf S. Aamodt.
Forest Pathology.....	Lee M. Hutchins.
Fruit and Vegetable Crops and Diseases.....	J. R. Magness.
Irrigation Agriculture.....	C. S. Scofield.
Mycology and Disease Survey.....	H. A. Edson.
Nematology.....	G. Steiner.
Plant Exploration and Introduction.....	B. Y. Morrison.
Rubber Plant Investigations.....	E. W. Brandes.
Soil and Fertilizer Investigations.....	F. W. Parker.
Soil Survey.....	Charles E. Kellogg.
Sugar Plant Investigations.....	E. W. Brandes.
Tobacco Investigations.....	W. W. Garner.

AGRICULTURAL ENGINEERING

Agricultural engineering research has aimed to make possible a greater use of labor-saving machinery and improvements in farm structures. This has involved studies of the ways in which machines can be kept in the best of repair; designing of simple attachments or adjustments to enable machines to do more and better jobs; development of new machines for producing, harvesting, and processing crops, including many not previously grown but brought into prominence by war requirements; and the designing of farm structures. The work in designing fertilizer-distributing machinery has also involved studies of fertilizer placement. The cutting-off of normal

¹The 1944 annual report includes 43 new and improved varieties—12 corn hybrids, 4 sorghum, 3 flax, 3 wheat, 2 alfalfa, 2 cabbage, 2 potato, 2 sugarcane, and 1 each of barley, bluegrass, bromegrass, broomcorn, buffalo grass, lespedeza, lettuce, onion, peach, pumpkin, snap bean, soybean, and strawberry.

supplies of hard fibers, oils, and insecticides has made especially urgent the development of new processing equipment and methods for use in producing emergency crops. Better farm storage for farm crops has been another objective of agricultural engineers. The shortage of materials heretofore commonly used for storage structures has called particularly for the development of plans for storages built of noncritical materials.

MECHANIZATION HELPS PEANUT GROWERS

On account of the importance of peanut production in the war program special attention has been given to the mechanization of this crop at all stages. It has always been difficult, for example, to obtain shelled peanuts for seed, because commercial shellers split a large number of nuts and unless the shelled seed were planted promptly the germination would be low. It was thus necessary generally to shell the peanuts by hand, a slow and tedious operation. As already pointed out on page 4, the farm-size sheller now developed can shell in an hour as many peanuts as a man can shell by hand in 300 hours.

A single-row, one-horse planter, particularly suited for use on small farms, has been developed that opens the seedbed, puts down the fertilizer, and plants the seed in one operation. This machine, which can be used for planting corn as well as peanuts, saves 50 percent of the time required for performing these operations in the usual manner. A commercial adaptation of this planter is now on the market, and a number of machines are being used in the planting of the 1944 crop. A harvester to dig, shake, and windrow two rows of vines at a speed of 4 miles an hour has already been described on page 4.

HOME-MADE EGG COOLERS DESIGNED

During 1943 about 239,000,000 dozen eggs were lost in this country somewhere between the nest and the table. Undoubtedly the greater part of this loss occurred on the farm before the eggs were put in the regular marketing channels. Two egg coolers using the cooling effect of water evaporated from saturated curtains have now been designed to help avoid this loss. Such inexpensive home-made coolers, when augmented by an electric fan, have maintained egg qualities so well during tests that one-third more eggs have been graded "extras" than after normal home storage.

TESTS SHOW HOW PROPER PLACEMENT OF FERTILIZER INCREASES YIELDS

Studies with vegetable crops during the past year have shown that, as with other crops, it is important to know how fertilizer is best placed to get the most out of its benefits. In western Washington, for example, deep placement of fertilizer directly under the seed gave the highest yields of carrots, spinach, and Swiss chard. Gains in crop yields per acre from this placement compared with the normal method of broadcasting the fertilizer were over 4,000 pounds of carrots, 136 pounds of spinach seed, 3,300 pounds of cannery spinach, and 6,800 pounds of Swiss chard. With peanuts under dry conditions in Virginia it was found, on the other hand, that yields were increased by placing the fertilizer in a band at each side of the row; placement immediately under the seed materially reduced the yields. Cannery peas also produced the largest yields when the fertilizer was placed in a band 1 inch to the side of the row and slightly below the seed level.

In New York State the highest yields of tomatoes were obtained when half the fertilizer was deeply placed in a band in each furrow at the time of planting and the other half placed in a band at each side of the row at the time of setting the plants. A similar system gave the best results with cabbage, two-thirds of the plant food in this case being applied in the bottom of the plow furrow. Yields for different placements of the fertilizer differed as much as 2 tons of cabbage per acre, showing the economic importance of proper placement.

PAINTING METAL GRAIN BINS WHITE GUARDS AGAINST INSECT DAMAGE

One of the principal difficulties encountered in grain storage in the southern part of the Grain Belt is the activity of insects in the early spring months. It has been found that if metal grain bins are painted white the temperatures of the grain within the bin will be about 10 degrees lower than in similar unpainted bins, a difference sufficient to keep dormant insects from propagating for around a month.

CORNCRIB STUDIES HELP PREVENT DAMAGE FROM MOISTURE

Studies of the storage of ear corn in cribs on farms have revealed that the most common cause of spoilage of ear corn in storage is the cribbing of corn with too high moisture content. Whenever the moisture content of the kernels at the time of storage is greater than 20 percent, storage without appreciable damage becomes difficult. With damp corn it is important that the cribs be narrow and that free circulation of outside air be obtained. This means that the cribs should be some distance from other buildings and from windbreaks, especially on the side toward the prevailing drying winds. A practical means of reducing loss from corn with too much moisture is turning or moving it in such a way that damaged ears can be sorted out and the others mixed with the drier corn.

COMPRESSING COTTON BALES SAVES STORAGE AND SHIPPING SPACE

The Cotton Ginning Laboratory, at Stoneville, Miss., has been working for several years in perfecting equipment to press cotton at the gin to a standard density of about 22 pounds per cubic foot to take the place of the ordinary ginning press that works only at a low density of 11 pounds a cubic foot. Last year an experimental press was installed in a commercial gin in the Mississippi Delta with more satisfactory results.

During the past year a similar press has been installed for extended trials in a commercial gin in the western Texas area where the cotton is different from that grown farther east. The operation of this press has been entirely satisfactory. It was found that 130 bales of standard density can be loaded in an ordinary freight car that would hold only 80 of the low-density bales. This means a considerable saving in storage space and in freight rates and speeds up the progress of the cotton from the gin to the textile mill.

NEW MECHANISM PREVENTS AIR CUTS IN COMPRESSED COTTON

For many years textile mills and export buyers of American cottons have reported that an excessive number of bales have been injured by air cuts while being compressed. It was originally thought that these cuts were due to air under pressure being forced out of the lint by the compress, but it has now been determined that they were caused

by unequal packing in the bales attributable to the action of the "dogs" used to hold the lint in place during pressing at the gin. A plate-dog mechanism that entirely eliminates cutting of the bale when it is compressed has accordingly been designed for use in ginning presses. This mechanism also makes for a more uniform distribution of the lint within the bale. More than 300 bales have been pressed in a commercial gin using this new device, and none of these bales showed any air cuts when the cotton was compressed to standard density. Prior to the installation of this new mechanism more than 50 percent of the bales pressed at this gin were cut during compression. This device is simple and easily installed, and the right to manufacture or use it has been made available to all through a public-service patent.

CEREAL CROPS

Research on cereals has been concerned mainly with the further development of varieties of these crops that will produce well in spite of disease and insect pests. Carried on in close cooperation with State agricultural experiment stations, the work has been aimed specifically at providing such varieties for each part of the country. Cereal crops have also been developed for special uses of their products, as waxy corn and sorghum for tapioca substitutes and flax for greater oil content. Other cereal studies have dealt with the practices used in planting, cultivating, and harvesting. Allied with the research on cereals have been intensive investigations on weed control.

CORN HYBRIDS GAIN MOMENTUM IN THE SOUTH

Hybrid corn got off to a slower start in the South than in the Corn Belt. As corn hybrids began to make good in the Corn Belt, corn breeders in the South turned their attention to the development of hybrids adapted to that territory. These efforts now are bearing fruit, and new hybrids bred in the South from adapted southern varieties rapidly are becoming available for commercial planting. Southern hybrids first became available in Tennessee and are now grown on about 150,000 acres in that State. The Tennessee hybrids also are well suited to parts of neighboring States.

Seven new Louisiana hybrids have entered commercial production in 1944. These hybrids have been exceeding by 25 percent the yields of the best local varieties now available. As a result of this outstanding performance, the demand for seed has far exceeded the supply. Plans are being developed to expand seed production as rapidly as possible. Five promising new double crosses also are coming into commercial production in North Carolina, two white and three yellow. The white hybrids are suited to the lower coastal plain, two of the yellow hybrids are suited to the Piedmont section, and the third yellow hybrid has made an excellent record in the mountain section.

HIGH EXPANSION AND QUALITY OF HYBRID POPCORN PUSH PRODUCTION

Popcorn hybrids developed in cooperation with the Kansas and Indiana Agricultural Experiment Stations are increasingly in demand by both growers and consumers. Consumer interest in these hybrids is based on their improved quality, tenderness, and flavor. Tenderness is associated closely with popping expansion, and the new hybrids have popping expansions of 26 to 33 times their original volume, exceeding the open-pollinated varieties by about 15 percent in this

respect. Grower interest centers in their yielding ability. The Kansas hybrids have outyielded Supergold and South American, the better open-pollinated varieties, by 50 to 100 percent and have been equal or superior to the varieties in other agronomic characters. In trials in 1941 and 1942 Indiana Popcorn Hybrid 31 averaged 4,600 pounds of ear corn per acre, compared with 2,600 pounds for open-pollinated South American, the most widely grown variety. Other Indiana hybrids have similar performance records.

EARLY VARIETIES OF WHEAT ESCAPE DAMAGE AND DISTRIBUTE RISKS

Wichita, a new very early maturing variety of hard red winter wheat, has been approved for distribution in southwestern Kansas, western Oklahoma, and northwestern Texas as soon as supplies of seed can be increased. It is expected to be an important addition to the list of varieties available to farmers in those areas who like to put a part of their acreage in an early-maturing variety in order to distribute harvest labor. Early-maturing varieties, also, may escape damage from rusts, hot winds, drought, or hail when others are badly damaged. Early Blackhull is the only very early maturing variety now grown in the southern Great Plains. Wichita, about as early as Early Blackhull, is of much better quality and produces heavier grain and higher yields.

NEW WHEAT VARIETIES RESISTANT TO HESSIAN FLY

The distribution of Pawnee hard red winter wheat in southeastern Nebraska and eastern Kansas is expected to reduce losses from hessian fly, which in 1943 amounted to an estimated 25,000,000 bushels of wheat in Kansas alone. Pawnee is not resistant to all races of hessian fly but will prevent some damage. It is also resistant to leaf and stem rust, loose smut, bunt, and lodging, and is highly satisfactory in other respects.

Other new varieties more completely resistant to hessian fly as well as to the more prevalent diseases are being developed. More than 300 selections of various crosses known to be resistant to hessian fly are being tested in Kansas for yield, quality, and resistance to various diseases. In a similar manner, several thousand selections from hybrids having hessian-fly-resistant parents are being grown in Indiana to test them for yield, quality, and resistance to the fly and various diseases generally prevalent in the East. Big Club 43, recently approved for distribution in California, is expected to reduce greatly the losses from hessian fly in that State. It is not only highly resistant to the prevailing races of fly but also to bunt and stem rust. Satisfactory fly-resistant varieties, by permitting the sowing of winter wheat at the most favorable time, will do a great deal to reduce losses from winter-killing.

GLACIER—A SUPERIOR NEW IRRIGATED BARLEY FOR MONTANA

Glacier, a new barley developed in cooperative tests in Montana, is a stiff-strawed, six-rowed type with a semismooth awn and relatively short semidense head, recommended for the irrigated lands of Montana and for nonirrigated land where moisture supplies are ample. It has yielded about one-fourth to one-third more than Trebi, formerly the leading variety commonly grown in Montana. Glacier matures early, which makes it a desirable variety to grow in the higher moun-

tain valleys, where the season is short. Its earliness also is of value when it is grown as a companion crop with legumes and grasses. It is highly resistant to covered smut but susceptible to loose smut. Glacier is less susceptible to attack by grasshoppers than varieties formerly grown. In hog-feeding tests, it proved to be slightly superior to Trebl.

FULLTIP BROOMCORN VARIETY MAKES BETTER BROOMS

Fulltip, a new variety of dwarf broomcorn, is unique in the large number of fine fibers or seed branches that develop near the tip of the brush, a characteristic which greatly enhances sweeping quality in a broom. First distributed in 1942, Fulltip is rapidly becoming popular in western and central Oklahoma. The brush is of medium length and smooth except near the tip, where the numerous seed branches are concentrated. These branches bear a large number of seeds so that good yields are obtained when the crop is saved for seed. Another important character is the long handle which bears the brush well out of the boot so that very little staining occurs, as is common in all other varieties of dwarf broomcorn. This greater freedom from staining enables farmers to grow the dwarf Fulltip in humid sections where heretofore only standard (tall) varieties relatively free from staining have been grown. The dwarf Fulltip can be cut or pulled directly from the standing stalk, whereas the standard broomcorn stalks usually must be broken over or "tabled" before cutting begins. The crop residues from dwarf broomcorn can also be turned under readily, whereas tabled standard broomcorn stalks often must be cut, raked, and burned before the stubble can be plowed.

NEW STIFF-STALKED SORGHUMS PREVENT LOSSES

A new unnamed variety of sorghum, Kalo Selection No. 617, seed of which was released for more than 20,000 acres in 1944, is remarkable in its ability to remain erect until long after maturity. It thus avoids the heavy grain losses from broken stalks common to other grain sorghum varieties that are harvested with a combine. Tests in 1943 on 400 acres of Kalo Selection No. 617 on 16 farms widely distributed over the western half of Kansas showed that the loss from lodged or broken stalks at the time of combine harvest was less than 0.5 percent. In ordinary varieties, losses up to 50 percent are common. The stalks of Kalo Selection No. 617 remain stiff and relatively free from decay, while those of other "combine" varieties often rot and break over at the upper joint soon after the grain is ripe.

CODY WAXY SORGHUM SUPPLIES STARCH FOR PUDDING AND PIE

Cody, a new variety of waxy sorghum, developed at the Fort Hays Branch Experiment Station, Hays, Kans., in cooperation with the Kansas Agricultural Experiment Station, was increased from breeding nursery rows in 1941 to sufficient seed for sowing on 32,000 acres in 1944. Tapioca starch, formerly imported from the Dutch East Indies, is no longer available here for use as food. Fortunately, starch from Cody sorghum has been found to be equal or superior to that from tapioca for either food products or for making adhesives. Cody was found to be superior to other waxy sorghums in several important characteristics. The grain is white and thus free from water-soluble pigments that are difficult to remove from starch, whereas other

commercial waxy varieties have colored or spotted seed coats. Cody grain is larger and softer and thus easier to mill. The stalks also are shorter, permitting the crop to be harvested with a combine more readily.

NEW FLAX VARIETIES HAVE GREATER OIL VALUE

War demands for increased supplies of linseed oil have given increased importance to the breeding of flax of higher oil content and quality of oil. An extensive flax-breeding program conducted in cooperation with the Minnesota, North Dakota, and Montana Agricultural Experiment Stations has resulted in the development of several new varieties of flax which not only yield more than varieties previously grown but also have a higher oil content and better drying quality of oil when grown under different climatic conditions in the United States. Three new varieties were released to growers of certified seed in 1943. Crystal, C. I. 982, is a selection from a cross of Bison with Ottawa 770-B, developed at University Farm, St. Paul, Minn. In addition to being highly resistant to rust, its seed yields a high percentage of oil of excellent drying quality. The variety appears to be well adapted to Minnesota conditions. Renew is an early-maturing, rust-resistant variety well adapted to the Northern Great Plains. Arrow, a selection from a cross between Bison and Renew, is similar to Bison in most characteristics except that it is resistant to rust. All of the new varieties are resistant to wilt. Seed will be available for general planting in 1945. In 1944 about 1,000 acres of Crystal was grown for increase of seed in Minnesota; 1,200 acres of Renew in North Dakota; and 400 acres of Arrow in Montana.

METHODS FOUND FOR CONTROLLING BINDWEED

New weed-control methods developed in a cooperative research program during the past 10 years are being rapidly adopted on farms throughout much of the Great Plains, in the Pacific Northwest, and in the Intermountain States. In Kansas, a control program based on research in cooperation with the State experiment station has eradicated bindweed on more than 50,000 acres of infested land, including more than 30,000 small patches that in a few years would otherwise have spread the infestation. It is estimated that the bindweed will be brought under complete control in the State within 10 years. Similarly, in Nebraska 48 weed-eradication districts comprising an area of approximately 6,200,000 acres are now in operation. The new practices are based on two discoveries: (1) That when perennial weeds are cut off they do not begin to replenish the food stored in their roots until they have grown above ground for some time, usually about 2 weeks, and (2) that European bindweed and some other weeds are very sensitive to shade and cannot grow well under a smother crop. These discoveries led to the simple and effective recommendation that to control such weeds one should cultivate every 2 weeks during the growing season or keep them completely covered with a smother crop.

COTTON AND OTHER FIBER CROPS

The research that during peacetimes has been designed to improve the quality of cotton, flax, hemp, and other fibers, develop better varieties, and improve cultural practices that will reduce cost of production has, during the war, been adapted to meeting emergency fiber and food problems. Research on cotton has been centered on in-

creased production of new and improved varieties that produce the kind and qualities of fiber needed in making more than 11,000 different cotton articles for war and civilian use and on increasing the supply of cottonseed for food, feed, and oil and for linters for smokeless powder and other war uses. Research with other fibers, such as abaca (Manila hemp), yucca, sansevieria, flax, hemp, certain imported fiber plants, and milkweed floss, has been directed toward developing improved practices and methods for increasing production of the fibers that can be grown in this country and toward aiding in the expansion of production in this hemisphere of abaca and other tropical fiber crops formerly supplied from the Philippines and other tropical islands and countries.

BREEDING WORK DEVELOPS COTTON WITH INCREASED STRENGTH

With X-ray, breeding, fiber, and spinning research as a background, rapid progress has been made in cooperation with the State experiment stations and private breeders in developing varieties with increased strength. In California, where the only variety that is grown originated from the Shafter Cotton Field Station, the strain of Shafter-Acala that was in production several years ago was found to produce a relatively weak fiber. Intensive breeding work has improved the strength, and a new strain is now in production on the entire cotton acreage of the San Joaquin Valley.

In Arizona the Pima variety of American Egyptian cotton, bred some years ago, had never been accepted by the spinners as being entirely the equal of imported Egyptian, and intensive fiber and spinning studies revealed that this was also relatively weak. The Pima Sakel cross (S×P) produced at the Sacaton Field Station is much superior to Pima and has entirely taken its place in the American Egyptian producing areas.

In New Mexico, College Acala, which was widely grown 4 or 5 years ago, was found to have poor fiber structure and less strength than was required. The new Acala 1517, bred at this station, is stronger than any other cotton of its length and is now in general production in the irrigated sections of New Mexico and west Texas. In Georgia the new variety Empire, developed in a joint breeding program at Experiment, is definitely better than the Stoneville variety from which it was selected and was in one-variety production for the first time during 1944. In the Mississippi Valley and the Southeast, Deltapine 14 and Coker 100, developed by private breeders, have been improved in strength by similar processes and are now planted on larger areas than any of our other improved varieties of cotton.

CELL STRUCTURE OF COTTON FIBERS EXPLORED

Studies in which it has been possible to explore even the cell structure of cotton fibers have shown that the strength of the fibers can be increased by causing a flow in the cell-wall substance that aligns crystalline cellulose more nearly parallel with the fiber axis. It has been demonstrated that undried cotton fibers are plastic, and even previously dried fibers can be rendered somewhat plastic in water at 58° to 60° C. or in a 7- to 8-percent solution of sodium hydroxide. The implication of this discovery is that commercial methods may be developed whereby previously dried fibers may be swollen and then stretched, resulting in a great increase in the tensile strength.

STUDIES MADE OF HARD FIBER SUBSTITUTES

Certain imported hard fibers—abaca, sisal, henequen, and istle—furnish the raw material for cables, rope, binder twine, and hard-fiber twines. The critical shortage of these fibers has necessitated a search for acceptable substitutes that might be produced in this country. In the Southwestern States there are large areas of different species of wild yuccas, all of which produce fiber. In Florida there are limited areas of sansevieria, which also produces a hard fiber. In order to determine the practicability of utilizing these plants for fiber, field surveys have been made of the principal yucca areas in the Southwest and detailed information has been obtained regarding the distribution and stands of these plants. Experimental plantings of sansevieria have been made in Florida, and methods of cleaning and processing this fiber have been investigated. Although neither yucca nor sansevieria fiber has yet been produced in commercial quantities, detailed information regarding the possibilities of these two plants as domestic sources of fiber is being made available through these studies.

MILKWEED FLOSS STUDIED AS SUBSTITUTE FOR KAPOK

Extensive research work testing the buoyant properties of many plant flosses and similar material have shown the relative value of a number of such materials as substitutes for kapok in lifesaving equipment, most important of which appears to be the seed floss of milkweed (*Asclepias syriaca*), which has a relatively high buoyancy and a specific gravity slightly less than that of kapok. These factors influenced its choice by Government agencies for utilization as a substitute to help conserve our diminished supplies of kapok. The War Production Board authorized the Department of Agriculture to collect milkweed floss from wild stands. The Commodity Credit Corporation, through its War Hemp Industries, Inc., collected in Michigan in 1943 sufficient pods to gin approximately 90,000 pounds of floss. In anticipation of a need for information in case it became necessary to cultivate milkweed, surveys and studies have been conducted in cooperation with State and Federal agencies to serve as a basis for cultural recommendations.

DRUG AND RELATED PLANTS

Research on drug and related plants has been concerned with a large number of more or less specialized commodities used in the manufacture of medicines, condiments, flavors, perfumes, paints and varnishes, insecticides, and tanning extract and produced by plants growing in various parts of the world. The possibilities and problems in growing or collecting such plants in the United States have been investigated by determining the cultural requirements of such plants, the regions most suited for their production, the cost of production, and the difficulties involved in their production under varying conditions. Such studies have included improvement of the plants for productiveness and quality of their products through the selection and breeding of new varieties and sorts possessing disease resistance and other improved quality characters. These investigations have involved field testing, plant breeding, experimental greenhouse work, and technical laboratory analysis and evaluation.

SPECIMEN GARDEN IMPORTANT RESERVE FOR DRUG AND RELATED PLANTS

Of practical importance to the many people interested in growing drug, condiment, and oil-yielding plants has been the specimen garden developed and maintained at the Plant Industry Station, Beltsville, Md. Of the large number of plants used for their drug and condiment properties, over 200 species and varieties have been assembled and grown in this garden. In many cases these plants have become the country's only reserve stock. Seeds and planting stock of authentic and tested varieties have been an invaluable source of propagating material for Japanese peppermint, belladonna, digitalis, Dalmatian sage, tarragon, pyrethrum, paprika, and many others. Observations and records made to determine the behavior and growth habits of these plants under existing soil and climatic conditions have likewise been invaluable as a guide for handling such little-grown plants.

RESEARCH PREPARES WAY FOR DOMESTIC INSECTICIDE PRODUCTION

To develop domestic sources for insecticides nonpoisonous to man, extensive research has been carried on with many plants of the world, and promising results have been obtained with one species in the United States, *Tephrosia virginiana*, commonly called devils-shoe-strings. This species is widely distributed throughout the eastern and Gulf Coast States and a few individual plants were found to contain as much as 2 percent rotenone. A cooperative breeding and selection program with the Texas Agricultural Experiment Station and other agencies has produced a population of plants that consistently yield about 2¼ percent rotenone in the roots, with a yield of approximately 2,500 pounds of dried roots an acre from 2-year-old plants. Approximately 8 acres of strains with a wide range in rotenone content are now on hand, being assayed to select those of greatest promise.

Much of the material now developed has more than 2¼ percent rotenone, and a considerable number of the strains contain as much as 8 and 9 percent, which is comparable to the rotenone content of other plant materials now imported for commercial use. When the high-yielding strains can be field-tested and increased they are expected to be of considerable importance in supplying planting stock that can be grown on sandy soils in the Gulf Coast States for insecticides for local use. They also suggest the possibility of supplying materials for commercial production of insecticides of domestic origin.

DRY-LAND AGRICULTURE

To aid in developing a more stable agriculture under dry-farming conditions in the Great Plains and other semiarid regions, research has been, as in the past, so directed as to improve cultural methods and crop rotations whereby adapted crops, including grasses, can be combined in farm practices that will make the most efficient use of limited rainfall on different types of soil for cash crop production and feed for livestock. Research on dry-land problems has also been concerned with the production of adequate supplies of home-grown fruits and vegetables and with the selection of the kinds of trees and shrubs best for windbreaks and the cultural methods through which they can best be grown in farmstead windbreaks on Great Plains farms. Studies both by specialists in dry-land agriculture and by other crop specialists of the Bureau have been carried on at dry-land field stations, and data have been acquired on the performance and

yield of crops under recorded conditions of soil, cultivation, weather, and soil moisture.

CRESTED WHEATGRASS PROVES PROFITABLE FOR PASTURE AND HAY

In pasturing experiments with steers at the Central Montana Branch Station, Moccasin, 10-year average annual gains per acre were 78.6 pounds on crested wheatgrass, 54.4 pounds on bromegrass, and 36.9 pounds on native range. It has also been determined that crested wheatgrass makes good hay. In winter feeding trials at Moccasin, crested wheatgrass hay cut prior to bloom stage proved equal to or slightly better than hay made from native grass.

NEW GRASS PROVES VALUABLE FOR NORTHERN PLAINS REGION

During the past year forage-crop specialists working at the Mandan (N. Dak.) station accumulated sufficient data to assure the potential value of Russian wild-rye grass (*Elymus junceus*) as a supplement to the native range grasses or crested wheatgrass for the dry-farming areas of the Northern Plains. Grazing and palatability trials have shown that crested wheatgrass is more palatable early in the season but that the Russian wild-rye is highly preferred later. During 1943, Hereford steers on Russian wild-rye pasture made average gains of 326 pounds per head over a 140-day period (May 11 to September 28) with a carrying capacity of 1½ acres per head. Similar animals on crested wheatgrass and mixed grass pasture gained 251 pounds per head, the crested wheatgrass furnishing pasture for only 80 days and the mixed pasture 75 days. *Elymus junceus* also has a much more rapid recovery after grazing than many other perennial adapted grasses. Preliminary tests indicate that this grass may be used in a mixture with crested wheatgrass to increase the pasture production and length of grazing season. The seed-production habits of Russian wild-rye are equal and possibly superior to that of crested wheatgrass. Russian wild-rye grass was imported in 1927 from the Western Siberian Experiment Station at Omsk and has since then been propagated at the Mandan station.

MOWING CONTROLS SAGEBRUSH AND INCREASES GRASS AND BEEF PRODUCTION

Millions of acres of range land in the West are heavily infested with sagebrush and other shrubs, which seriously compete with adapted grasses and reduce livestock production. A surprisingly high degree of improvement in grass and beef production has been obtained at the Woodward (Okla.) station in recent years by mowing of sagebrush and other competitive plants, in accordance with the results of investigations by forage crop specialists working at this station. The combined results of field and laboratory studies show that mowing once each year for 2 successive years, sometime between May 15 and July 15, but preferably in June, has reduced the cover of sagebrush over 90 percent and of skunkbrush by 70 percent. This practice also makes the remaining brush plants more palatable as winter browse, controls many weeds, and doubles the cover of grass on the land. In addition, the mowed pastures produced greater gains in livestock. Mowed pastures supported 55 percent more cattle on 17 percent less total acres of land than did the nonmowed pastures. The grade Hereford steers used in this experiment gained an average of 384 pounds per head during the season on the mowed pastures, or 79 pounds more than those on the nonmowed pastures.

INSECT- AND DISEASE-RESISTANT SORGHUMS DEVELOPED

Cache feterita, a new sorghum highly resistant to chinch bugs, and Club \times Day No. 16 milo, the only combine-type milo resistant to chinch bugs and charcoal diseases, have been developed at the Lawton (Okla.) station in a cooperative program to produce insect and disease-resistant sorghums. A few small lots of seed were distributed this year.

FORAGE CROPS

Special emphasis has been placed on those lines of investigational work with forage crops that have seemed to make possible the greatest contributions toward increasing the production of feed and seed to help meet wartime demands for increased supplies of meat, dairy products, and wool and toward increasing the production of soybeans and other critical crops. The research objectives have included reductions in losses from drought, disease, cold, heat, and other hazards, increases in yields of forage and seed; improvements in the value of forage for livestock feed; and a greater and more successful use of legumes for winter cover crops. As in the past, the work has consisted primarily of field, greenhouse, and laboratory experiments carried out in cooperation with State agricultural experiment stations, different Federal agencies, farmers, various crop-improvement associations, and other similar groups. Forage crop scientists have also helped in the establishment and maintenance of turf cover on military airports, cantonments, and other problem areas.

METHOD DEVELOPED FOR PRODUCING HYBRID ALFALFA

A method has been developed by which hybrid alfalfa is produced by natural crosses between specially selected, self-sterile plants, vegetatively propagated. Double crosses may be made by planting seed of two single crosses in alternate rows in a seed-producing field. In cooperative work with the Nebraska Agricultural Experiment Station, single crosses have been made under field conditions and tested for forage production. Some of these were significantly higher in forage production than the best commercial varieties. In addition to resistance to bacterial wilt some of the single crosses were relatively resistant to alfalfa yellowing caused by the potato leafhopper. Some of the leafhopper-resistant hybrids had a carotene (vitamin A) content twice as high as that of standard commercial varieties grown under similar conditions.

BUFFALO AND NEMASTAN ADDED TO THE GROWING LIST OF NEW ALFALFAS

Buffalo, a wilt-resistant strain of alfalfa, adapted to approximately the same area as Kansas Common, has been developed in cooperation with the Kansas Agricultural Experiment Station. In 1943 about 5,000 pounds of seed of this strain were produced. The new wilt-resistant strains are demonstrating their superiority in tests where bacterial wilt is a factor. In the third year of a test at the Iowa Agricultural Experiment Station, for example, Buffalo and Ranger, a wilt-resistant variety announced last year, were the highest yielding strains. They produced 69 percent more forage than Grimm and Kansas Common. In a seed-productivity test in Utah, Ranger and Buffalo ranked first and second in a comparison of 25 strains and varieties.

The stem nematode has made alfalfa production in some areas of Nevada, Utah, California, and adjacent States almost impossible. To combat this condition a new strain called Nemastan is being increased for commercial use in these areas. Nemastan is a selection from a collection of alfalfas brought back from Turkistan by H. L. Westover that proved to be resistant to nematodes, as well as to bacterial wilt. Food production in many of the irrigated valleys of these States will profit by the use of this new strain, because alfalfa hay is the mainstay of livestock production in many of these areas.

CULTURAL PRACTICES RECOMMENDED TO PREVENT CLOVER FAILURES

Failure to establish stands and to obtain good growth of clovers has caused extensive losses in the South and led to studies of improved practices. It has been found, for example, that annual fall applications of 20-percent superphosphate or its equivalent at the rate of 300 to 500 pounds an acre result in fewer fall-stand failures and in better growth. Potash fertilizers applied at the rate of 100 to 200 pounds per acre on sandy and light soils have likewise been shown to be beneficial. One ton of limestone per acre on more acid soils has proved profitable.

Supplementary inoculation with nodule-forming bacteria applied 2 to 4 weeks after seeding, even when the seed has been well inoculated at sowing, has resulted in good stands and growth in comparison with poor stands and growth when only the seed was inoculated. Seedings, it has been shown, should be made from October 1 to December 1, depending upon the latitude; the companion grass must be either closely grazed or clipped to facilitate seedling establishment; and a freshly prepared seedbed must be thoroughly compacted preferably by using a corrugated roller.

IMPROVED ANNUAL LESPEDEZA MADE AVAILABLE

The very extensive acreage (40,000,000) occupied by lespedeza has made it desirable to emphasize the development of improved strains to insure economical and increased production. A new variety, F. C. 31,249, now known as Climax, was made available in 1943. This has given larger yields of hay than standard varieties and has a late season of maturity, which extends the grazing season 2 weeks when it is used in pastures.

SUPERIOR BROMEGRASS STRAINS BLENDED IN NEW STRAIN

Bromegrass is one of the most promising grasses for hay or rotation pastures in the Corn Belt and Northeastern States. It is one of the best grasses to grow in combination with alfalfa or other rapid-growing legumes. At Lincoln, Nebr., from extensive tests of over 35 different sources of bromegrass seed, it was found that seed originating from old established fields in the central latitudes were superior in performance to those coming from farther north. A blend of these central-adapted strains has been developed as a new strain called Lincoln bromegrass. This strain has a marked degree of early seedling vigor, along with a high yield of forage and seed. In 1943, about 87,500 pounds of certified seed were produced in Nebraska, and the greater part was purchased by farmers in Iowa, Illinois, and Indiana.

NEW STRAIN OF BUFFALO GRASS DEVELOPED

Buffalo grass, one of the most desirable range grasses in the Great Plains region, is not only well adapted for hay and pasture but is also being used extensively by military authorities on airfields, cantonments, and other areas where heavy-duty turf is desired under dry-land conditions. A new strain of buffalo grass, as yet not named, but designated as Selection 1-1, has been developed at Hays, Kans. This strain has superior turf qualities and also is more productive both for forage and seed than the old established buffalo grass. Seed has been distributed to the public for seed increase and to military organizations for establishment of turf.

PASTURE RENOVATION INCREASES PRODUCTIVITY

Experiments carried on between five State experiment stations in the Northeast and the United States Regional Pasture Research Laboratory, State College, Pa., indicate that productivity of poor permanent pastures may be increased greatly, even in the first year, by renovation. Renovation involves the establishment of the large grass and legume species accompanied by the application of adequate quantities of lime, phosphorus, and potash. For the successful establishment of the grasses and legumes, it was found necessary to weaken or kill the existing vegetation so that it would not choke out the new seeding.

Since many of the areas in need of renovation are steep and stony, subjugation of the existing vegetation without excessive erosion and with a minimum of effort presents a special problem. For this purpose, disking proved more satisfactory than plowing, since the organic matter was left on the surface to reduce erosion. Furthermore, the seedlings became established more rapidly and the plants grew better throughout the first year on the disked than on the plowed areas. Ordinary disk harrows proved too light for effective tillage. In general, the heavy cutaway disk (bush-and-bog) has been the most effective implement tested. After the seedlings have started, proper management practices (controlled grazing or clipping) are required to promote establishment during the first year and to maintain the proper species balance in succeeding years, a problem that is receiving further attention.

NEW VARIETY OF KENTUCKY BLUEGRASS DEVELOPED

A new variety of Kentucky bluegrass, developed by the United States Regional Pasture Research Laboratory in cooperation with the Pennsylvania Agricultural Experiment Station, has proved superior in yield to other varieties and to commercial seed lots in tests at State College, Pa. The superiority is particularly evident during the critical midsummer period when yields from Kentucky bluegrass pastures normally are low. Three other new varieties because of their growth habits show promise of being tolerant to close grazing. These new varieties, if they continue to maintain superiority in tests that are now in progress, may be released for commercial production, and seed increase fields are now being grown.

LINCOLN SOYBEAN VARIETY RELEASED FOR COMMERCIAL PRODUCTION

The yellow-seeded soybean variety, Lincoln, produced in cooperation with the Illinois Agricultural Experiment Station and other States in the North Central region, has been released for commercial use in the Soybean Belt. In extensive testing at many locations

over several years, it has yielded 5 bushels per acre more than the mean of Illini and Dunfield, the most commonly grown varieties, and contains about 0.7 percent more oil. An intensive seed-increase program is under way; from the 291 bushels of Lincoln seed harvested in the fall of 1942, there were produced 13,345 bushels in 1943. In 1944 over 900 cooperators in the Soybean Belt planned to grow a total of 19,805 acres, and by the spring of 1945 there is expected to be enough seed to plant over 400,000 acres. The Lincoln variety, a selection from a cross between Mandarin and Manchu, combines such desirable qualities as high yield, high oil content, good seed quality, and good lodging resistance.

FERTILIZER INCREASES GRASS-SEED PRODUCTION

With the increased demands for hay and pastures and requests by lend-lease for grass seed, there is an urgent need for increasing the production of various grass seeds. Fertilizer tests conducted in different regions of the United States have indicated that complete or nitrogen fertilizers may be used effectively in increasing the seed production of a number of adapted grasses. At Lincoln, Nebr., 35 strains of bromegrass receiving 250 pounds of sulfate of ammonia per acre produced an average of 200 pounds of seed per acre, while the corresponding untreated plots average only 114 pounds. At Wooster, Ohio, a 150-pound-per-acre application of nitrogen fertilizer increased the seed yield of an old-established field of timothy over 50 percent. Similar tests have been conducted at Tifton, Ga., and nitrogen alone or a complete fertilizer with at least 4-percent nitrogen has increased the seed production of Bermuda, Bahia, and ribbed paspalum, three grasses widely used for hay and pasture in the southeast.

FOREST PATHOLOGY

To increase the certainty of results in timber production and shade-tree preservation, research in forest pathology has been carried on to develop methods of controlling coniferous and broadleaf tree diseases caused by fungi, bacteria, viruses, or harmful environmental conditions. Such control has been sought indirectly by modification of forest practices, directly in nurseries and among shade trees, and through selection and breeding of resistant trees. Methods of avoiding deterioration of forest products during seasoning, storage, and use have also been devised, deterioration of wood and fiberboard being of special significance in wartime because of their increased use under harsh conditions in containers, aircraft, boats, and temporary housing.

LONDON PLANE DISEASE CONTROLLED

Control measures have been devised for the deadly canker stain of the London planetree, and virtual elimination of this fungus disease has already been accomplished by municipal authorities who have adopted these measures. Experiments proved that the disease can be carried from tree to tree in contaminated wound-dressing paint and on contaminated pruning equipment, such as saws, pruners, knives, and ropes. Control measures devised included sterilizing tools by brief immersion in denatured alcohol, sterilizing ropes by exposure to formaldehyde gas, and adding 0.2 percent phenylmercury nitrate to wound-dressing paint of the gilsonite varnish class. Experiments

further demonstrated that in the latitude of New York City pruning may be done during December, January, and February without sterilizing tools, providing no wound-dressing paint is used on the cuts. Branch infections, it was found, can be pruned successfully, but trees with cankers on the trunks cannot be saved and should be removed at once to prevent spread of the disease.

MOLDS AND BACTERIA ATTACK PLYWOOD GLUES

Studies on glue, supplementing those being made by the Forest Products Laboratory, indicate that some of the variation in the strength of casein glues under conditions too wet for mold action are due to previously unrecognized heat-resistant bacteria. Although unextended phenolic and melamine resin bonds continue to appear resistant to the action of micro-organisms, evidence was obtained that those applied in sheet form readily permit the passage of fungi from one wood lamination to another.

PLYWOOD SPECIES DISCOLORATIONS EVALUATED

With the tremendous increase in importance of plywood in war construction, the work on the decay of plywood species that previously resulted in reports on birch, yellow poplar, and sweetgum was extended to include beech, mahogany, and khaya. Inspectors' specimen sets of mahogany and khaya samples showing acceptable discolorations and those that must be rejected have been prepared for use in connection with aircraft plywood manufacture and use. A course of lectures was given at the plant producing the largest output of such plywood. All of the species for which the discolorations were previously studied for toughness have been further studied for bending tolerance, to determine their relation to use on curved surfaces. In general, discolorations found negligible from the toughness standpoint did not disqualify plywood to be used on curved surfaces.

FRUIT AND VEGETABLE CROPS

Research on fruit and vegetable crops has been concerned with production, disease control, breeding, transportation, and storage of deciduous tree fruits, grapes, and berries; citrus fruits, dates, avocados, and other subtropical fruits; vegetables, including potatoes, sweet-potatoes, and peanuts; edible nuts and tung nuts; and ornamental plants and florists' crops. Investigations have been made on fertilizer, cultural, pruning, pollination, and other needs of these crops; their diseases and methods of disease control; the effect of handling, transportation, and storage methods on their quality and preservation; and their suitability for preservation by dehydration, canning, and freezing. Through breeding studies and operations, special emphasis has been placed on developing new varieties that are superior in resistance to diseases and insects; high in quality, in vitamin content, and in other food values; and adapted to growing conditions found in various parts of the country.

FIRST HYBRID-SEED ONION VARIETY INTRODUCED

A method developed for obtaining the highly prized hybrid vigor in onions through commercial production of hybrid seed is expected to make possible an increase of 20 to 50 percent in yields of onions. This has been achieved by breeding male-sterile onion strains that bear seed but do not supply pollen. When such onions are interplanted

with a strain of another variety producing normal pollen all the seed borne by the male-sterile plants are hybrid seed. With strains well chosen for crossing, this hybrid seed gives uniform, vigorous plants with high bulb yields.

First hybrid-vigor onion variety to be introduced is California Hybrid Red No. 1, developed in cooperation with the California Experiment Station with male-sterile Italian Red 13-53 and Lord Howe Island as the parents. This variety is adapted chiefly for growing as a winter crop in the Southwest, where it has given high yields of uniform onions. Varieties for other regions are expected to be available soon, for male-sterile lines of all important onion varieties are being bred and made available to cooperating agencies for prompt development of locally adapted hybrids.

RED-STELE-RESISTANT STRAWBERRY NAMED TEMPLE

In cooperation with the Maryland Agricultural Experiment Station, a new strawberry variety resistant to red stele disease has been developed from a cross between Aberdeen and Fairfax, and has been introduced under the name Temple. It is a satisfactory strawberry for land infested with red stele disease but is not equal in all respects to some of the older varieties.

BORAX TREATMENT CORRECTS ENGLISH WALNUT DISORDER

A Persian (English) walnut disorder known for more than 20 years to occur in orchards on certain soils in the Pacific Northwest and called variously dieback, snake head, baldhead, and winter-kill, as well as an associated leaf-scorch condition, has been corrected by applications of borax broadcast around the trees. In one instance trees after treatment averaged 185 pounds of nuts per tree in 1943, while similarly affected untreated trees yielded 29 pounds.

NEW VARIETIES OF CABBAGE AND PUMPKIN INTRODUCED

Two improved varieties of cabbage, Huguenot and Madison, have been released by the United States Regional Vegetable Breeding Laboratory, at Charleston, S. C. These are roundheaded, cold-hardy, nonbolting types with high vitamin C content.

An early-ripening bush type of pumpkin developed at the Cheyenne Horticultural Field Station has been introduced under the name Cheyenne Bush. It seems well adapted to the Central Great Plains. Because of its bush habit of growth it should prove of special value in small gardens and where irrigation is practiced.

FUNGUS CAPTURES AND DESTROYS MINUTE INSECTS

A microscopic soil-inhabiting fungus has been discovered that has the remarkable ability to capture and destroy certain minute though active insects, the springtails. These insects have recently been found to be fairly destructive to a number of crop plants.

FULLY MATURED POTATOES NEEDED FOR DEHYDRATION

Dehydration studies of potatoes have been extended to include early-crop southern potatoes grown in a considerable number of production centers. Mediocre quality of dehydrated product was found to be associated with the customary harvesting of the crop before maturity. Higher yields of dry product of much better quality were obtained by allowing the potatoes to reach full maturity before digging. This

work has added considerably to knowledge of causes of discoloration in preparing and drying potatoes and of methods of preventing some of them.

TWO DISEASE-RESISTANT POTATO VARIETIES INTRODUCED

Under the cooperative National Potato Breeding Program, which during the past 11 years has resulted in new varieties that now produce about a third of all certified seed potatoes, two new varieties were named in 1943. Potomac, a late variety somewhat resistant to leafhoppers and flea beetles and to late blight, has proved to be very productive at the high elevations of western Maryland. Menominee, highly resistant to common scab and moderately resistant to late blight, has given high yields of No. 1 grade potatoes in parts of Michigan where scab had become a limiting factor in potato production. In quality and productiveness Menominee is good but not outstanding.

HIGH-YIELDING SWEETPOTATO VARIETIES TESTED

In cooperative tests for 3 years in nine locations in principal sweet-potato areas in the Southeast two new seedlings and three introductions from Australia consistently gave higher yields and more starch per acre than any variety now grown commercially. In these sweet-potatoes, high starch content has been shown to be a strongly fixed varietal character. Percentage of starch increases with the longer growing season from Maryland southward. Drought reduced the starch content, but rainy seasons did not. Some of the highest yielding varieties proved to be resistant to wilt.

NEW STRAINS OF PEANUTS GIVE HIGHER YIELDS

Three superior strains of the Spanish type of peanut have been developed and tested in cooperation with the Georgia Experiment Station. They are selections from variety crosses made many years ago by the Georgia workers. They outyield current standard kinds by 15 to 20 percent and produce 50 to 100 pounds more oil an acre on good land. These strains are being increased on a commercial scale for release through organized channels.

Profitable increases in yield have been obtained by planting both Spanish and Runner peanuts at twice the currently practiced rate of seeding. The yields much more than pay for the extra cost.

NEW LETTUCE VARIETY SHOWS ADAPTATION FOR MANY REGIONS

The Great Lakes variety of lettuce, developed in cooperation with the Michigan Experiment Station, has proved to have wide adaptation for north-central to northeastern parts of the country. Furthermore, it has been demonstrated to be particularly suited to certain central valleys of California during parts of the season when other varieties are not satisfactory and also to the Georgia coastal region where conditions are severe for most lettuce varieties. This variety has thus extended the profitable growing season and growing area for head lettuce.

VITAMIN C LOSSES STUDIED IN DEHYDRATED VEGETABLES

Vitamin C determinations before and after dehydration have been made on important varieties of a number of vegetables. Dehydration loss of vitamin C varied greatly among varieties and kinds of vege-

tables, ranging from 90 to 40 percent. Sweetpotatoes, okra, and some varieties of pumpkin had relatively high original vitamin C content and suffered smallest losses, ranging from 40 to 60 percent. Other pumpkin varieties and sweet corn also lost about half but had much lower original levels of vitamin C. Carrots and summer squash lost most heavily and also had low original levels. Snap beans lost very heavily, but from a relatively high level. Sulfur dioxide treatment increased retention of vitamin C in green material, like snap beans and summer squash, but not in carrots, sweetpotatoes, and pumpkins.

CARBON DIOXIDE REDUCES DECAY IN SHIPMENTS OF SNAP BEANS

In the control of watery soft rot of snap beans, which has come to be a very serious problem in shipments from southern Florida, promising results have been obtained in shipments with dry ice as a source of carbon dioxide. Use of 25-percent carbon dioxide during the first 25 hours of transit, without refrigeration, reduced the loss by two-thirds.

COLD STORAGE OF VEGETABLES FOR DEHYDRATION IMPROVES PRODUCT

Cold storage of onions for dehydration gave a gain over common storage of 44 percent in the yield of dried product, largely because of better control of decay. Appearance and quality of the final product were also superior. In the storage of potatoes for dehydration the best-quality product was from stock held at 50° to 60° F. At lower temperatures the potatoes developed excessive quantities of sugar and became undesirably darkened during dehydration. The best dried sweetpotato product came from stock stored at 55° to 60° F.; even a few days' exposure to temperatures below 50° resulted in poor quality.

AEROSOL APPLICATION OF HORMONES INCREASES TOMATO SET

A method of applying plant hormones in practically gaseous form (aerosol) has been experimentally successful in treating blossoms of tomatoes to insure setting of fruit in greenhouses, thus obviating laborious hand pollination. Tomatoes thus produced without pollination are seedless and come to maturity somewhat earlier than normally pollinated fruits. In this method the plant hormone is dispersed by means of a substance which is liquid under moderate pressures but volatilizes and diffuses as a vapor when released from pressure, carrying the hormone with it. The method is being tested for its possible effectiveness on tomatoes out-of-doors and with other crops in which there is sometimes trouble in getting fruit to set.

NEW SNAP BEAN DEVELOPED FOR SOUTHERN CONDITIONS

Logan, a new variety of snap bean, has been developed at the United States Regional Vegetable Breeding Laboratory, at Charleston, S. C., from a cross between Stringless Black Valentine and U. S. No. 5 Refugee, the latter being a very hardy type. Logan is highly resistant to common bean mosaic and to powdery mildew and has some tolerance to bacterial blights. It has the ability to set pods and produce in hot weather, which makes it available for spring, summer, and fall planting in the South. Its disease resistance makes dusting with sulfur unnecessary. It seems to be desirable for market garden, home garden, and canning, with ability to yield under a variety of conditions.

NEW PEACH VARIETY RELEASED

The Dixigem Peach, resulting from a cross of (Admiral Dewey × St. John) × South Haven, made at Beltsville, Md., in 1936 and grown and tested at Fort Valley, Ga., was released for commercial propagation. It is yellow-fleshed, medium to firm, fine-textured, of excellent flavor, and ripens approximately a month ahead of Elberta.

IRRIGATION AGRICULTURE

Special research on irrigation agriculture has been conducted to find out how crop yields may be maintained or increased under irrigated conditions by means of crop rotations and improved cultural practices. Correlated with these studies are investigations concerning the salinity of irrigation and drainage waters and soil solutions. Special attention has been given to the need for more exact information on the water requirements of various crops, investigations having included precise measurements of the irrigation as applied to crops in different locations and as correlated with crop yields.

ROOT-ZONE STUDIES HELP IMPROVE YIELDS AND CONSERVE WATER

Studies to determine the moisture conditions in the root zone and to measure water input and crop yields have indicated that in numerous instances not only may crop yields be improved but also the use of water may be made more economical by insuring adequate water penetration yet at the same time avoiding too frequent and excessive applications. Laboratory and spinning tests have shown, for example, that such improved practices in growing cotton under irrigation result in better fiber structure and higher lint-spinning quality.

INVESTIGATION LEADS TO CORRECTION OF BORON CONTAMINATION

An investigation of conditions in the Cache Creek drainage area, completed in cooperation with the University of California and the Clear Lake Water Co., revealed that practically all the water from the area was contaminated with boron, chiefly from hot mineral springs. Remedial measures indicated have included diversion of water from some of these springs. In other instances it was shown that the boron content could be reduced to a subtoxic concentration by blending with water from other sources.

STUDY SHOWS EFFECT OF SOIL SALINITY ON PEACHES

In a 5-year study, the first known controlled experiment on the salt tolerance of a tree crop, the United States Regional Salinity Laboratory, Riverside, Calif., has shown that peaches are not tolerant of either chloride or sulfate salts in the soil in excess of $2\frac{1}{2}$ atmospheres osmotic pressure. Further increase of either salt, it was found, reduces the vegetative growth, yield, and quality of the fruit, though at equal pressures the chloride salts are the more toxic. Regarding some areas these findings show for the first time why peach growing has been unsuccessful.

MYCOLOGY AND DISEASE SURVEY

Identifications and subsequent mycological studies have been made of extensive series of fungi concerned as pathogenic agents of cinchona, hevea, mango, magnolia, and many other plants of economic importance, particularly those of the subtropical and tropical areas of the

Americas. A preliminary study of the plant diseases of El Salvador has been completed. The economic fungus herbarium maintained for study and identification purposes now totaling 449,173 specimens, was increased by the addition of 6,622 specimens, and 8,840 fungus records were added to the files, together with the listing of 1,938 new species. Reports of plant-disease occurrence and severity supplied by State collaborators have been made available to plant pathologists and agricultural workers throughout the United States who have requested the service, and reports on the effectiveness of new control measures, especially new nonmetallic fungicides, have been published with other plant-disease information in the mimeographed Plant Disease Reporter.

NEMATODOLOGY

Basic research on nematodes (eelworms or roundworms) has continued to be a search for fundamental knowledge of the thousands of species of these organisms that are present in all soils with plant growth, though usually too small to be seen with the naked eye. These organisms puncture roots, buds, leaves, and seeds; attack plants in many other ways; and cause gall formations, leaf spots, crinkling and dwarfing of parts or entire plants, blinding of buds, poor growth, wilting, decay, and other disease symptoms. Surveys have been made of pest outbreaks and of the distribution of nematode plant diseases, and control methods have been devised and tested.

NEW NEMATODE PEST OF POTATOES SPREADS RAPIDLY

Observations have shown that man is the main distributing agent of the golden nematode of potatoes (*Heterodera rostochiensis*), a new pest first found in this country in 1941, which doubled its area in 1943, when about 840 acres were infested, as compared to 434 acres in 1942. Tools, implements, and trucks used on infested land have spread this nematode rapidly to noninfested fields, and floodwaters, bags and baskets with adhering soil and debris, and unclean potatoes have also been carriers.

Maximum infestations of 1,185,000,000 cysts or 200,370,000,000 infective larvae per acre, or about 12,523,125 per potato plant, were observed, and in experiments yield losses of 50 percent and more were observed. A 1-year rotation reduced the infestation by about 20 percent. Of the tested potato varieties none was found immune or resistant, but the early ones—Cobbler, Warba, and Chippewa—gave significantly higher yields, apparently because they made considerable growth in cool spring weather before the nematodes were very active. Numerous soil fumigants have been tested, but all the effective treatments have so far cost more than the market value of the resulting crop increase.

PROMISING NEW SOIL FUMIGANT FOUND FOR NEMATODE CONTROL

Preliminary tests have confirmed in this country the report of an Hawaiian investigator that a mixture of dichloropropylene and dichloropropane is highly effective against the root-knot nematode and possibly also against other detrimental soil organisms. This mixture, called DD, for short, is a byproduct in the manufacture of allyl chloride, which is used in the production of certain pharmaceuticals and also plastics. In dry sandy loam soil with temperatures of from 60° to 90° F. the fumigant was found to have an efficacy of 99 to 100

percent in the control of the root-knot nematode. Applications were 10 cc. at 18-inch intervals in staggered rows 6 inches deep; that is, about 500 pounds to the acre.

Additional tests appeared to show that the dosage per acre may be reduced to 200 pounds without much loss in efficacy.

To avoid retardation and reduction in germination and emergence of plants, an interval between treatment and planting of 2 to 3 weeks or even longer in wet soil seemed best. The DD mixture is easy to handle but must be kept off the skin and clothing; its storage involves no special danger; and at the present price it is a fumigant with possibilities for large-scale economical treatment of more valuable cropland. Specific recommendations for growers have, however, been withheld pending further studies.

PLANT EXPLORATION AND INTRODUCTION

Through a special staff concerned with plant introduction, material of possible value in improving American agriculture has been obtained from all parts of the world by exploration, exchange, or purchase, and such introductions have been propagated at Plant Introduction Gardens. This staff also administers the living plant collections at the National Arboretum. Investigations and tests have been made on problems and practices in plant introduction and propagation, and a herbarium and other reference aids for this work have been developed—aids that have also made possible a botanical service not only to the Bureau but to other public and private agencies.

PRODUCTION OF PLANTS FOR PLACEMENT IN AMERICAS CONTINUES

Production of *Cinchona* seedlings in this country for planting programs in other American countries to insure quinine production has continued on a full-scale basis, with approximately 250,000 seedlings shipped and about as many more under glass. Heaviest demands have come from the War Department's plantations in Costa Rica, and heavy demands have continued from Peru and Puerto Rico. Several thousand seedlings of *Elaeis* (oil palm), *Caesalpinia* (tannin), and *Derris* (insecticide) have also been grown and shipped.

FRUIT INTRODUCTIONS OFFER RESISTANCE TO COLD AND DISEASE

In tests on some 200 introductions of peaches unusual cold resistance has been discovered in clones obtained from the Caucasus region of Russia. As high as 72 percent survival was observed at winter temperatures that completely destroyed the buds of standard varieties. The same strains have shown remarkable resistance to spring frosts. Aside from the Shalil and Yunnan peaches, which had already been demonstrated as highly resistant to root-knot nematode, 9 additional introductions have shown this characteristic. Several apple varieties, showing greater resistance to spring frosts than the standard variety Rome Beauty, have been noted for their possible value in the development of late-blossoming varieties.

INTERNATIONAL MOVEMENT OF PLANTS CONTINUES

Plant-introduction gardens during the past year have distributed 231,481 items to foreign countries, as compared with 38,558 items placed domestically, and in addition sizable quantities of material have been furnished by various crop specialists of the Bureau and other agencies. Most of the material went to Latin America, but countries

of Africa, Europe, and Asia also benefited. A total of 3,728 introductions to this country were inventoried for the year, with perhaps the most important collections coming from Iran. Through Government personnel abroad on various missions small quantities of interesting material have been obtained, but a majority of the introductions were procured through correspondence requests for specific items.

RUBBER INVESTIGATIONS

Rubber investigations, begun in 1922 through participation with the Department of Commerce in surveying sources of crude rubber, have been intensified since 1940 when the Congress authorized a long-term investigation to aid in establishing a permanent self-sustaining rubber-producing industry in Latin America based primarily on the small-farm or single-family type of hevea planting. Under cooperative agreements with 14 countries, research has been conducted, superior planting material distributed, and technical guidance furnished on all phases of rubber production.

A long-range breeding program, utilizing the rich plant material resources of the Amazon and the highest yielding hevea clones from the Orient, has given promise of new disease-resistant strains with increased production and lower costs for a gradually expanding and permanent American industry. Outbreak of war brought on need for the quicker producing rubber plants—guayule, goldenrod, and *Cryptostegia*—on which considerable information had accumulated from the earlier investigations. These plants, together with the kok-saghyz, or Russian dandelion, imported in 1941, have been the subject of enlarged research projects integrated with the emergency rubber-production project of the Forest Service.

RESEARCH PLANTINGS MADE IN FLORIDA FOR BETTER HEVEA STRAINS

A research collection of outstanding hevea breeding and commercial clones is being established in Florida, where the South American leaf blight does not occur, and outstanding high-yielding clones are being grafted onto large seedling trees to induce early flowering. These trees are being intermixed with other trees top-budded with disease-resistant strains selected in Latin America. The requisites for natural and artificial intercrossing between the high-yielding and disease-resistance strains are thus being built up in the expectation that the seeds obtained will largely represent crosses and that there will develop from this research new strains of great value to the rubber plantation industry in Latin America.

TECHNICAL GUIDANCE GIVEN TO RUBBER PROJECTS

Representatives stationed in 10 tropical American countries have furnished technical guidance for the multiplication and field establishment of some 750,000 budded plants of high-yielding strains required for completion of about 9,000 acres of planting up to the end of 1943. Some 350,000 plants and 12,000,000 rubber seeds have been distributed for new nurseries of the cooperating governments and growers. Methods of encouraging small-farm rubber planting, involving sometimes joint action of agricultural, farm credit, and colonization agencies of the cooperating governments, have been evolved and programs inaugurated in Mexico and Costa Rica. The cooperative breeding program with Brazil has involved 53,880 hand pollinations

representing 161 different combinations and 20 backcrosses to both Brazilian and Oriental parent strains.

SOILS AND FERTILIZERS

Investigations of soil management practices have been concerned with variations in cropping systems, use of cover crops, green manuring, mulching, liming, fertilizing, and various cultural practices. Special studies have been made on chemical and physical changes in soil; soil-fertilizer relations to plant nutrition; functions of organic matter and its influence on soil fertility; and relations of microorganisms to other soil constituents, to cultural practices, and to factors affecting soil fertility. Investigations relating to the production and use of fertilizers have included studies on the development or improvement of processes for economical production of nitrogen, phosphorus, potash, and other fertilizer materials and of mixed fertilizers; on reactions between components of mixed fertilizers that influence physical properties or crop-producing powers; preparation of new fertilizer materials or development of new sources; on methods of analysis; and on fertilizer tests to determine crop responses and efficiency in production.

MUNITION NITROGEN MADE USABLE FOR FERTILIZER

Following the release of ammonium nitrate from Canadian and United States munitions plants in the spring of 1943, intensified and diversified investigations were undertaken in cooperation with the producers and the fertilizer industry to overcome the difficulties arising from the tendency of ammonium nitrate to absorb moisture and cake in storage. As a result, within less than a year, methods were devised for conditioning and treating ammonium nitrate so that it does not cake under ordinary conditions of transit or storage and does not become undrillable in fertilizer distributors because of moisture absorption. Ammonium nitrate has thus become available in quantities large enough to insure against further nitrogen shortages, and the product devised—granular ammonium nitrate with a moisture-resistant coating on the granules—has been consumed in large quantities by those who earlier considered its use undesirable, if not unfeasible.

WAY FOUND TO USE SUPERPHOSPHATE IN FARM-STOCK DRINKING WATER

A method devised for using superphosphate to provide nutritional phosphorus for farm animals has made it possible to offset a wartime shortage of bonemeal—normally the principal source of phosphorus for this purpose. A high content of toxic fluorine made the direct use of phosphate-rock products unsafe, but it was found that water solutions of superphosphate could be so handled as to meet the need. In accordance with the recommendations formulated, 20 pounds of superphosphate, for example, is added to 40 gallons of water in a wooden barrel, stirred several times in 2 hours, and allowed to stand overnight. The clear liquid is then siphoned off with care to avoid removing any of the sediment. One gallon of the original mixture, it has been found, contains 0.63 to 0.77 ounce of phosphorus and 0.095 to 0.30 ounce of fluorine, whereas a gallon of the clear liquid siphoned off the next morning contains 0.53 to 0.73 ounce of phosphorus but only 0.0024 to 0.037 ounce of fluorine. This liquid is added directly to the farm stock's drinking water.

IMPROVED FERTILIZER PRACTICE INDICATED IN MAINE

Soil studies in potato-growing areas of Maine have shown that continued heavy fertilization has resulted in such an accumulation of available phosphoric acid and potash in the soil that the crops are utilizing only 10 to 15 percent of the applied phosphorus. In test plots a 50-percent reduction in phosphate fertilizer did not appreciably reduce potato yields. These findings indicate that growers may reduce their applications considerably, but it has been pointed out that the specific reduction an individual grower can make will depend on his soil conditions and the cropping system he employs.

SOIL SURVEYS

Detailed examinations of the nature and use of the soils of the United States, carried out cooperatively with State agricultural experiment stations, have provided a basis for classifying and grouping local soil types in a uniform system with uniform naming. They have further provided a basis for showing the soil-type distribution on maps of such detail and accuracy that the production possibilities of each field and farm may be seen. As a result it has been possible to indicate more accurately adaptability of soils for crops, grasses, and trees, their management requirements for sustained production, and the estimated yields of individual crops under different systems of use and management. General surveys have been curtailed in war circumstances but have been replaced with special surveys and with added attention to applying the results of previous work to crop production. The soil surveys have provided an accurate basis for—

Prompt application of tried methods and new discoveries in soil and crop management by farmers, county agents, and other agricultural technicians;

Planning agricultural research and extending the results to the kinds of farms where they apply;

Rural land classification, rural zoning, and public-land management;

Planning engineering works like highways and airports as well as those for flood control, drainage, irrigation, and conservation;

Expressing the potential distribution and adaptability of individual crops, crop rotations, and soil management practices in the United States; and

The correlation of soil conditions in this country with those of other countries so that applicable experience in other lands may be available to farmers, engineers, and agricultural scientists of the United States.

PROGRESS CONTINUES IN MAKING AND PUBLISHING SOIL MAPS

Even though nearly all field scientists normally engaged in making new soil maps have been occupied with studies of the soil requirements and potential distribution of special war crops and food crops, substantial progress has been made in developing vitally needed soil maps, mostly by personnel in cooperating State organizations. About 1,500,000 acres were examined and mapped in detail and more than 600,000 acres in reconnaissance, largely by cooperating scientists in the States. Eleven printed reports with colored maps were issued during the year, bringing the total number of published surveys to 1,535. The new reports were for—the Santa Cruz and Tracy areas, Calif.; the Black-foot-Aberdeen area, Idaho; Vanderburgh County, Ind., the Upper

Musselshell Valley area, Mont.; Coos County, N. H.; Henderson County, N. C.; Billings County, N. Dak.; Lucas County, Ohio; Choctaw County, Okla.; and Dimmit County, Tex.

SOIL DATA HELP ARMY AND NAVY

Much assistance, based upon the large collection of domestic and foreign soil samples and the personal knowledge of the scientists, has been given the Army, Navy, and other war agencies regarding soil conditions in this and other countries in relation to food production, airport construction, camouflage, ground conditions, and land problems.

SUGAR PLANTS

Research on sugar plants has been directed toward discovering improved methods of crop production, breeding better varieties, providing seed and planting stock to bring new varieties to the farmer promptly, and finding control measures to reduce disease losses and prevent the spread of new and dangerous diseases. Because new and more virulent strains of viruses and other pathogens are constantly being evolved in nature, research on breeding and on disease control has been made a continuous activity to prevent the recurrence of disease situations, which have had calamitous effects on sugar plants in the past.

IMPROVED SUGARCANE VARIETIES RELEASED

Two new and improved sugarcane varieties, C. P. 33/310 and C. P. 33/425, were released in the fall of 1943. The new varieties are high yielding and are resistant to sugarcane mosaic. They are "early" canes showing a high sugar percentage relatively early in the harvest season. Both have the highly valuable characteristic of producing erect, straight stalks adapted to machine harvest.

FLAMING MAY MEET WEED MENACE

Preliminary experiments have indicated that singeing with the intense heat from a properly devised torch is an effective and relatively inexpensive means for controlling alligator weed and Johnson grass on fallow land that is later to be planted with sugarcane. Acute shortages of farm labor have made impossible hand hoeing of middles to hold these weeds in check. In some areas in Louisiana the weeds have taken over, infestation being so extensive as to preclude growing sugarcane on lands otherwise suitable. The excellent results from repeated flamings as a clean-up measure on infested land before the crop is planted and from carefully applied singeing of weeds along the rows of the growing crop thus offer distinct promise of utilization of a labor-saving machine method in the fight against the weed enemies of sugarcane.

TROPICAL AFRICA COMBED FOR NEW SORGO GENES

Representative types of the lush-growing sorgos of tropical Africa have been obtained for breeding a true sugar sorgo for the United States, as a result of a scientific mission to primitive Ethiopia made possible through cooperation with the South Coast Corporation and the American Sugar Cane League. Journeys of 500 miles or more were made in several directions from Addis Ababa into the region believed to be the center of origin of sorgo. The manifold types of the region as grown in native gardens were thoroughly sampled, and seed grain was brought back to this country, the Ethiopian Govern-

ment cooperating. Up to the present, the sorgos in commercial culture in the United States have traced back to subtropical- or temperate-zone types, and although highly valuable as a source of sirup, they have not shown decided promise for practical sugar manufacture. Many sirup sorgos have juice of satisfactory sugar content, but these have produced a relatively low yield of stalks and have not come up to required standards in acre yield of sugar. The newly acquired group of tropical varieties includes robust tall-growing forms, and these may possibly supply the genes needed for combination with the better of the sirup sorgos to produce a true sugar sorgo. An intensive breeding and testing program to utilize the new genetic material has been begun.

LEGUME SODS SAFE FOR SUGAR BEETS IF PLOWING TIME IS RIGHT

Greenhouse and laboratory experiments and field tests have shown that seedling diseases are likely to be serious when a sugar-beet crop immediately follows alfalfa, sweetclover, red clover, or crimson clover. Although highly beneficial in rotation, legumes have been found, under ordinary methods of handling, to favor the increase in the soil of the pathogens attacking the sugar beet, whereas corn and soybeans repress them. It has been found that if legume sods are plowed in late summer or very early in the fall so that decomposition of the green manure takes place promptly, then the period of increase of the soil pathogens may pass and not synchronize with the period of sugar-beet planting. Selection of proper plowing dates for legume sods may thus make the legume, sugar-beet sequence safe.

TOBACCO

Tobacco investigations have been conducted to aid farmers in maintaining production from the limited acreage that can be grown with wartime shortages of farm labor, materials, and equipment. The studies are designed to reduce the heavy losses which occur each year from disease and other hazards, to improve yields of the grades of leaf most in demand, and to reduce the costs of production, with special reference to labor requirements. The work has been concerned with introduction of disease-resistant varieties; use of effective, inexpensive sprays, and dusting preparations and chemical treatments of the soil; reduction of plant-bed failures by chemically treating the soil for control of weed seeds, by preventing losses from late freezes and other unfavorable weather conditions through emergency covers, windbreaks, and the improvement of soil tilth, and by carefully selecting open field sites with reference to soil drainage and light exposure; development of improved varieties capable of producing increased yields of the more desirable grades of leaf and making possible the use of more intensive methods without sacrifice of quality of product; most effective use of suitable substitutes for fertilizer materials formerly used very generally but not now available; cropping systems best suited to production of tobacco of high quality; and development of varieties of *rustica* tobacco capable of yielding larger quantities of nicotine for insect control.

SOIL TREATMENT CONTROLS BACTERIAL WILT

Experiments completed in 1943 have shown that the wilt disease in a tobacco crop can be controlled effectively in the field by applying

in the preceding year about 500 pounds of nitrogen per acre in the form of urea, ammonium carbonate, or ammonium sulfate. Of the three, urea has proved the most practical to use. In replicated plots, urea at rates of 250, 500, and 1,000 pounds per acre—representing, respectively, about 115, 230, and 460 pounds of nitrogen per acre—gave 63, 36, and 13 percent of wilt in the succeeding tobacco crops. When tobacco was grown immediately after the urea treatment, it was commercially worthless because of excessive nitrogen, but when corn was grown after the urea treatment and tobacco the following year, wilt was effectively controlled and the tobacco crop was of high quality.

RECOMMENDATIONS MADE FOR PLANT-BED MANAGEMENT

Simple and effective measures have been made available to growers for meeting difficulties in plant-bed management. The essential measures include selection of properly drained sites with southern slope, with a nearby water supply; effective windbreaks; use of improvised heavy covers, with certain precautions, when freezes threaten; use of abundant organic matter to provide proper soil tilth; control of weed seeds and soil diseases by chemical sterilization of the soil; and use of spray or gas treatments for blue mold.

ADDING ORGANIC MATTER TO SOIL CONTROLS ROOT KNOT

Adding organic matter to the soil, it has been shown, is effective in controlling root knot, which creates a serious problem for flue-cured tobacco growers throughout the entire Coastal Plain areas of North Carolina, South Carolina, and Georgia. In an experiment conducted at Tifton, Ga., on land heavily infested with both root knot and meadow nematodes, certain plots received peanut hay (the residue after the nuts are harvested) at the rate of 4 tons an acre and other plots were untreated. All were planted to tobacco each year. In 1941, the first year of the experiment, there was a slight reduction in the amount of disease in the peanut-hay plots. In 1942 and 1943 nematode damage was practically eliminated from the peanut-hay plots, while the tobacco grown in the check plots continued to be severely diseased. Average yields of cured leaf from the peanut-hay plots were 1,233 and 1,141 pounds per acre in 1942 and 1943; the corresponding yields from the check plots were 416 and 466 pounds. Similar results have been obtained in North Carolina by winter cover cropping with vetch, but in this experiment it was not until the third year that marked reduction in nematode damage was secured. In each experiment the effects from organic matter were cumulative and nonleguminous residues showed little disease-control value.

INCREASED DAMAGE TO TOBACCO CAUSED BY MEADOW NEMATODE

Damage from meadow nematodes having become increasingly serious, root collections were made in 1943 from 60 damaged fields in the South Carolina area. Microscopic examination disclosed that in most of the fields meadow nematodes were a chief cause of damage. The survey also indicated that an important factor in the increased losses from meadow nematode was late transplanting made necessary in order to avoid blue mold. Two remedial measures have been recommended—use of the new varieties 400, 401, and White Mammoth, which have moderate meadow nematode resistance, and use of a available blue mold control measures that would largely eliminate the need for late transplanting.

**REPORT OF THE CHIEF OF THE OFFICE OF
EXPERIMENT STATIONS, AGRICULTURAL
RESEARCH ADMINISTRATION, 1944**

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1944.

DR. E. C. AUCHTER,
Agricultural Research Administrator.

DEAR DR. AUCHTER: I transmit herewith a report of the Office of Experiment Stations for the fiscal year ended June 30, 1944.

Sincerely yours,

JAMES T. JARDINE, *Chief.*

**WARTIME ACTIVITIES AND SERVICES OF THE OFFICE OF
EXPERIMENT STATIONS**

THE PRIMARY function of the Office of Experiment Stations from the time of its establishment in 1888 has been the administration of the Federal grants to the States for research by agricultural experiment stations. The primary objective of the work is to aid in acquiring and diffusing useful and practical information on subjects connected with agriculture and to promote scientific investigation and experiment respecting the principles and applications of agricultural science in fulfillment of the purposes of the Federal-grant acts. In this objective the needs of the United States and the individual States and Territories are each given due regard.

With this broad objective in mind, the Office advises and assists the experiment stations in planning their research programs and through annual review of projects offers suggestions as to current progress and proposed work under specific projects. Thus, the Office has an important role in cooperation with the stations in the planning and adjustment of research to meet the most urgent needs.

Throughout the emergency there has been continuing review and redirection of research projects in line with the changing needs of the war food program. Greatly expanded demands for food, fibers, oils, and other strategic farm products have brought new problems to the stations for solution. Problems of transporting products and supplies, of best ways of processing and storing, of substitution for critical materials in short supply, and of helping to alleviate farm-labor shortages have demanded and received attention. National consciousness of the importance of adequate nutrition for civilians and the armed forces has called for new facts on nutritive requirements and nutritive values of foods.

In response to the need, the stations have focused their research on the most urgent problems of the States and localities within the

framework of national programs and requirements. Significant facts on many new problems have been sought and obtained in the least possible time commensurate with sound results. These facts have been blended with the cumulative findings and practices of a half century of agricultural science to form a body of information which farmers have applied in producing the greatest volume of food in the history of the Nation. Except for the timely aid of research facts, production might have fallen far short of needed goals.

POINTING RESEARCH TO WAR NEEDS

In administering the grant fund in 1944 the policy of pointing research to the solution of the most urgent wartime problems received continuing emphasis by the Office and the stations. The adjustment of experiment station research programs under the Federal-grant funds involved the undertaking of 641 new and revised projects in 1944 and the continuation of 2,843 projects begun prior to 1944. In all, 3,484 projects were active during the year. Many projects continued from 1943 had already yielded important information which had been released for immediate use, but other phases of the problems required additional study. Because of continuing losses of staff members, especially to the armed forces, a number of projects were necessarily discontinued.

Detailed outlines for each of the 641 new and revised projects were reviewed by the Office prior to approval for expenditures of Federal-grant funds. Following critical study of these proposals by specialists of the Office, suggestions were made to the stations as to the scope of the proposed research, details of procedure, and related work by other stations and the Department, in line with the responsibility of the Office for furnishing advice and assistance and helping to promote cooperation.

NEW STUDIES TO SOLVE EMERGENCY PROBLEMS

The following are examples of studies undertaken during 1944 to help solve emergency problems under the varying conditions of the States or of investigations contributing to the solution of problems of national significance. Many other examples could be cited.

Increased feeding of poultry to produce meat and eggs needed for the war has resulted in a shortage of protein and vitamin supplements required in poultry rations for greatest efficiency. Dried milk has been diverted to human use, and alfalfa meal, distillery byproducts, and fish meal, formerly available for poultry rations, have become scarce. Investigations are needed of all possible sources of supplementary poultry feeds. Among other possibilities, the waste products of the vegetable canning industry appeared to offer particular promise. Accordingly, the Delaware station undertook a study of the feeding value of dehydrated vegetable wastes produced by the Eastern Regional Research Laboratory, which according to laboratory analyses contained large amounts of carotene and riboflavin (see the Report of the Chief of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, 1944). The large-scale vegetable canning industry of the State makes such studies particularly applicable in Delaware. Dehydrated vines of peas and lima beans, turnip tops, broccoli, and carrot wastes supplied by the laboratory were

fed to poultry by the station. Broiler mashes of 8 percent of such material gave a rate of growth equal to mash containing alfalfa leaf meal and were more palatable.

In meeting the same problem of supplements for poultry rations from local sources, the Maine station undertook a study of Ladino clover as a substitute for alfalfa. Pullets were fed laying rations containing Ladino clover in the form of dehydrated meal, sun-cured hay and meal, and silage in comparison with alfalfa leaf meal. The dehydrated Ladino meal was found to be high in carotene and the equal of alfalfa leaf meal in every respect. Ladino silage was also a good source of carotene. Although further studies are needed to substantiate these first year's results, they indicate the possibility that Maine poultrymen in the future may use home-grown Ladino products with satisfactory results.

The availability of large supplies of fish in Oregon, including some types not in commercial use at present, prompted the Oregon station to investigate methods of preparing new fishery products. Good progress has been made within the year in preparing a canned product. Other experiments are being conducted with a view to developing a fish loaf or other product suitable for Army and domestic use. This work has been followed closely by the Quartermaster Corps, which has accepted one of the products and requested additional work by the station along these lines.

Large-scale cultivation of waxy corn as a wartime source of waxy starch for human food and industrial uses prompted the Nebraska station to study its feeding value as compared with Yellow dent corn. In two experiments waxy corn used in rations for growing chicks proved as good as the Yellow dent, with the trend of advantage slightly in favor of the waxy corn. In years when the production of waxy corn exceeds industrial requirements, farmers may, therefore, use any surplus in poultry rations with assurance of no loss in their efficiency.

The high waterproof qualities and buoyancy of milkweed floss has led to its wide-scale use in lifebelts and airmen's jackets in place of kapok. Looking toward future supplies from cultivated plants, the Michigan station, cooperating with the United States Department of Agriculture and the University of Michigan, began an investigation aimed at the discovery and development of high-yielding strains of milkweed having valuable properties of floss. The study involves species of *Asclepias* and near relatives. Already material has been assembled representing various pod types with distinct differences as to length of floss, weight per pod, and number of floss strands per tuft. Plantations of seedlings and roots have been established. At least one type superior in floss production has been isolated. The discovery of severe virus infection in some of the material may complicate the problem. While commercial production is still in the trial stage, the Michigan studies should prove a sound foundation for such an enterprise.

A project begun by the New Mexico station near the end of the year is designed to assist in the commercial production of a new antioxidant needed in the preservation of fats and oils for use as food by the armed forces. The work is a follow-up of research by the University of Minnesota showing that NDGA (nordihydroguaiaretic acid) is an effective preservative for animal fats and oils, retarding the rancidity

of lard for many months. The only available source of this compound is the creosote bush (*Larrea divaricata*) estimated to occur on some 10,000,000 acres of land in New Mexico. The content of NDGA varies in the creosote bush up to 7 percent, and the station is studying the factors influencing this variability and will attempt to locate areas of plants having a maximum concentration. Harvesting and curing methods will be investigated as aids in obtaining maximum yields. A commercial plant is now in operation in the creosote bush area of New Mexico preparing NDGA for Army use, and the research is directed to assist this effort and aid in the development of a local enterprise that offers promise of expansion after the war since there are many civilian uses for this product in foods and drugs.

ASSISTING IN PROMOTING COOPERATION

The wide diversity of agricultural conditions in the States and Territories quite naturally calls for a considerable degree of localization in the problems selected for investigation. Many of these local problems, however, cross State lines and are the common concern of groups of experiment stations and of research bureaus of the Agricultural Research Administration and other agencies of the Department that are primarily concerned with problems of regional and national scope. Such regional and national problems offer opportunities for coordinated attack by groups of stations and the Federal agencies, and a noteworthy degree of teamwork in research has been attained in recent years. The Office of Experiment Stations assists in the coordination of research between experiment stations and between the stations and the Department, and formal memoranda of understanding between the State stations and the Department are cleared through the Office for approval before becoming operative. Within the year approximately 1,190 formal cooperative agreements and memoranda of understanding were approved by the Office. These agreements provided the basis for cooperative work on more than 1,030 separate research undertakings. The scope of some of this cooperative work is illustrated by studies of various aspects of soil erosion control effective between 48 stations and the Soil Conservation Service; investigations of breeding, culture, and diseases of potatoes between 28 stations and the Bureau of Plant Industry, Soils, and Agricultural Engineering; and research on cereal crops and diseases between 25 stations and the same bureau.

Among Nation-wide undertakings in 1944 were studies made by virtually all stations in cooperation with the Department and State agencies of farm production possibilities in 1945 for the respective States by localities. Similar studies in previous years supplied information on which production goals and other national programs for 1943 and 1944 were based. The stations also joined with the Department in the preparation of preliminary post-war planning reports. The Office assisted in these and other cooperative studies through correspondence and conferences with the directors and in the clearance of projects for use of the Federal-grant funds. The post-war planning reports were reviewed by the staff of the Office, and statements were prepared as to problems and suggestions outlined in each which would involve additional research by the stations. A statement was prepared on research in nutrition as presented in the State reports

for use in connection with the work of the subcommittee for nutrition of the Interbureau Committee for Post-War Planning.

Upon request of the State experiment stations the Office continued to render over-all assistance and to help coordinate the cooperative studies on the conservation of the nutritive values of foods in processing, marketing, storing, and cooking. This national project, as previously reported, was undertaken upon recommendation of the Committee on Food and Nutrition of the National Research Council. Experiment stations in 44 States are participating in securing information on approximately 65 different foods. The information has immediate value to those responsible for the food supply of our armed forces. It is of both immediate and long-time value to agriculture in meeting increasing interest and demand for high nutritive quality in foods. The Chief of the Office, by request, acts as coordinator in the planning and organization of this cooperative study. Within the general scope of this project a group of stations has undertaken a cooperative study of cooking losses in Army and Navy training camps at land-grant institutions as requested by the Quartermaster Corps. The project calls for determinations of ascorbic acid and carotene in raw, canned, or frozen foods at the time when prepared for cooking and the level of these vitamins in the cooked food before, during, and after serving.

Similarly, the Office participates in a study actively under way in 20 State experiment stations and the Department to determine the extent to which butter in the usual trade channels can be depended upon to furnish a uniform supply of vitamin A and in what amount. As in the case of the above study, this joint effort was undertaken upon recommendation of the Committee on Food and Nutrition of the National Research Council.

SPECIAL SERVICES BY THE OFFICE

Again the Office served as a clearinghouse for information and services on request of the State experiment stations and agencies of the Department. Almost daily calls were received by the Office for such assistance.

As in past years of the war emergency, problems and questions involved in production and distribution of agricultural products were given priority.

The shortage of legume and grass seeds called for a special program of increased production in 1944 to provide for hay and pasture seedings to meet, if possible, the needs in 1945. The Office cooperated with the Seed Production Committee of the Department and with the War Food Administration in arranging for help on this special program on the part of State station directors and their staffs.

Upon request of the War Food Administration, the Office arranged with a few State experiment stations for additional rather immediate studies and feeding trials to obtain additional needed facts relative to the feeding value of potatoes for different kinds of livestock. The purpose was to meet feed problems in localities where potatoes may be available and other customary feeds may not be available or may be in short supply.

Necessary restrictions on sale of corn for livestock feed in 1944 brought requests to the Office from State experiment stations to assist

in obtaining corn for continuation of essential livestock feeding experiments. In cooperation with a special Corn Committee of the War Food Administration, needed information was assembled and the stations were provided with corn to meet minimum requirements in order to secure reliable data from the more essential studies in progress.

Research on questions and problems relating to dehydration of foods continued to be important. A list of all State experiment station projects relating to dehydration of foods was assembled for use by the stations as a whole. For experiment stations where dehydration research is in progress this list was supplemented by a collection of progress reports covering methods and results of research by British laboratories in the dehydration of foodstuffs.

In a similar way, the Office assisted experiment stations by bringing together a list of currently active research projects dealing with soybeans, including edible soybeans and soybean products.

Throughout the year the Office continued to assist the stations in obtaining urgently needed equipment, materials, and supplies.

Contacts of representatives of other countries were arranged with State experiment stations, and the Office helped in meeting the requests of other countries for publications and information.

The work load along these and similar lines as a result of war emergency conditions required a considerable amount of time on the part of all staff members. This assistance undoubtedly saved time, travel expense, and worked for effectiveness of other agencies.

INFORMATION SERVICES

Beginning February 1, 1942, the Office has issued a series of mimeographed quarterly reports dealing with war activities of the Office of Experiment Stations and the State agricultural experiment stations. These reports serve as a brief current historical record of activities and services, new research projects, and significant results of research contributing to the war effort. Through this service timely information has been made available to the stations and officials of the Department often in advance of other forms of release. Three war activities reports were issued for the fiscal year 1944 covering the periods July to December 1943, January to March 1944, and April to June 1944.

Printed publications issued during the year by the Office included the report of the Chief of the Office for 1943; the reports to Congress on the agricultural experiment stations for the fiscal years 1942 and 1943 and a reprint from the report for 1943 entitled "Conservation of Food Resources"; a list of workers in subjects pertaining to agriculture in land-grant colleges and experiment stations for 1943-44 contained in Miscellaneous Publication 535; a publication entitled "Derris Culture in Puerto Rico"—Puerto Rico Station Circular 24; and the reports of the Puerto Rico Experiment Station in English for 1943 and in Spanish for 1941 and 1942. A special report on Experiment Station Research on the Vitamin Content and the Preservation of Foods was issued as Miscellaneous Publication 536.

EXPERIMENT STATION RECORD

During the year volumes 89 and 90 of Experiment Station Record were completed, containing 3,657 and 3,694 abstracts, respectively, or

a total of 7,351 abstracts. The number of printed pages per volume of 6 monthly issues was 780 and 864 pages, respectively, a total of 1,644 pages. This was a reduction of about 10 percent over the previous year in pages and 6 percent in abstracts, occasioned in part by a decrease in personnel and in part by economies effected in the methods of coverage and handling.

In the main the continuity of treatment essential to an abstracting journal utilized both for current information and permanent reference was preserved. Publications reporting work by experiment station personnel, both within and outside the stations' own series, were as usual completely covered. Special attention was given to work emanating from the Americas, and the supplying of abstracts requested by the Office of War Information for foreign use was continued and enlarged.

On November 1, 1943, Dr. W. A. Hooker retired as senior economic zoologist after nearly 40 years' service mainly spent in abstracting the technical literature in economic zoology, entomology, and veterinary medicine. For the remainder of the year his duties were absorbed on a temporary basis by other members of the staff.

WAR ACTIVITIES OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO

War activities of the Federal Experiment Station in Puerto Rico have been directed to increasing sources of rotenone and quinine in the Western Hemisphere, increasing the production of local food supplies, research on new crops of importance to Puerto Rico, studies of the production and utilization of bamboo, the more effective control of insect pests and diseases, and supplying planting materials for use by the armed forces and in other tropical countries of Latin America. The work on new crops and on bamboo is being conducted in cooperation with the Government of Puerto Rico, which appropriates funds for the support of research by the station on these crops.

The Office of Experiment Stations has responsibility for administration of the Federal Experiment Station on the island. In this capacity the Office cooperates with the several agencies involved in the inter-American program of research and helps to coordinate the work of the Experiment Station of the University of Puerto Rico with that of the Federal station.

INCREASING WESTERN HEMISPHERE SOURCES OF ROTENONE

Derris root, formerly obtained from the Far East, and *Lonchocarpus* root, produced in South America, have been the world's main source of rotenone, an insecticide toxic to insects but harmless to man and domestic animals.

There is immediate need for increased sources of rotenone, over 6 million pounds of root having been used in 1942 by the American farmer as an insecticide in the production of food. The availability of large quantities of propagating stock of *Derris* at the station afforded an opportunity to make wide-scale distribution of planting material throughout the Western Hemisphere with the result that new plantations were established to provide a yearly source of rotenone. In cooperation with the Foreign Economic Administration and the Office

of Foreign Agricultural Relations, over 1¼ million cuttings were distributed throughout Latin America in the fiscal year 1944.

In addition to work connected with increasing the available supply of planting material, investigations were conducted to find better methods of propagating and improving cultural practices with this crop.

Clonal studies of new high-yielding material of *Derris* obtained from Sumatra have indicated the rotenone yield to be as much as 100 percent above that of ordinary commercial material. The propagation and distribution of this high-yielding material is being continued as rapidly as possible.

The propagation of *Lonchocarpus* by methods other than rooting of leafless stem cuttings indicated that marcottage (air layering), leafy cuttings, and leaf-bud cuttings give satisfactory results.

Investigations of other plants of possible insecticidal value showed that a common tropical plant, mamey, gave high toxicity to many insects under laboratory conditions, indicating possible uses of the seed and leaves of this plant, at least under tropical conditions, where it is easily obtained and prepared.

AIDS IN ESTABLISHING QUININE PRODUCTION

The drug quinine, obtained from the bark of the *Cinchona* tree, has increased in importance as theaters of war have expanded to the tropical areas of the world. The major source of supply was lost with the occupation of Java by the Japanese. The secrets of cultivation of the plant have been carefully guarded by the Dutch planters, and little or nothing was known regarding plantation cultivation.

The work of the Puerto Rico station has been concentrated on the development and selection of high-yielding strains of *Cinchona* and on the solution of cultural problems. The plant has proved to be one of the most difficult to grow, requiring very careful attention throughout the nursery stage and being specific as to its needs for soil and light conditions.

Investigations to date have resulted in the solving of many seedbed and nursery problems, and it is now possible to grow unlimited quantities of seedlings with assurance of survival through the nursery stage. Areas in the island that are considered to be the best available for the purpose have been selected for the establishment of permanent plantings. It is hoped that it will be possible to maintain and to continue to develop plantings of known high quinine content as a permanent source of seed of such high-yielding strains. These investigations solve problems in the establishment of permanent plantings such as soil requirements, fertilizer practices, cover crops, and a breeding program.

In an experiment testing soil mixtures for use in *Cinchona* seedbeds a mixture of fresh humus, sand, and composted manure, ratio 1:2:1, gave highly significant increases in growth after 6 months as compared with humus alone or with combinations of humus and sand.

During the year a total of 12,200 *Cinchona* seedlings, obtained from material collected in the Philippines and flown out just before the Japanese occupation, were sent to Puerto Rico and are being grown in nurseries for later establishment in permanent plantings. In addition, a considerable quantity of seed of these high-yielding strains

was also obtained. The first extensive permanent plantings of the material grown from seed obtained locally from initial plantings made some years ago have resulted in the establishment of approximately 1,700 plants in permanent locations in the Toro Negro National Forest.

The result of the investigations being conducted in Puerto Rico are being made available to other Government agencies interested in the establishment of *Cinchona* in the Western Hemisphere.

HELPING FOOD PRODUCTION IN PUERTO RICO

Puerto Rico, in spite of its insular nature and tropical climate, has been dependent upon the importation of staple foods from the mainland. Under war conditions, it was imperative that the production of local foods be increased materially and as rapidly as possible. Owing to the entire lack of commercial seed sources, one of the immediate needs of the program was sources of seed supplies of crops known to be adapted to the Tropics.

In conjunction with the Works Project Administration and the war emergency program of the insular government, the Puerto Rico station cooperated extensively in the production of seed for distribution in the food production program. Three crops with which the station had been working experimentally received special attention, namely, USDA-34 sweet corn, a variety developed by the station some years ago; the Seminole variety of soybean, introduced and tested by the station; and various varieties of yams.

In the course of the year, 9,155 pounds of USDA-34 sweet corn, 3,290 pounds of the Seminole variety of soybeans, and 24,610 pounds of yams were distributed. In addition, a small quantity of these seeds were supplied to other Latin American countries in conjunction with their food production programs. The military forces throughout the Caribbean area received considerable quantities of all of these seeds for planting in their local gardens to increase available supplies of fresh vegetables for the troops stationed in these areas. The continual need for protein in the diet of tropical peoples makes the growing and consumption of soybeans an important factor in improving the general health.

Selections of avocados, introduced many years ago by the station, resulted in the grafting of over 1,500 seedlings of promising varieties on local West Indian stock for testing in various locations of the island. These new varieties are known to fruit during the winter months when native avocados are unavailable.

For many years studies have been undertaken in the propagation of the mangosteen, a rare and delicious tropical fruit. A study of the relation between weight of seed and subsequent survival and vigor of the young seedlings has indicated at the end of 6 months' growth that the heavier seeds had a decided positive influence on survival and growth.

NEW CROPS FOR PUERTO RICO

For several years the Government of Puerto Rico has annually appropriated funds for expenditure by the Federal station on the island to make possible close and active cooperation in agricultural research of local importance to the island. This program has been directed

principally to work concerned with vanilla, essential oils, spices, and the utilization of bamboo.

Experiments on Chinese ginger have given promising results, and yield data would indicate that this crop may be highly profitable to the agriculture of the island. Planting material is being propagated as rapidly as possible, and the station has been unable to fill the demands of local farmers for this new crop.

Investigations on vanilla root rot have included methods of soil alteration, nutrient studies, and the effect of sunlight on the incidence of the disease. Superior growth and healthier plants have been obtained where limestone was used in connection with mulching practice. Nutrient experiments have indicated that calcium is unquestionably the most important element in the production of vanilla. Experiments on the curing of vanilla beans have shown that beans killed by scratching with a pin, dipping in hot water, or freezing yield larger quantities of vanillin and phenol content than beans killed by other methods.

Work on spices has been largely concerned with the propagation of planting material and field testing of various spices with respect to their adaptation to Puerto Rican conditions. Nutmeg, allspice, and cloves have now been established at the station in good supply and are being studied.

PRODUCTION AND UTILIZATION OF BAMBOO

Bamboo, for many years one of the chief cheap building materials of the Far East, has never been used extensively in the American Tropics. Probably the main reasons for this have been that most of the bamboos grown in the Western Hemisphere were of poor quality for construction purposes and were subject to severe attack by the bamboo powder-post beetle, which tended to destroy the wood within a few months after cutting.

As a result of the establishment of the bamboo furniture industry in Puerto Rico through the efforts of the Office of Inter-American Affairs and the Puerto Rico Development Company, considerable interest has developed in bamboo as a cash crop for the island.

The station program has been concerned with the introduction of species of bamboo from the Far East, and, of some 38 species introduced, 5 show great promise for use in the development of a bamboo industry in Puerto Rico. With increased propagating materials available, more extensive tests are being undertaken on many phases of production, harvesting, and curing which need study.

In cooperation with the Soil Conservation Service a number of test plantings of bamboo have been made on steep hillsides and on gullied and severely eroded land classified as unfit for cultivation. Previous work along these lines has indicated that bamboo will serve as an excellent erosion control crop and that through it unprofitable land may be utilized for the growing of a cash crop.

Studies on the propagation of bamboo have shown that cutting material for industrial purposes during the dry season at a time most favorable for this purpose permits use of the remaining rootstock for planting material during the subsequent rainy season several months later.

Studies on the curing of bamboo to prevent checking and splitting, and to minimize the attack of the bamboo powder-post beetle in susceptible species have indicated that water curing, as practiced in India does not give highly satisfactory results. A method developed in previous years at the station, known as clum curing, has proved to be the best method found to date.

In cooperation with the College of Agriculture and Mechanic Arts of the University of Puerto Rico, work has been undertaken on the use of bamboo as a reinforcing material in concrete construction. While initial results have not been too promising, there are indications that bamboo may be successfully used as reinforcing material in floors and in simple farm structures.

More than 25,000 bamboo plants were distributed during the year, including distributions to a number of other Latin American countries and islands in the West Indies.

CONTROL OF INSECT PESTS AND DISEASES

The Federal Experiment Station in Puerto Rico is working on many different plants of economic and strategic importance. The successful establishment of these plants is often dependent upon the control of insect pests and diseases which attack them.

Two species of thrips were found attacking young seedlings of *Onchona*. The infestation was successfully controlled by the application of a 1:800 solution of 40 percent nicotine sulfate.

Investigations of the damage caused by defoliating insects attacking soybeans showed that the velvetbean caterpillar and the bean leaf webber were largely responsible for the damage. The extent of infestation was reduced by the presence of native parasites and of fungi harmful to insects. The treatment of soybean seeds with various fungicides protected the seeds from disease and decay and resulted in increased stands up to 100 percent. Treatments with any of these chemical compounds are inexpensive and, on the basis of results recorded, the treatment of the seed is not only profitable but imperative in view of present seed shortages.

The station continued to receive requests for introduced parasites and predators which have been successfully established in Puerto Rico, and during the course of the year a shipment of 6,500 specimens of a pineapple mealybug parasite introduced from Hawaii some years ago was forwarded to Florida for release.

Cooperation with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture in the introduction of parasites and predators was continued, and shipments of sugarcane borer parasites for release in Puerto Rico were received from Brazil.

SUPPLYING PLANTING MATERIALS FOR THE ARMED FORCES AND TROPICAL COUNTRIES

The work at the Puerto Rico station in connection with plant introductions has been concentrated largely on furnishing planting materials and information on the types of plants needed by the armed forces for camouflage purposes at the bases being developed in Puerto Rico and the Virgin Islands. Information has been furnished on planting plans, varieties adapted to particular purposes, planting

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thods, care of material, and the control of insect pests and diseases.

During the fiscal year 1944 a total of 186,502 plants were distributed to Federal and insular agencies and to private individuals for testing purposes. In addition, large quantities of seed and grass sod were distributed. Requests for planting material and exchanges were maintained with the tropical countries of Latin America. Collections of *Hevea* rubber seed were made from the plantings available at the Puerto Rico station and shipped to the Dominican Republic for planting under the rubber program of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Seed of *Aleurites trisperma*, a relative of the tung tree, and a source of bagilumbang oil, was sent to the same bureau for distribution and trial throughout Latin America.

FUNDS FOR EXPERIMENT STATION WORK

The funds available for expenditure by the agricultural experiment stations of the 48 States, Alaska, Hawaii, and Puerto Rico include the Federal grants and funds from non-Federal sources, i. e., appropriations by the State and Territorial legislatures, special grants from industrial and other sources, and income derived from sales of products, and miscellaneous sources. The Federal-grant funds are authorized by the Hatch Act of March 2, 1887; the Adams Act of March 16, 1906; the Purnell Act of February 24, 1925; the Hawaii Act of May 16, 1928; the Alaska Acts of February 23, 1929, and June 20, 1936 (sec. 2); the Puerto Rico Act of March 4, 1931; and title I of the Bankhead-Jones Act of June 29, 1935.

FEDERAL-GRANT FUNDS

The total of funds authorized under the Federal-grant acts for the fiscal year 1944 was \$7,001,207.

Each State received \$90,000 under the Hatch, Adams, and Purnell Acts. Alaska received \$37,500; Hawaii, \$90,000; and Puerto Rico \$90,000 under the authorizations of the special acts listed above.

The appropriation under title I of the Bankhead-Jones Act was \$2,463,707. This was allotted to the States, Alaska, Hawaii, and Puerto Rico on the basis of their rural population, \$63,707 of this amount being allotted for the purpose of preventing any reductions due to changes in population as shown in the 1940 census.

NON-FEDERAL FUNDS

The exact total of non-Federal funds available to the experiment stations in 1944 cannot be determined until the financial reports for that year have been received. In 1943, these non-Federal funds totaled \$17,277,666. Preliminary information indicates that the funds available for 1944 will equal or exceed the amount available in 1943.