

AGRICULTURAL EXPERIMENT STATION
of the RHODE ISLAND STATE COLLEGE

Kingston, Rhode Island, U. S. A.

Blackhead (Enterio-Hepatitis) Investigations

BY JOHN P. DELAPLANE AND HOMER G. QUART

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G5 ABSTRACT

The disease known as blackhead of turkeys was first recognized by Cushman as a serious infection of turkeys as the result of a survey made by him of the turkey industry of Rhode Island in 1892.

From evidence obtained by Cushman, it is apparent that the disease had been present in Rhode Island for several years prior to this time

The disease was studied by Smith in 1894 as a result of specimens having been sent to him by Cushman. He found the disease to be of a protozoan nature. The causative organism resembled an amoeba and he suggested the name *Amoeba meleagridis* for it.

For a number of years following Smith's report, little was done in studying the nature of the infection. In 1902, Curtice continued the studies at this station. He studied the manner in which the disease was disseminated and made several important contributions. He found that blackhead infection was not transmitted through the egg, that the common fowl and turkey hen were carriers of the infection and contaminated soil on which they run, that soil unused by poultry was probably not infected.

All of these points are considered in sanitary management programs for rearing turkeys at this time.

Cole and Hadley studied the nature of the causative organisms and considered the amoeba of Smith to be the shizont stage of a coccidium. Later, Hadley considered the amoeba of Smith to be the trophozoite stage of a trichomonad.

Smith again studied the disease in 1915 and reaffirmed his earlier studies with regard to the nature of the blackhead parasite.

Tyzzar found that the amoeba of Smith had certain flagellate structures and suggested the name *Histomonas meleagridis* for the blackhead parasite.

Delaplane isolated flagellate protozoa similar to the *Histomonas meleagridis* (Tyzzar) which produced fatal blackhead when used to infect several successive groups of poults, thus supporting Tyzzar's studies that the amoeba of Smith was actually a flagellate in its free form.

Several drugs and chemicals have been studied at this station which have been found of no value in the prevention or treatment of this disease.

The ceca of a number of turkeys were occluded by the use of clamps to prevent blackhead organisms from gaining entrance and giving rise to infection. Turkeys surviving the operation were protected against blackhead for a period of at least four months after which time some contracted the disease as a result of the ceca again functioning.

A comparison of the feed consumption and the mortality from blackhead of the turkeys reared on range and in confinement showed the range group to consume on an average of 58.00 pounds of feed as compared with 58.66 pounds for the confinement group over a 25-week period. The range group of turkeys averaged 12.37 pounds in weight as against 13.32 pounds for the confinement group over the same period of time. The feed cost for the confinement group was slightly greater than for the range group. Four turkeys from the range group contracted blackhead as against one for the confinement group during the course of the experiment.

Blackhead (Enterio-Hepatitis) Investigations¹

BY JOHN P. DELAPLANE and HOMER O. STUART

A short time after the Rhode Island Agricultural Experiment Station was established, the increasing difficulty of growing turkeys was brought to the attention of those connected with the station staff. Efforts were made to determine the cause of these difficulties and a survey of the turkey industry of the state was conducted to find the methods of management which were proving most satisfactory. It was hoped that information would be gained from the survey which would be of value in subsequent suggestions for the betterment of the industry. This study resulted in a bulletin in 1893 by Cushman which dealt largely with management phases of turkey production but which also called attention to the extent of a so-called "bowel trouble" of turkeys in the flocks of many of the breeders of the state. The autopsy of birds dying from this cause showed the livers to be diseased and the condition referred to has come to be commonly known as blackhead disease.

The earliest reference to the disease appeared in the annual report of the station in 1893 (22),² and consisted of a summary of Cushman's (?) findings.

How long the disease had existed in this country prior to 1892 is difficult to ascertain but from evidence presented by Cushman, it would seem that the disease had been present for several years.

EARLY INVESTIGATIONS

At the time of the above survey, the general feeling among the turkey growers of the state was that the industry was declining, partially as a result of the failure to introduce new breeding stock, and as a consequence the breeding flocks were becoming less vigorous and thus their offspring were more susceptible to disease. In view of this, the station introduced turkeys of wild origin to mate with the station flock. The gobblers from the resulting crosses were to be distributed to the turkey producers of the state for crossing with their flocks and in this manner increase the vigor of the turkeys resulting from these matings.

Cushman brought the disease to the attention of Dr. Theobald Smith (then of the Pathology Division of the U. S. Bureau of Animal Industry) in the fall of 1893 and the spring of 1894 by sending him specimens of turkeys suffering from the disease. As a result of the studies of this material it became apparent to Smith (23) that the disease was of a specific nature and during the summer of 1894 he arranged to spend a few weeks at the Rhode Island Agricultural Experiment Station to study the disease and collect material. Circulars were sent to the turkey producers describ-

¹Contribution No. 464 of the station.

²Reference is made by number (*italics*) to Literature Cited, p. 15.

ing the symptoms of blackhead and asking their cooperation by sending diseased birds to the station so as to obtain ample material for this study. From the examination of fresh and histological material from diseased liver and ceca, Smith (23) observed organisms of a protozoan nature. The protozoon for the most part resembled an amoeba and he suggested the name *Amoeba meleagridis* for it.

The disease was characterized by ulcerative areas in the ceca and rounded necrotic areas in the liver. The cecal lesions were the primary ones from which the liver infection subsequently resulted by the organisms being carried there by the blood.

Following Smith's report, very little was done in studying the disease until 1902 when Curtice continued the study at this station. Meanwhile the infection continued to spread and became the worst disease with which the turkey producer had to contend. It was almost responsible for the almost complete abandonment, for a time, of what had been a very successful poultry enterprise in Rhode Island as well as in other states.

The work of Curtice (5, 6) consisted for the most part of an epidemiological study of the disease. The results of his findings constitute hygienic factors which once again have made turkey production a more successful enterprise so far as this infection is concerned.

The principal findings of Curtice were:

1. That blackhead infection was not transmitted through the egg. If final incubation of the eggs was done artificially and the poults kept on board floors away from ordinary fowls or turkeys, blackhead could be escaped for several weeks. In contrast, if the poults were exposed to the ground of the poultry plant, they contracted it in from 12 to 20 days from the time of probable exposure.

2. Evidence was produced to show that ground on which ordinary fowl had run was heavily infected while soil uncrossed by poultry probably was not infected.

3. Common fowl were hosts of the disease—creating parasites and, with adult turkeys, spread the infection. Occasionally chickens which had died were observed to show typical lesions of the infection.

4. Experiments in which both common fowl and turkey hens had been used to brood young poults resulted in most instances in the young fowl contracting the infection.

5. Earthworms obtained from yards on which fowl had ranged and fed to young poults resulted in infection. He thought that the worm was a carrier of infected soil rather than a secondary host for the parasites.

6. Wild, half-wild, Narragansett, Bronze, Mammoth bronze, and White Holland turkeys all suffered losses from blackhead thus showing that none of the breeds tested were immune and that any benefit derived by wild turkey crosses from the standpoint of blackhead was probably from the fact that they were more apt to roam at some distance from farm buildings thus avoiding the surrounding contamination of the latter.

7. Four-fifths of the young poults exposed in infected yards contracted the disease and died before they were six weeks old although prior to this time the disease was popularly supposed to be confined to older birds.

8. Immunity in the offspring that might be expected from the parents having been immune to or having recovered from the disease as was the case with some of the station flock, was not apparent.

9. Older turkeys apparently resist the disease better than younger birds since 20 per cent of the former and 90 per cent of the latter were found to die in the course of a year.

10. The duration of the disease was found to be from 12 to 14 days from the probable date of exposure in young poults. Older birds would sometimes die within 17 days from the probable date of exposure. Prior to this time it had been impossible to judge the probable duration of the disease from the lesions alone.

11. He demonstrated that turkeys may be raised to maturity with a minimum of 15 to 20 per cent mortality from blackhead in contrast to 80 per cent in turkeys not so reared by finishing the hatching of eggs in an incubator, brooding the poults for a few weeks on disinfected board floors and placing them on range in a location removed from ordinary fowl.

One of the important points described by Curtice, for which a more scientific explanation was needed, was that pertaining to the manner in which soil used to range common fowls or turkeys became infected with blackhead and remained so for a long period of time. He suspected some secondary host as playing a part in the infection. The work of Graybill and Smith (14) in finding that cecal worms played a role in the infection was a great step forward in this understanding. They found that the embryonated eggs of this parasite when fed to the birds were capable of inducing the infection in turkeys with great regularity. They were not sure at the time whether the resistant phase of the blackhead protozoon was capable of living in the eggs of this parasite or whether they presented an avenue for development of organisms already present in the bird. Tyzzer (33, 32) later confirmed the work of Graybill and Smith and in addition proved that the eggs of this worm were capable of harboring a resistant form of the blackhead protozoon. As these parasites are common to both chickens and turkeys and since their eggs are quite resistant outside the body of the fowl, it explained the reason why soil on which these fowl had run became contaminated and remained so for a long period of time. Tyzzer (30, 33) demonstrated that the free protozoa themselves were unable to live for any great period of time outside the body of a suitable host.

Curtice resigned from the staff of the Rhode Island station in 1907 and the investigations were continued by Cole and Hadley whose studies for the most part concerned the etiology of the infection. In 1908, they (3) reported that they had been unable to observe any consistent morphological differences between the amoeba described by Smith and the shizont stage of another protozoon, a coccidium, and that the blackhead parasite might be a variety of this organism. Chester and Robin (2) had referred to the blackhead organisms as coccidia.

Cole and Hadley, 1910 (4), considered the coccidium, the shizont stage of which they believed to be the same as the amoeba of Smith, the cause of blackhead infection. They had observed coccidia in chicks, fowl, pigeons, geese, pheasants, guinea fowl, squabs, grouse, sparrow and other birds, and suggested that blackhead disease was not so limited in character

insomuch as these birds had the same infection with different disease manifestations.

They were able to produce blackhead in young poults and chicks by feeding them diseased organs. The chicks were more resistant to the disease than poults although three out of five young chicks became infected from receiving this material. They could not by this method produce infection with any degree of certainty as the results obtained from other trials at artificial attempts to produce the disease were inconclusive.

Attempts to determine whether lice could serve as carriers of the infection gave negative results.

Of several medicinal agents used in an attempt to control blackhead, none were found to be of any value. Those tried were salol, sulfur, iron sulfate, quinine sulfate, and sodium salicylate.

Hadley and Aminson in 1911 (17) suggested that in addition to coccidia being the causative factor of blackhead, that certain flagellate protozoa trichomonads might play a role in the disease alone or together. Jowett (18) studied the disease in South Africa and believed the blackhead protozoa to be trichomonads.

Hadley (15, 16), 1916, presented evidence of the pathogenic role of the flagellate protozoon trichomonas in blackhead disease. These organisms were observed in both healthy and diseased fowls and he suggested that successful infection probably depended upon factors present in the host quite unrelated to virulence on the part of the infecting organisms. He suggested that the organisms became tissue invaders as a result of a more or less fluid condition of the cecal content resulting in the multiplication of the flagellates in vast numbers which tended to produce bulging of the *fundi* of the crypts of Lieberkuhn then through pressure or invasive power, or both, the motile flagellates (trophozoites) penetrated the goblet cells and subsequently the basement membrane and submucosa.

The organism which he had earlier considered to be the shizont stage of a coccidium and which Smith had considered as an amoeba, he now considered to be the trophozoite stage of the trichomonas.

Insomuch as these organisms were present in both diseased and healthy fowl, he no longer considered blackhead disease to be infectious in character as that term would ordinarily imply, but that under certain conditions, trichomonads already present in the intestinal tract became tissue invaders.

Smith (24) in 1915 again studied the etiology of blackhead infection and reaffirmed his earlier beliefs that the blackhead protozoon was an amoeba.

Up until this time, the study of blackhead had been difficult as the disease could not be produced with any degree of regularity by artificial methods. Moore (19) had been able to infect three out of four turkeys with the disease by feeding them the excrements of turkeys infected with the disease but subsequent workers found this difficult to accomplish with any degree of certainty.

Tyzzer (25) 1919 supported Smith's view with regard to the protozoon of blackhead and additional evidence was presented to indicate that the organism possessed certain flagellate characteristics. Later he (26) suggested the name *Histomonas meleagridis* for the organism because in addition to possessing amoeboid characteristics, it also had certain flagellate structures. Tyzzer (29, 32) later observed the *Histomonas* in its

free flagellate form when examining the intestinal contents of turkeys and chicks thus confirming his earlier histological studies.

In contrast to a trichomonas, the histomonas does not possess an axostyle nor undulating membrane and most commonly possesses only a single flagellum although occasionally from one to four flagella may be observed.

Tyzzar (31) was able to produce blackhead infection by the subcutaneous inoculation of turkeys with infective liver material which resulted in lesions of the lungs, liver, and kidneys, from which histomonas could be observed. He (30) was also able to induce infection in young poults by the rectal injection of infective liver material in the absence of embryonated cecal worm eggs showing that the mere establishment of the organism in the ceca was all that was necessary for successful infection.

RECENT INVESTIGATIONS AND EXPERIMENTAL CONTROL MEASURES

Delaplane (8) isolated protozoa from young poults and chicks which were capable of producing typical blackhead in successive transfers to several groups of young poults. The organisms were isolated from poults and chicks which had been maintained free of intestinal protozoa until receiving rectal injections of infective liver material. The protozoon thus isolated was a flagellate possessing usually only one flagellum although occasionally organisms possessing more than one were observed. The live organisms examined microscopically moved in a rotating-like manner usually making about one-fourth of a complete rotation although occasionally some made a complete rotation. Amoeboid processes were observed to be extended and retracted from time to time. An axostyle and undulating membrane were absent, differentiating it from a trichomonas. The organism was similar to the *Histomonas meleagridis* (Tyzzar) and was considered as such, thus supporting Tyzzar's studies that the amoeba of Smith was actually a flagellate and responsible for blackhead infection.

Young chicks infected with *Histomonas meleagridis* resulted in some showing typical liver lesions while cecal lesions were almost invariably observed.

The organisms were cultured on an egg medium but the growth was scanty and difficult to maintain.

Several drugs and chemicals have been employed by Hadley, May, and others at this station (See annual reports, R. I. Agricultural Experiment Station, 1909-1933) to determine if they were of any value in preventing blackhead infection in turkeys. All of those tried have been of little or no value. Some of the chemicals used were neorarsphenamin, arsenic trioxide, ipecac, iron strychnine citrate, organic sulfur, iodine, resorcinol, ethyl alcohol, turpentine, nicotine sulfate, alpha naphthol, tartar emetic, and beta naphthol.

Tyzzar (28) studied several drugs and chemicals and the one he found most effective was tryparsanamide. Others used were tartar emetic, quinine hydrochloride, neorarsphenamin, arsenious acid, atoxyl, chaparro amargosa (27), ipecac and sulfur (32).

Chemicals and drugs have been found to be of little or no practical value in the treatment or prevention of blackhead infection and the successful production of turkeys is still dependent upon sanitary management practices. Sanitary management programs for rearing turkeys have been

planned with considerable success. These programs incorporate the important findings of Curtice and others in overcoming the principal sources of this infection. A well-known plan of this type is that known as the Billings (1) plan for rearing turkeys. The value of sanitary practices has been further proven by Rettger and Kirkpatrick (20-21).

It is evident from a survey made of the management methods used in rearing turkeys in Rhode Island during the 1933 season that practically all commercial turkey producers are following a sanitation program which has been quite satisfactory in controlling blackhead infection (Table 1). Those producers who had not followed a sanitary program, permitting the turkeys to run with chickens, etc., reported a loss of approximately 45 per cent from this infection as against only an estimated few per cent reported by those following sanitary methods. One producer who had suffered a high percentage of loss from blackhead in previous years reported that he had been able to raise 111 out of 120 poults to maturity by confinement rearing of the turkeys on wire platforms which would otherwise have been impossible due to heavily infected ranges with which he had to contend.

TABLE 1.—*Summary of survey made of 10 representative turkey producers in Rhode Island*

Producers using sanitary practices		Total mature turkeys 1933		Estimated loss from blackhead		Producers using no sanitary practices		Total mature turkeys 1933		Estimated loss from blackhead	
Number	Number	Number	Per cent	Number	Number	Number	Per cent	Number	Number	Number	Per cent
8	2661	126	4.73	2	225	101	44.8				

Cecal abligation (9) by the use of clamps was performed on several groups of turkeys during the growing season of 1932 in an effort to determine the value of this method as a means of controlling blackhead infection and to note the mortality as a result of such an operation on poults of various ages. Durant (10, 11, 12, 13) had shown the efficacy of such a procedure in the prevention of blackhead. The operation described by Durant for the most part had consisted in the use of ligatures in tying off the ceca at their junction with the main intestine and the mortality from the operation was quite high. He had also used clamps in occluding the ceca of 14 turkeys, 8 of which had died as a result of the operation.

The technique of the operation consisted in making an incision through the left abdominal wall of the bird at the site commonly used in caponizing and drawing the ceca, the necks of which lie opposite the operative incision, into a convenient position for the application of the clamps. The clamps were placed about 5 mm. from the junction to the main intestine and closed by means of pliers just sufficient to effect closure of the ceca but not sufficient to crush the underlying structures. The clamps used consisted of aluminum bands 5 mm. wide and $\frac{1}{2}$ mm. thick.

Of 85 birds operated in this manner at three weeks of age (Table 2), 17 or 20 per cent died as a result of the operation from peritonitis. Of 64 operated at six and seven weeks of age, 5, or 7.8 per cent, died as a result of the operation. Of 23 poults operated at six weeks of age, at which time

TABLE 2.—Results of cecal ablation of turkeys by clamping

Group	Age at operation	Date (1932)	Birds	Mortality				Average exposure of birds dying of blackhead
				From operation		From blackhead		
	Weeks			Number	Per cent	Number	Per cent	
I	3	May 15	21 operated 5 controls	4 ..	19.1	1 5	5.9 100.0	5 months 3 weeks
II	3	May 23	14 operated 4 controls	3 ..	21.4 ..	0 3	0 75.0	6 months 4 weeks
III	3	June 15	50 operated 13 controls	10 ..	20.0 ..	2 7	4.0 53.8	5 months 6 weeks
Summary (groups I, II, III)			85 operated 22 controls	17 ..	20.0 ..	3 15	4.4 68.2	5 $\frac{1}{8}$ months 4 $\frac{1}{8}$ weeks
IV	6	June 22	10 operated	1	10.0	0	0	
VI	7	July 12	54 operated ^a 50 controls	4 ..	7.4	3 10	6.0 20.0	4 months 4 "
Summary (groups IV and VI)			64 operated ^a 50 controls	5 ..	7.8 ..	3 10	5.1 20.0	4 months 4 "
Summary (all groups)			149 operated 72 controls	22 ..	14.7 ..	6 25	4.7 34.7	4 $\frac{3}{4}$ months 2 $\frac{3}{8}$ "

NOTE.—Group V omitted due to high mortality occurring as the result of being operated upon while they were infected with coccidiosis.

^a These birds are used as controls inasmuch as they were with the operated birds on range.

they were infected with coccidiosis, 20, or 87 per cent, died from the operation, indicating such an operation is hazardous under these conditions.

Those poults surviving the operation at three weeks of age, along with 22 control birds, were exposed to severe blackhead infection from which 15 of the controls contracted the infection and died with an average exposure period of four and one-third weeks. In contrast, three operated birds contracted the infection and died with an average exposure period of five and one-third months or a percentage mortality of 68.2 per cent for the controls against 4.4 per cent for the operated birds.

The turkeys surviving the operation at six and seven weeks of age were placed on range along with 50 control birds. These birds were shifted to clean range at weekly intervals. Ten of the 50 controls, or 20 per cent, contracted blackhead and died at approximately four months of age. In contrast, 3, or 5.1 per cent, of the operated birds contracted the infection and died. The source of infection for these birds was probably drinking water furnished them by mistake from a brook which ran through a range used for chickens.

The examination of the six birds operated upon and dying from blackhead showed five of them with one or both ceca functioning. The autopsy examination of 27 (Table 3) of the operated birds showed 15 of those observed four to six months after operation with one or both ceca functioning. This was not observed to have occurred in less than four months following the operation. In those birds in which the ceca remained occluded, the clamps were found embedded in the tissue at the point of application.

TABLE 3.—*Postoperative examination of 27 turkeys one to six months following operation*

Turkeys examined	Time after operation	Cecums functioning			Cecums	
		One	Both	Per cent	Enlarged	Normal
	<i>Months</i>	<i>Number</i>				
9	1—4	0	0	0	2	7
18	4—6	9	6	83.33	15	3

It is possible that the ceca refunction as a result of bacterial action in and around the embedded clamps causing a fistulous opening which becomes increased in size due to material passing in and out of the ceca. The fact that the clamps were found often within the ceca at their blind extremity, being unable to pass out the narrow refunctioning lumen, would tend to support this view.

The operation was effective in preventing blackhead infection in turkeys for at least four months but is of questionable value for longer periods due to changes which favor these organs resuming their function or from enlargement.

Weldin and Kay (unpublished data) conducted seriological tests of the precipitin type to determine whether such a test could be found of any value in detecting blackhead infection. Antigens were prepared by using diseased tissues. The results of the tests were variable and not satisfactory for diagnosis of either acute or chronic cases of blackhead. Rettger and Kirkpatrick (20) likewise had had unsatisfactory results from the use of similar tests.

A phase of the blackhead project which dealt with management factors was studied during the growing season of 1933³ with the intention of obtaining information concerning the incidence of blackhead in turkeys reared in confinement using sunporches with mesh floors as compared with turkeys grown on rotated range, also to consider the food consumption and gain between the two groups.

Thirty-three bronze-Narragansett cross poults were selected for the group to be placed on range and 35 poults of the same cross were selected to comprise the group to be maintained in brooder houses with wire porch runs. After the experiment was in progress, sixteen of the range group were killed by dogs and an outbreak of coccidiosis in the confinement group resulted in the death of nine birds from this infection.

The range group had been reared in a brooder house with a wire porch run until they were nine weeks old at which time they were placed on range. These birds were shifted to a different range at weekly intervals.

The weights of the turkeys (Table 4) were taken at weekly intervals from the time of hatching until the end of the experiment. Likewise the feed consumed by the birds was computed on a weekly basis.

TABLE 4.—Average gain and feed consumption (computed in pounds) of Bronze-Narragansett cross turkeys over a 25-week period of birds reared on range and in confinement

(Both groups reared in confinement until the ninth week)

Weeks	Range Group				Confinement Group			
	Average weight	Average consumption		Meat scrap	Average weight	Average consumption		Meat scrap
		Mash	Scratch			Mash	Scratch	
1	0.134	0.131	0.0	0.0	0.117	0.11	0.0	0.0
2	.28	.23	0.0	0.0	0.256	.238	0.0	0.0
3	.416	.4	0.0	0.0	.371	.389	0.0	0.0
4	.585	.588	0.0	0.0	.551	.466	0.0	0.0
5	.817	.605	0.0	0.0	.739	.563	0.0	0.0
6	1.24	0.891	0.0	0.0	0.992	0.956	0.0	0.0
7	1.539	1.245	0.0	0.0	1.32	.994	0.0	0.0
8	1.958	1.515	0.0	0.0	1.43	1.150	0.0	0.0
9	2.575	1.781	0.0	0.0	1.546	1.210	0.0	0.0
10	3.507	2.181	0.0	0.0	2.198	1.64	0.0	0.0
11	3.831	2.230	0.046	0.041	2.96	2.2	0.04	0.0
12	4.23	2.151	0.15	0.041	3.58	3.18	.06	.0
13	5.204	2.53	.13	.054	4.23	2.16	.196	0.0
14	5.334	3.38	.26	.075	4.87	2.3	.06	0.0
15	6.06	2.635	.3	.13	5.697	2.478	.15	.029
16	6.58	2.79	0.164	0.13	6.348	2.5	0.435	0.225
17	7.5	3.0	.093	0.0	7.166	2.83	.32	.15
18	8.27	2.45	.84	0.0	7.937	2.43	.79	.304
19	8.88	2.79	.76	.012	8.838	2.23	1.13	.4
20	10.35	2.52	.8	0.0	9.65	1.85	1.74	.404
21	10.24	2.51	0.88	0.0	10.51	1.36	2.1	0.458
22	11.51	1.85	1.5	.041	11.296	.762	3.16	.375
23	11.361	1.57	1.9	.041	11.813	.945	2.94	.27
24	12.17	1.53	2.44	.05	12.497	.391	3.758	.233
25	12.37	.98	2.57	.07	13.32	.316	3.08	.233
Totals	12.37	44.48	12.83	0.69	13.32	35.62	19.96	3.08

³We are indebted to T. C. Higgins, Plant Foreman, for obtaining the data used in this phase of the project.

The average total food consumption for each bird of the confinement group was 58.66 pounds as against 58.00 pounds for the range group over a 25-week period. The average weight of the confinement group birds was 13.32 pounds against 12.37 pounds for the range group at the end of the twenty-fifth week.

During the coccidiosis epidemic in the confinement group, the average gain per week was 0.108 pounds over a two-week period as compared with 0.518 pounds for the corresponding period for the range group. Following this period, the confinement group of turkeys made a steady gain and at the end of the twenty-third week, had exceeded the weight of the other group.

One death occurred from blackhead in the confinement group. It is possible that both the coccidiosis and blackhead infection occurred as a result of these birds accidentally gaining access to the ground surrounding the brooder house where birds had died from these diseases the previous year.

Four birds in the range group contracted blackhead and died during the corresponding period of time.

The results of the experiment, although data was obtained from comparatively few birds, would suggest a possible successful and desirable means of rearing turkeys under close confinement for those who have a limited amount of range which has become heavily contaminated with blackhead infection. The birds reared in confinement consumed 0.66 pounds more feed than those grown on range and exceeded the latter in weight over a corresponding period of time (Table 5). The feed cost was \$1.20 each for the confinement group and \$1.17 for those grown on range.

TABLE 5.—Average total food consumption in pounds and feed costs

Group	Average total				
	Feed consumption	Mash	Scratch grain	Meat scrap	Feed cost
Confinement	58.66	35.62	19.96	3.08	\$1.20
Range	58.00	44.48	12.83	0.69	1.17

NOTE:—Feed cost computed on the basis of mash at \$2.07 per 100 pounds; scratch grain, \$1.78 per 100; meat scrap, \$3.15 per 100; (our average cost of feed for the summer of 1933).

SUMMARY

The disease known as blackhead of turkeys was first recognized by Cushman as a serious disease of turkeys as a result of a survey made by him of the turkey industry of Rhode Island in 1892.

How long the disease had existed in this country prior to this time is difficult to ascertain but from evidence obtained by Cushman (7), it would seem that the disease had been present for several years.

The disease was first studied by Dr. Theobald Smith (23) 1895 as a result of specimens having been sent him by Cushman. He discovered that the disease was of a protozoan nature due to an organism which resembled an amoeba and for which he suggested the name *Amoeba meleagridis*. Later, in 1915, Smith (24) reaffirmed these earlier findings.

Little was done following Smith's report in studying blackhead until 1902 when Curtice took up the study of the infection at this station.

Curtice (5, 6) studied the manner in which the infection was disseminated and made the following important contributions on which all sanitary programs of rearing turkeys are based at this time. These were: that blackhead infection was not transmitted through the egg; that the common fowl and turkey hen were carriers of the infection and contaminated soil on which they run, while soil unused by poultry probably was not infected; that wild turkey crosses were susceptible to the disease, hence any value to be gained from these crosses was that they were more apt to range away from farm buildings thus avoiding the contamination surrounding the latter.

Following the resignation of Dr. Curtice, Cole and Hadley continued the study of blackhead for the most part studying the nature of the causative organisms. In 1908, they (3) reported their inability to note any morphological differences between the shizont stage of a coccidium and the amoeba of Smith. Later they (4) considered the amoeba of Smith to be the shizont stage of a coccidium.

Hadley (17) 1911, suggested that in addition to coccidia being a causative factor in blackhead, that certain trichomonads might play a role either alone or together. In 1916 (15, 16), he considered the amoeba of Smith, which he had earlier thought to be the shizont stage of a coccidium, the trophozoite stage of a trichomonad and the cause of the disease.

Tyzzar (25) supported Smith's studies with regard to the nature of the protozoon and later suggested the name *Histomonas meleagridis* for the organism for in addition to amoeboid characteristics, it possessed certain flagellate structures. Tyzzar (29, 32) later observed *Histomonas meleagridis* in its flagellate form, thus confirming his earlier studies.

Delaplane (8) isolated protozoa from chicks and turkeys which had been maintained free of protozoa until infected in the rectum with infective liver material which produced typical blackhead in several successive groups of poults. The organism was a flagellate in character and capable of amoeboid movement resembling the *Histomonas meleagridis* (Tyzzar) thus supporting his studies that the amoeba of Smith was actually a flagellate and responsible for blackhead.

Several drugs and chemicals have been studied at this station which have been of little or no value in the prevention or treatment of this disease. Some of those used were neoarsphenamin, arsenic trioxide, ipecac, iron and strychnine citrate, organic sulfur, iodine, resorcinol, ethyl alcohol, turpentine, nicotine sulfate, alpha and beta naphthol, quinine sulfate, salol, iron sulfate and sodium salicylate.

An operation by occluding the ceca by means of a clamp in a manner similar to that described by Durant to prevent organisms from gaining entrance to the ceca where they most commonly develop and give rise to infection was performed on several groups of poults. Turkeys surviving the operation were protected against blackhead for at least four months after which time some of the birds contracted blackhead as a result of the ceca again functioning.

Experiments to determine the incidence of blackhead in turkeys reared in confinement in contrast to those reared on range and to note the amount of feed consumed under the two methods, indicated that bronze-Narragansett cross birds consumed on an average of 58.66 pounds of feed in confinement over a 25-week period while those reared on range consumed on an average of 58.00 pounds over a corresponding period. The average weight of the confinement group birds was 13.32 pounds as against 12.37

pounds for the range group at the end of the twenty-fifth week. As both groups of birds were reduced in numbers through accident and disease, figures were available from only a limited number of birds in each group.

A survey of the sanitary methods used by Rhode Island turkey producers showed that practically all followed a sanitation program which was quite satisfactory in controlling blackhead infection.

LITERATURE CITED

- (1). Billings, W. A., 1929. Talking turkeys. Minn. Agr. Ext. Division Spec. Bul. 124.
- (2). Chester, F. D. and Robin A., 1900. Entero-hepatitis or blackhead of fowls. Del. Agr. Exp. Sta. Report No. 12, p. 60-66.
- (3). Cole, Leon J. and Hadley, Philip B., 1908. Blackhead, a coccidial disease of turkeys. Science, N. S. 27: p. 994.
- (4). Cole, Leon J. and Hadley, Philip B., 1910. Blackhead in turkeys: A study in avian coccidiosis. R. I. Agr. Exp. Sta. Bul. 141, p. 139-259.
- (5). Curtice, Cooper, 1907. Further experiments in connection with the blackhead disease in turkeys. R. I. Agr. Exp. Sta. Bul. 124, p. 65-105.
- (6). Curtice, Cooper, 1907. The rearing and management of turkeys with special references to the "blackhead" disease. R. I. Agr. Exp. Sta. Bul. 123, p. 1-64.
- (7). Cushman, Samuel, 1893. Turkeys, experiments with; management by successful producers; wild turkey crosses, their desirability, and where they may be obtained. R. I. Agr. Exp. Sta. Bul. 25, p. 85-123.
- (8). Delaplane, John P., 1932. Etiological studies of blackhead (entero-hepatitis) in turkeys. R. I. Agr. Exp. Sta. Bul. 233, p. 1-15.
- (9). Delaplane, John P. and Stuart, Homer O., 1933. Cecal abligation of turkeys by the use of clamps in preventing entero-hepatitis (blackhead) infection. Jour. Amer. Vet. Med. Assoc. 83: p. 238-246.
- (10). Durant, A. J., 1926. Cecal abligation in fowl. Vet. Med. 21: 392-395.
- (11). Durant, A. J., 1926. Entero-hepatitis in turkeys. Mo. Agr. Exp. Sta. Bul. 244, p. 60.
- (12). Durant, A. J. 1927. Cecal abligation for prevention of entero-hepatitis in turkeys. Mo. Agr. Exp. Sta. Bul. 256, p. 100.
- (13). Durant, A. J., 1930. Blackhead in turkeys—surgical control by cecal abligation. Mo. Agr. Exp. Sta. Res. Bul. 133, p. 1-32.
- (14). Graybill, H. W. and Smith, Theobald, 1920. Production of fatal blackhead in turkeys by feeding embryonated eggs of *Heterakis papillosa*. Jour. Exp. Med. 31: p. 647-655.
- (15). Hadley, Philip B., 1916. The role of the flagellated protozoa in infective processes of the intestine and liver. R. I. Agr. Exp. Sta. Bul. 166, p. 1-40.
- (16). Hadley, Philip B., 1916. The avenue and development of tissue-infection in intestinal trichomoniasis. R. I. Agr. Exp. Sta. Bul. 168, p. 1-57.

- (17). Hadley, Philip B. and Aminson, Elizabeth E., 1911. Further studies on blackhead in turkeys. *Centbl. f. Bakt. Abt. 1, Orig.*, 58: p. 34-41.
- (18). Jowett, W., 1911. Infectious entero-hepatitis—a disease of young turkeys. *Jour. Comp. Path. and Ther.* 24: 289-302.
- (19). Moore, V. A. 1896. The direct transmission of infectious entero-hepatitis in turkeys. *U. S. Dept. Agr. Bur. Anim. Ind. Circ.* 5.
- (20). Rettger, Leo F. and Kirkpatrick, Wm. F., 1927. An epidemiological study of blackhead in turkeys. *Storrs Agr. Exp. Sta. Bul.* 148.
- (21). Rettger, Leo F., Kirkpatrick, Wm. F., and McAlpine, James G., 1929. Epidemiological studies of blackhead in turkeys: II. Ordinary barnyard fowl as important agents of transmission. *Storrs Agr. Exp. Sta. Bul.* 156.
- (22). R. I. Agr. Exp. Sta. Annual Report, 1893.
- (23). Smith, Theobald, 1895. An infectious disease among turkeys caused by protozoa (infectious entero-hepatitis). *U. S. Dept. Agr. Bur. Anim. Ind. Bul.* 8.
- (24). Smith, Theobald, 1915. Further investigations into the etiology of the protozoan disease of turkeys known as blackhead, entero-hepatitis, typhilitis, etc. *Jour. Med. Res.* 33: p. 243-270.
- (25). Tyzzer, E. E., 1919. Developmental phases of the protozoan of blackhead in turkeys. *Jour. Med. Res.* 50: p. 1-26.
- (26). Tyzzer, E. E., 1920. The flagellate character and reclassification of the parasite producing blackhead in turkeys, *Histomonas* (Gen. Nov.) *meleagridis* (Smith). *Jour. Parasitology* 6: 124-130.
- (27). Tyzzer, E. E., 1920. The effects of the administration of chaparro amargosa on the intestinal protozoa of the turkey. *Jour. Med. Res.* 41: 211-219.
- (28). Tyzzer, E. E., 1923. Arsenical compounds in the treatment of blackhead in turkeys. *Jour. Exp. Med.* 37: 851.
- (29). Tyzzer, E. E., 1924. The chicken as a carrier of *Histomonas meleagridis* (blackhead); the protozoan in its flagellate stage. *Jour. Med. Res.* 44: 676.
- (30). Tyzzer, E. E. and Collier, J., 1925. Induced and natural transmission of blackhead in the absence of heterakis. *Jour. Inf. Dis.* 37: 265-276.
- (31). Tyzzer, E. E. and Fabyan, M., 1920. Further studies on "blackhead" in turkeys with special reference to transmission by inoculation. *Jour. Inf. Dis.* 27: 207.
- (32). Tyzzer, E. E. and Fabyan, M., 1922. A further inquiry into the source of the virus in blackhead of turkeys together with observations on the administration of ipecac and sulfur. *Jour. Exp. Med.* 35: 791-812.
- (33). Tyzzer, E. E., Fabyan, M. and Foot, N. C., 1921. Further observations on blackhead in turkeys. *Jour. Inf. Dis.* 29: 268-286.