

A COMPARISON OF THE RESISTANCE OF THREE  
BREEDS OF CHICKENS TO THE NEMATODE, ASCARIDIA LUMATA

by

HEN GLADING

A. B., University of Michigan, 1932

---

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE  
OF AGRICULTURE AND APPLIED SCIENCE

1933

Doc  
NCIR  
LD  
266  
T4  
1933  
655  
C. I

## TABLE OF CONTENTS

	page
INTRODUCTION .....	2
ACKNOWLEDGMENTS .....	3
MATERIAL AND METHODS .....	4
EXPERIMENTAL DATA .....	10
Group I .....	10
Experiment I .....	10
Experiment II .....	17
Age Resistance .....	19
Group II .....	21
Experiment III .....	21
Experiment IV .....	22
DISCUSSION .....	23
SUMMARY .....	28
LITERATURE CITED .....	30

## INTRODUCTION

The general effects of parasitism by the large round-worm of the chicken, Ascaridia lineata (Schneider), have been known for some time (Ackert and Herrick, 1928). Quantitative studies on the effects of host chickens on the viability and growth of this nematode have been made by Ackert et al (1929, 1931a, 1931b, 1931c, 1932a, 1932b).

This work has been done with the Single Comb White Leghorn as a host fowl. Whether variations occur in the relations of different breeds of chickens to this parasite is not known. The only work to date of importance in the field of comparative breed resistance to disease has been done with the fowl typhoid bacterium, Salmonella gallinarum (Lambert, 1932) on the White Plymouth Rocks, White Leghorns, White Wyandottes and Rhode Island Reds. A comparison of the death rates of various fowl breeds has been made by Dudley (1928) and Harris and Boughton (1928), but to date nothing appears to have been done in the field of the resistance of various breeds of chickens to helminth infestations.

Since researches in this field may prove to be of benefit to the poultry industry, and since it would be advantageous to know the most desirable breed of fowl for future researches in the field of parasitic resistance, it seemed desirable to study the comparative resistance of certain standard breeds of chickens to A. lineata.

#### ACKNOWLEDGMENTS

The writer wishes to thank Dr. James E. Ackert for suggesting this problem and for the advice and help that were given by him throughout the course of the investigation. Appreciation is also due to Mr. Leslie Eisenbrandt

and Mr. James Wilmoth for valuable assistance in carrying out the mechanics of the work.

#### MATERIALS AND METHODS

The basic plan of the research was to subject three breeds of chickens, White Leghorns, Barred Plymouth Rocks, and Buff Orpingtons to exactly the same degree of parasitism with A. lineata (Schneider), and to determine the resistance of these breeds to the infestations of the worms. The work was divided into two groups each of two experiments. Experiments I and II were conducted in the fall of the year of 1932, and Experiments III and IV during the late winter and early spring of 1933.

In each group of experiments, 50 birds of each of the three breeds mentioned were obtained from an accredited commercial hatchery and raised helminth free in sanitary, cement-floored, rat proof pens in a steam-heated frame building. They were all fed on a diet adequate for chickens raised indoors. This diet, which was fed in hoppers, was composed of the following ingredients mixed in the proportions indicated: yellow corn meal, 40 parts; alfalfa leaf meal, 4 parts; meat meal, 10.4 parts; skim milk powder, 6.4 parts, Oatona, 12 parts; cracked wheat, 15 parts; and 1.642 parts of cod liver oil. As far as possible these three

breeds were subjected to exactly the same conditions of heat, light, feed and amount of floor space. The floors of the pens were covered with a litter of clean straw, which was changed at regular intervals for sanitary purposes. The chickens were all banded at the age of two weeks, and from that time on were weighed weekly, and an accurate record of each chicken's growth was kept; growth curves were later plotted for the breeds as a whole.

At the age of four weeks, the chickens were divided into two groups, the first of which was composed of about 25 birds picked at random from each of the three breeds. These chickens which were used in Experiment I were parasitized with the nematode A. lineata at the age of 30 days. The remainder of the original flocks of 50 birds per breed were kept for Experiment II. The number of birds in the group varied from 15 to 25 per breed, depending on the mortality before this separation occurred. In all cases, chickens that were obviously weak or crippled were culled out at an early stage in order that their later possible death would not interfere with the progress of the experiment.

Eggs of the nematode A. lineata in the coiled embryo stage were used for parasitizing the chicks. Gravid female worms obtained from a poultry packing house were used as a

source of the parasite eggs. The anterior ends of the worms were excised and the contents of their bodies pressed out into a clean Petri dish. The uteri were then separated from the rest of the viscera and punctured in several places to be examined for the presence of fertilized eggs. Ackert (1931) found that the largest percentage of fertilized eggs lie in the proximal end of the uteri. The criterion for determining whether eggs were fertilized was the presence of a light central spot (Ackert, 1931). The fertilized eggs were pressed from the uteri and covered with distilled water in which was placed four or five drops of two per cent formalin (about 1-1000 dilution) as a protection against bacteria and molds which would be injurious to the egg culture. The eggs were then incubated at room temperature (approximately 27°C.) for three weeks, time being arranged so that they would be in the infective stage when the chickens were ready to be parasitized.

When the chickens were to be parasitized, the eggs were counted on glass microscope slides with the aid of a compound microscope and a mechanical stage. After the proper number of eggs were on the slide, they were carefully wiped off onto a small piece of filter paper which was then inserted into the chicken's esophagus with a pair of blunt forceps. In all cases, the chickens were fed within the

range of fifty plus or minus five embryonated eggs of A. lineata. This number seemed desirable since it had the threefold advantage of not being too large to count for the large number of chickens handled, of being large enough to give a workable number of A. lineata (Ackert, Graham, Nolf, Porter, 1931), and of not being large enough to affect the mortality of the chickens involved (Ackert and Herrick, 1928).

Each chicken in Experiment I was parasitized at the age of 30 days with 50 eggs of A. lineata. The worms were allowed to hatch and develop in the chickens for three weeks, at which time all of the birds in this experiment were killed and examined for worms. The chickens in Experiment II were likewise parasitized with 50 eggs of A. lineata at the age of 44 days. In this case also, three weeks were allowed for the development of the worms. The three weeks period of parasitism is of approximately the proper length, since at the end of this time, the worms have assumed the habit of living free within the intestine and have withdrawn from among the villi (Ackert, 1923).

A little later than this, there is also a rapid elimination of the worms from the digestive tract (Ackert and Herrick). Care was taken to keep the parasitized birds separate from the non-parasitized ones, in order that the

birds would not acquire two infestations of worms. This also eliminated the possibility of acquired resistance to the parasite (Graham, Ackert and Jones, 1932).

On the evening of the twentieth day of parasitism, the chicks were taken off feed and placed in clean pens on the bare cement floor until they were killed the next day. This expedient was taken in order that their intestines be free of food and debris so that they may be more easily examined later for the presence of worms. On the twenty-first day of parasitism, the chicks were killed, and their intestines from the gizzard to the openings of the caeca were quickly removed. These small intestines were then broken into three or four pieces and their contents flushed out with hot water under pressure (Ackert and Nolf, 1929).

At autopsy, the sexes of the birds, and the lengths of their intestines from the gizzard to the openings of the caeca were recorded. Averages were later made of these figures.

The intestinal material procured was placed in Mason jars with the chicken's leg band as a label. Enough formalin (about 5 per cent) was added to the jars to insure preservation. Later this material was examined by means of a binocular microscope mounted on a movable arm, the worms

removed from the debris and counted out into vials of 4 per cent formalin, using the leg band of the chicken as a label for the vial.

Measuring the worms obtained was accomplished by first projecting an onion skin paper an enlargement of them by means of a photographic bellows, so that they were magnified exactly six diameters. The projections were then traced by means of a milled wheel which gave a direct reading of the lengths of the worms in millimeters.

The degree of infestation was determined by the average number of worms appearing in the various breeds. The amount of resistance was measured by the average lengths of A. lineata obtained from the different breeds. These two factors were taken as criteria for measuring the natural breed resistance of the chickens. Relative mean lengths of worms were held to be more important than relative numbers because they are more constant. The use of rather large numbers of chickens and of chickens of the same age, coupled with the fact that the worm eggs were obtained from worms of uniform length, made it probable that any differences in numbers or lengths of resulting worms would be due to variations in the resistance of the breeds of chickens.

## EXPERIMENTAL DATA

## Group I

Fifty chickens of each of three breeds, White Leghorns, Buff Orpingtons, and Barred Plymouth Rocks, were obtained from a commercial hatchery. They were hatched October 2, 1932, and delivered the following day. At the age of four weeks, they were divided into two separate lots, 25 of each breed being used in Experiment I, and the remainder in each breed in Experiment II.

Experiment I. The 25 chickens of each of the three breeds, White Leghorns, Buff Orpingtons and Barred Plymouth Rocks, were parasitized at the age of 30 days with 50 (plus or minus five) eggs of Ascaridia lineata in the coiled embryo stage. At the end of a three weeks' period of parasitism the chickens were killed and their intestines examined for evidences of worms.

Weekly weights were taken and averages were made for each breed, from which growth curves (Figs. 1 to 4) were plotted. It will be seen upon examination of Fig. 1 that the White Leghorns were slightly the heaviest of the three breeds at the beginning of the experiment. However, at the age of about four weeks, the weights of the Barred Plymouth Rocks and Buff Orpingtons exceeded that of the White

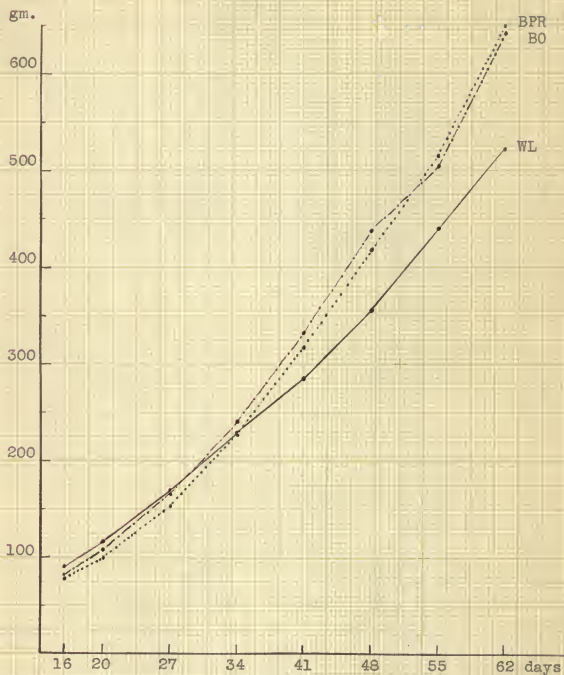


Fig. 1. Showing growth of chickens in Group I (all chickens). WL - White Leghorns; BO - Buff Orpingtons; BPR - Barred Plymouth Rocks.

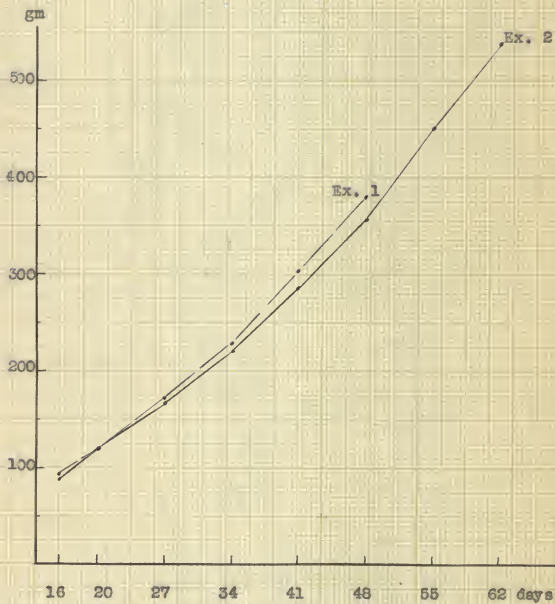


Fig. 2. Showing growth curves of White Leghorns  
Used in Group I.

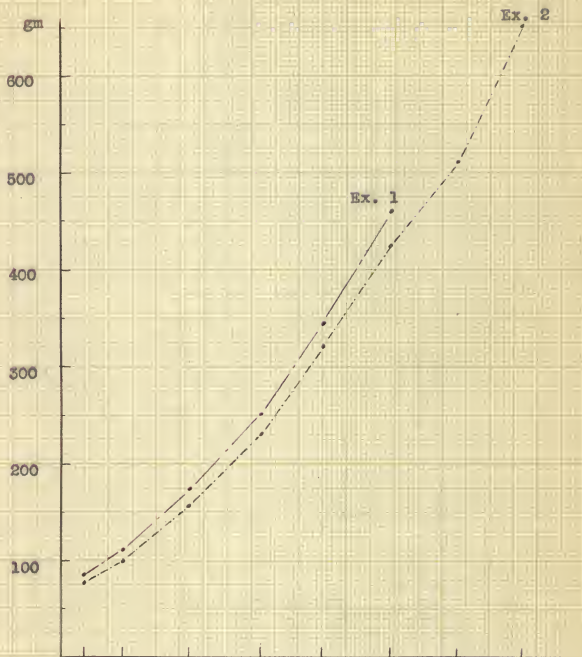


Fig. 3. Showing growth curves of Buff Orpingtons used in Group I.

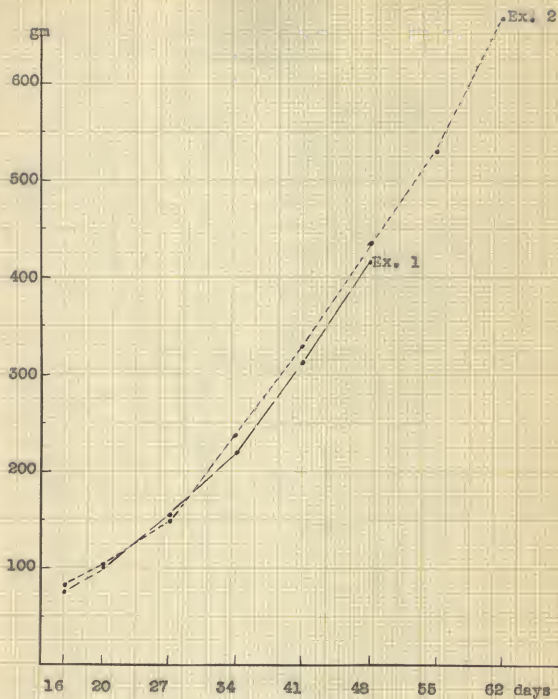


Fig. 4. Showing growth curves of Barred Plymouth Rocks used in Group I.

Leghorns, and at the termination of the experiment they averaged 100 grams heavier than the Leghorns.

It was noted that the White Leghorns were the most active of the three breeds studied, the first to assume full plumage, the first to acquire the characteristics of a mature bird, such as combs and ability to crow. The Buff Orpingtons were somewhat more advanced in these respects than were the Barred Plymouth Rocks, but these differences were so slight as compared with the variation between these two heavy breeds and the game fowl, the White Leghorns, that they are not worth noting.

In comparison of the numbers of worms found in the three breeds, it became obvious that the White Leghorns were infested to a greater degree than were the two heavier breeds, the Buff Orpingtons and the Barred Plymouth Rocks. Reference to Table I shows that the Leghorns had an average of 5.33 worms per chicken and the Buff Orpingtons a mean of 3.58 worms per chicken. This gives a mean difference of 1.75 worms, which is 1.74 times the probable error of the difference, and hence probably not significant.<sup>1</sup> In a

-----  
<sup>1</sup> When the difference of two means is at least 5.0 times its probable error, it is considered to be significant.

comparison of the numbers of worms found in the White Leghorns and Barred Plymouth Rocks, it was found that the Rocks had an average of only 2.3 worms per chick as compared with the Leghorn mean of 5.53, giving a difference of 3.23, which is 2.93 times the probable error, almost enough to be considered significant. The 3.58 mean number from the Buff Orpingtons, and the 2.8 mean from the Barred Plymouth Rocks gave a difference of .78, which is not significant. A rating of the three breeds on the basis of the incidence of infestation would place the Barred Plymouth Rocks as the most resistant, the Buff Orpingtons next, and the White Leghorns the least resistant of the three.

In a study of the lengths of worms found in Experiment I it was found that the mean length of the A. lineata from the White Leghorns is 22.29 mm., while that of the Buff Orpingtons was 18.27 mm., the difference between the two breeds being 4.02 mm. This difference is 7.07 times the probable error, which obviously is significant. A comparison of the White Leghorns with an average worm length of 22.29 mm. with the Barred Plymouth Rocks, having an average worm length of 15.25 mm., yielded a difference of 7.04 mm., which is significant (Table I). The difference between the 18.27 mm. mean of the Buff Orpingtons and 15.25 mean of the Barred Plymouth Rocks yielded a differ-

Table 1. Comparison of Ascaridia lineata found in chickens in Experiment I.

	Breed	: Number : : of : : hosts :	Mean :	: Stand. : : Dev. :	: Error : : of : : mean :	: Probable : : error of : : Dif. : : difference :	: Ratio : : D : P.M.D. :
Numbers of Worms	: White Leghorns	24	5.53	5.55	.76	1.75	1.004
	: Buff Orpingtons	24	5.58	4.734	.652		1.74
	: White Leghorns	24	5.53	5.55	.764		
	: Barred Plymouth : Rocks	25	2.8	2.979	.401	2.83	.862
	: Buff Orpingtons	24	3.58	4.734	.652		2.93
	: Barred Plymouth : Rocks	25	2.8	2.979	.401	.78	.765
Lengths of Worms (mm.)	: White Leghorns	24	22.29	6.852	.409		
	: Buff Orpingtons	24	18.27	5.436	.395	4.02	.567
	: White Leghorns	24	22.29	6.852	.409		
	: Barred Plymouth : Rocks	25	15.25	7.713	.621	7.04	.743
	: Buff Orpingtons	24	18.27	5.436	.395		
	: Barred Plymouth : Rocks	25	15.25	7.713	.621	3.02	.735
							4.10

ence of 3.02 mm., which in turn is significant. (4.10 times the probable error). Thus, in comparing the mean worm lengths as well as the mean numbers of worms found in the three breeds, we may again rate them with the Barred Plymouth Rocks as the most resistant, and the White Leghorns the least resistant, with the Buff Orpingtons having an intermediate position.

In searching for possible physical differences between the various breeds of chickens, records were made of the lengths of the small intestines, the habitat of the worms. Intestine lengths of the birds in this experiment averaged as follows: White Leghorns, 93 cm., Barred Plymouth Rocks, 93.2 cm. and Buff Orpingtons, 93.1 cm. Obviously, there are no significant differences in these figures.

Experiment II. The chickens of Experiment II, comprising 24 White Leghorns, 21 Buff Orpingtons, and 20 Barred Plymouth Rocks, were parasitized at the age of 44 days and killed at the age of 65 days. As in Experiment I, the chickens all received approximately 50 infective eggs of A. lineata. After the three weeks period of parasitism the chickens were killed and the worms collected and measured.

The results of a biometrical analysis of the worms found in Experiment II correspond very well with those of

Table 2. Comparison of Ascaridia lineata found in chickens in Experiment II.

	Breed	: Number : : of : : hosts :	Mean	: Stand. : : Dev. :	: Error : : of : : mean :	: Probable : : error of : : Dif. difference:	: Ratio : : D : P.E.D.
Numbers of Worms	: White Leghorns	24	1.66	1.609	.221	.56	1.87
	: Buff Orpingtons	21	1.0	1.877	.275	.352	
	: White Leghorns	24	1.66	1.609	.221	1.06	4.29
	: Barred Plymouth : Rocks	20	.6	.734	.110	.246	
	: Buff Orpingtons	21	1.0	1.877	.275	.4	1.35
	: Barred Plymouth : Rocks	20	.6	.734	.110		
Lengths of Worms (mm.)	: White Leghorns	24	17.31	5.599	.597	1.43	1.33
	: Buff Orpingtons	21	15.88	6.028	.885		
	: White Leghorns	24	17.31	5.599	.597	1.31	4.25
	: Barred Plymouth : Rocks	20	13.00	4.203	.818		
	: Buff Orpingtons	21	15.88	6.028	.885	2.88	2.38
	: Barred Plymouth : Rocks	20	13.00	4.203	.818	1.205	

Experiment I. There was an average of 1.66 worms per chicken found in the White Leghorns as compared with a mean of 1.0 worm in the Buff Orpingtons giving a difference of .66 which is 1.87 times the probable error. The Barred Plymouth Rocks had an average of .6 worm as compared with the 1.66 of the Leghorns, which gave a difference of 1.06 and a ratio of 4.29. The Orpingtons with 1 worm per chick, and the Rocks with .6 of a worm per chick gave a difference of .4, which is 1.35 times the probable error. Here again, it is found that the arrangement of breeds in order of their resistance is (1) Barred Plymouth Rocks, (2) Buff Orpingtons, and (3) White Leghorns.

A comparison of the measurements of the worms shows a difference of 1.43 mm. between the mean length of 17.31 mm. found in the Leghorns and 15.88 mm. of those found in the Buff Orpingtons. This difference gives a ratio of 1.33. The worms from the White Leghorns had a mean length that was 4.31 mm. longer than was the mean of 13.00 mm. found in the Barred Plymouth Rocks. This difference is 4.25 times the probable error. A difference of 2.88 mm. which is 2.38 times its probable error was found between the Buff Orpingtons with an average of 15.88 mm. worm length and the Barred Plymouth Rocks, whose worms averaged 13.00 mm. in length. Here again the biometrical analysis yielded a rating that

shows the Barred Plymouth Rocks significantly more resistant than the White Leghorns, with the Buff Orpingtons again assuming an intermediate position.

Average intestine lengths for the chickens in Experiment II were as follows: White Leghorns, 98.6 cm., Barred Plymouth Rocks, 101.6 cm., and Buff Orpingtons, 104.5 cm. Here again, as in Experiment I, the differences were so small as to easily fall within the limits of chance variation.

Age Resistance. A biometrical analysis of the results of Experiments I and II confirms in part Herrick's (1926) work on age resistance of chickens to this nematode. Table III shows the effect of an extra two weeks' growth before receiving an infestation of parasites. Thus, in the Leghorns, the chicks parasitized at the age of four weeks had an average of 5.33 worms per chicken, and those of the second group had an average of 1.66 worms per chicken. The difference of 3.67 gives a ratio of 4.61. The Buff Orpingtons also exhibit this age resistance, since the Experiment I chickens had an average of 3.58 worms per chick, and the Experiment II chickens had an average of only 1 worm per chick, giving a difference of 2.58, which yields a ratio of 3.64. In the Barred Plymouth Rocks there is also definite evidence of age resistance, since those chicks

Table 3. Showing evidences of age resistance to Ascaridia lineata in various breeds of chickens.

		: Number :	: Error :	: Probable :	Ratio
		: of :	: Stand. : of :	: error of :	: D
	: Breed	: hosts :	: Mean :	: Dev. : mean :	: Dif. : difference :
					P.E.D.

parasitized at the age of 30 days had an average of 2.8 A. lineata per host, while those parasitized two weeks later had an average of only .6 of a worm per host, showing a difference of 2.2 on the averages, which is 5.29 times the probable error of the difference. In all of these three breeds, definite proof of age resistance was shown, since in all of the cases, the differences were significant when given biometrical analysis.

Likewise, a comparison of the lengths of the worms will also further bear out Herrick's findings. In the Leghorns, it is found that the group of fowls that were parasitized the earliest had A. lineata that averaged 22.29 mm. in length, while the group that was parasitized later had worms that were 17.31 mm. in average length. The difference here is 4.98 mm., which is 6.88 times the probable error of the difference. The Buff Orpingtons with an average of worms 18.27 mm. in length in the four weeks group, and 15.88 mm. in length in the six weeks group had a difference of 2.39, which is 2.37 times the probable error. The Barred Plymouth Rocks likewise show an age resistance since the first group of chicks had a mean length of worms of 15.25 mm., while the second group had a mean of 13.00 mm. for the worm length, showing a difference of 2.25 mm. which is 2.19 times the probable error of the

difference. While the only difference in the length of the worms that could be called significant is that in the Leghorns, where the ratio is 8.88, still there is a very definite tendency toward age resistance shown in the other two breeds.

### Group II

Experiment III. Twenty-five birds of the White Leghorn and Barred Plymouth Rock breeds, and 23 birds (all that remained of the original 50) of the Buff Orpington breed were used in Experiment III. Each chicken was parasitized with 50 eggs of A. lineata at the age of 28 days. Unfortunately the parasite eggs used in this experiment had been accidentally killed just prior to their introduction into the chickens so that no worms were obtained from the experiment. One worm 12 mm. in length was found in one of the Leghorns, but this was probably an accidental infection from another chicken, or perhaps some few of the eggs escaped the fate of the others. Growth curves made of the chickens in this Experiment show that as in the first group of experiments the Barred Plymouth Rocks, while starting out somewhat lighter than the White Leghorns, exceeded their weight by a 100 gm. average at the end of the nine weeks of the experiment. Reference to Fig. 5 shows that

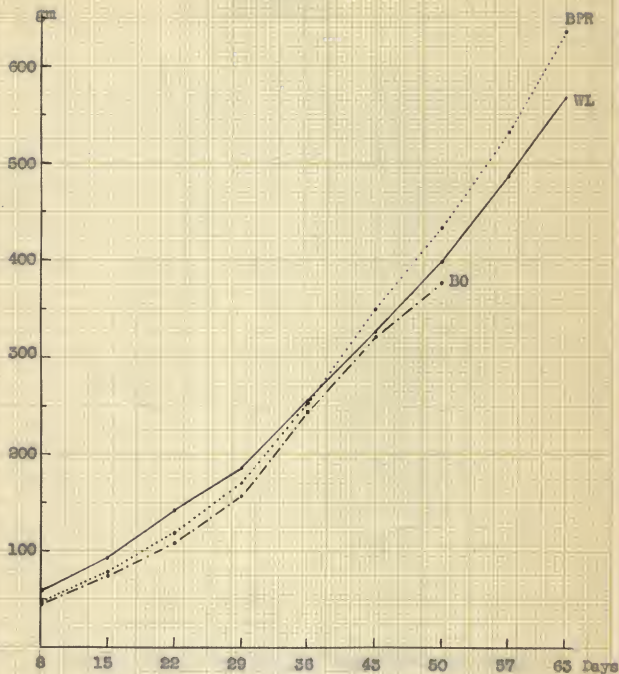


Fig. 5. Showing growth curves of chickens used in Group II. WL - White Leghorns; BPR - Barred Plymouth Rocks; B O - Buff Orpingtons.

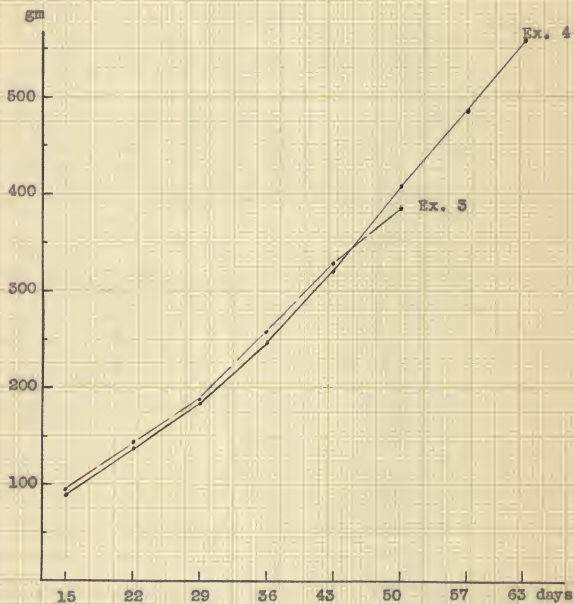


Fig. 8. Showing growth curves of White Leghorns used in Group II.

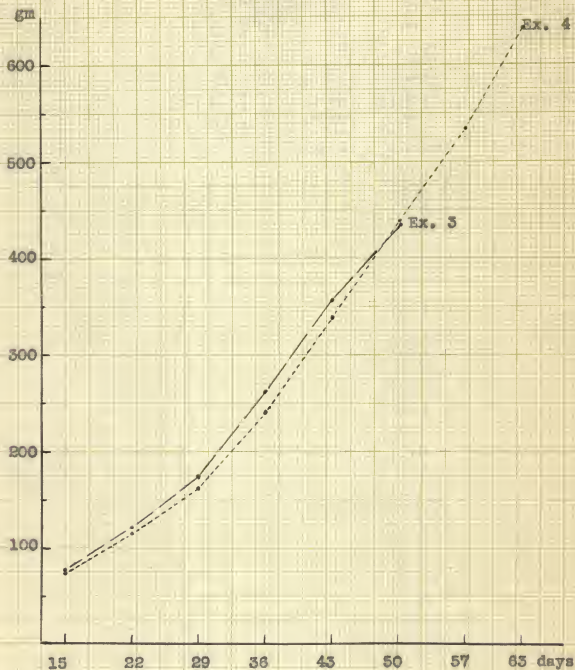


Fig. 7. Showing growth curves of Barred Plymouth Rocks used in Group II.

Table 4. Comparison of Ascaridia lineata found in chickens in Experiment IV.

		Number:	Mean	Stand. Dev.	Error of mean	Probable error of difference	Ratio
	Breed	of hosts					D
Numbers of Worms							P.E.D.
	White Leghorns	22	2.36	1.049	.265		
	Barred Plymouth Rocks	15	.80	1.326	.230	1.56	.350
							4.45
-----							
Lengths of Worms (mm.)							
	White Leghorns	22	24.63	6.401	.598		
	Barred Plymouth Rocks	15	21.83	5.660	1.102	2.80	1.253
							2.23

the Buff Orpingtons fall far behind the other chicks in weight, a situation which will be explained later.

The intestine lengths were taken also in this experiment. The White Leghorns' intestines averaged 86.1 cm. in length, those of the Barred Plymouth Rocks, 84.8 cms. in length, and those of the Buff Orpingtons, 95.0 cms. in length. A possible explanation of the longer intestine in the Buff Orpingtons would lie in the fact that their muscular tone was poor, and slight stretching in measuring would alter their lengths to the extent of making the group as a whole seem to have longer intestines.

Experiment IV. The chickens used in Experiment IV consisted of 22 White Leghorns and 15 Barred Plymouth Rocks. They were parasitized at the age of 42 days when each bird received approximately 50 infective eggs of A. lineata. After a three weeks period of parasitism, they were killed and their intestinal contents examined for A. lineata, which were counted and measured.

It was found that the Leghorns had an average of 2.36 worms per chicken while the Barred Plymouth Rocks averaged .80 of a worm per chick. This yields a difference of 1.56 which is 4.45 times the probable error, and therefore significant. The average lengths of the worms found in the Leghorns was 24.63 mm., and those found in the Barred

Plymouth Rocks averaged 21.83 mm. in length, showing a difference of 2.80, which gives a ratio of 2.23. Thus in this experiment as in Experiments I and II we find indications that the Barred Plymouth Rocks are more resistant to A. lineata than are the White Leghorns.

Average intestine lengths of the chickens from this experiment on autopsy were as follows: White Leghorns, 92.8 cm., and Barred Plymouth Rocks, 85 cm.

#### DISCUSSION

From the data presented it appears that the Barred Plymouth Rocks are the most resistant to A. lineata of the three breeds of chickens studied. Experiments I and II show that the Buff Orpingtons are next in the order of their resistance to the parasite. The Leghorns appear to be the least resistant of these three breeds of chickens. Just why this occurs is not apparent.

According to Jull (1926) the Leghorns are normally a smaller bird and are kept for their egg producing qualities rather than for their meat. Their comparative size corresponds well with the growth curves of our chickens in Experiments I and II. The Barred Plymouth Rocks and the Buff Orpingtons tend to be heavier birds, and are used for both egg laying and meat production. Harris and Boughton

(1928) found that the death rate of Leghorns during the pullet year was considerably lower than that of two other breeds, namely the White Wyandottes and the Rhode Island Reds. However, Dudley (1928) who questioned the methods used by Harris and Boughton, did not find significant differences between the death rates of the same three breeds. Lambert (1932) in working with the fowl typhoid bacterium found that the White Plymouth Rocks were the most resistant to this disease, with the White Leghorns, White Wyandottes, and Rhode Island Reds following in the order named. In working in the field of resistance of fowls to pullorum disease, Card and Roberts (1930) found strains of chickens that were resistant to this disease. This resistance factor was carried on to later generations. A comparison of various breeds was not made, however. Weaver (1930) discovered a slight variation in the death rates of Barred Plymouth Rocks and White Leghorns due to parasitic infestations. The Single Combed White Leghorns had a slightly higher mortality due to helminths than did the Barred Plymouth Rocks. These findings are in accord with the present results.

In the chickens of the first two experiments it was noted that the Leghorns attained the characters of the mature bird much more rapidly than did the other two breeds.

In Experiments III and IV it was noted that at the age of five days, the primary feathers of the Leghorns were from one to two inches long, and the secondaries were beginning to develop. The primaries of the Barred Plymouth Rocks and of the Buff Orpingtons were only about one-fourth inch long, and there was no evidence of secondaries. At the age of eight days, tail feathers about one-half inch long had appeared on the Leghorns, while there was no evidence of tail feathers on the other two breeds. So, throughout the course of the experiments, the records show that the Leghorns in every way were maturing faster than were the other, heavier breeds. Perhaps the fact that they use more of their energies in growing renders them more susceptible to parasitism. Another possible factor in the lower resistance of the Leghorns is their greater activity. It was noted throughout the course of the experiments that the Leghorns were much the most active of the three breeds under observation. Possibly there is some degree of correlation between this excess nervous activity and a low degree of resistance. No evidence was obtained from the comparative study of the intestine lengths of the three breeds, as the mean lengths in all of the experiments fell well within the limits of individual variation. At any rate the figures show definitely that there is a tendency for the Leghorns to be the least

resistant of the three breeds studied. Since significant differences were obtained in practically every case in which a comparison of the Leghorns and Barred Plymouth Rocks were used (see Tables I, II and IV) it may be stated that the Leghorns in these experiments were less resistant to A. lineata than were the Barred Plymouth Rocks.

A comparison of the growth curves (Figs. 2, 3, 4, 6, 7) shows that the light parasitism had no very definite effect on the birds. During the two weeks that the Experiment I chickens were parasitized, the Experiment II chickens were not parasitized, thus affording a good check on the effect of the parasitism. Only in one breed (the Barred Rocks, Fig. 4) did the parasitism appear to have any effect. Since they had no more worms than the other two breeds, the slower growth of this group of Rocks was probably due entirely to chance.

Evidences of differences in race resistance to helminthic infestations has been found in man. Knowlton (1919) noted that the Negroes of the Carolinas and Florida harbored only about one-fourth as many hookworms as did the Whites that lived in the same areas. Cort et al (1929), in their hookworm studies in Panama, found similar differences in the resistance of these two races to infestation by hookworms.

Many efforts have been made to determine the exact nature of resistance to parasitic infestations. This problem is well discussed by Chandler (1932). The whole problem is still in the elementary stages of its solution, and while many factors influencing immunity and resistance to metazoan parasites have been discovered by various workers, such as Blacklock and Gordon (1927) and McCoy (1931), the actual immunity or resistance are yet to be discovered.

Another conclusion reached is that, of the three breeds studied, the White Leghorns are the best adapted to studies of the host parasite relationships of A. lineata since in this host are found the greatest numbers and lengths, thereby facilitating comparisons.

Further investigation of this problem would perhaps include two other phases: (1) infect chickens of these three groups with sufficient worms (feed 1000 or 2000 worm eggs) to produce effects which could be compared in the different breeds; (2) study the comparative numbers and lengths of A. lineata found in large numbers of barnyard fowls of these three breeds taken at random on farms and from packing houses. Askert and Herrick (1928) studied the effects of A. lineata on White Leghorns and Askert (1930) made a survey of 1000 chickens from various farms about Manhattan to find the occurrence of A. lineata, but in

neither case were comparisons of breeds made.

#### SUMMARY

1. Four experiments involving a total of 249 chickens of three breeds, namely 96 White Leghorns, 85 Barred Plymouth Rocks, and 68 Buff Orpingtons, were used to determine if there is a difference in the breed resistance of these fowls to the intestinal nematode of chickens, Ascaridia lineata (Schneider).

2. The general method of procedure was to infect the birds with 50 embryonated eggs of A. lineata and to determine later the numbers and the lengths of the worms left in the chicks.

3. The numbers of worms were taken as a criterion of the size of the infestation and the lengths of the observed worms were used as a measure of the resistance of the chickens to the growth of the worms, both factors being used in a determination of the comparative resistance of the breeds in question.

4. It was found that the Barred Plymouth Rocks were the most resistant of the breeds studied with the Buff Orpingtons next in order and the White Leghorns the least resistant.

5. Further proof of age resistance of chickens to

this nematode was obtained.

6. No effect of the light parasitism resulting from the administration of 50 eggs of A. lineata was evident on the chickens.

7. Intestine lengths taken for the three breeds observed showed no significant differences.

8. Of the three breeds studied the White Leghorns are the best suited for use in experiments with the parasite, A. lineata.

## LITERATURE CITED

- Ackert, James E.  
On the habitat of Ascaridia persicillum (Rud.). Jour. Parasitol. 10:101-103. 1923.
- Fowl resistance to parasitism affected by vitamins A and B. Arch. Zool. Ital. 26:1369-1379. 1930.
- The morphology and life history of the fowl nematode Ascaridia lineata (Schneider). Parasitology 24:360-378. 1931.
- Ackert, James E., Graham, G. L., Wolf, L. O. and Porter, D. A.  
Quantitative studies on the administration of variable numbers of nematode eggs (Ascaridia lineata) to chickens. Amer. Mic. Soc., Trans. 50:208-214. 1931.
- Ackert, James E. and Herrick, C. A.  
Effects of the nematode Ascaridia lineata (Schneider) on growing chickens. Jour. Parasitol. 15:1-13. 1928.
- Ackert, James E. and Wolf, L. O.  
Resistance of chickens affected by vitamin B. Amer. Jour. Hyg. 13:337-344. 1931.
- Ackert, James E. and Spindler, L. A.  
Vitamin D and resistance of chickens to parasitism. Amer. Jour. Hyg. 9:292-307. 1929.
- Beach, T. D. and Ackert, J. E.  
Does yeast affect the growth and infectivity of the nematode Ascaridia lineata (Schneider) to chickens? Jour. Parasitol. 19:121-129. 1932.
- Blacklock, D. B. and Gordon, R. H.  
The experimental production of immunity against metazoan parasites and an investigation of its nature. Ann. Trop. Med. Par. 21:181-224. 1927.
- Card, L. E. and Roberts, E.  
Inheritance of resistance to pullorum disease. Fourth Worlds Poultry Cong. Rep. of Proc. 526-533. 1930.

- Chandler, A. C.  
Susceptibility and resistance to helminth infections.  
Jour. Parasitol. 18:138-152. 1932.
- Cort, W. W., Stoll, R. R., Sweet, W. C., Riley, W. A. and Schapiro, Louis  
Studies on hookworm, *Ascaris*, and *Trichuris* in Panama. Embodying the results of the researches of an expedition to the Republic of Panama. May to September, 1926. Amer. Jour. Hyg. Monogr. Series 9. 1929.
- Dudley, F. S.  
The death rate of three standard breeds of fowl during the pullet year. Poul. Sci. 7:245-253. 1928.
- Graham, G. L., Ackert, J. E., and Jones, R. W.  
Studies on the acquired resistance of chickens to the nematode *Ascaridia lineata* (Schneider). Amer. Jour. Hyg. 15:726-740. 1932.
- Harris, J. A. and Boughton, D. G.  
Death rate of three standard breeds of fowl. Poul. Sci. 7:129-131. 1928.
- Herrick, C. A.  
Studies on the resistance of chickens to the nematode *Ascaridia perspicillum* (Rud.). Amer. Jour. Hyg. 6: 153-172. 1926.
- Jull, M. A.  
Standard breeds and varieties of chickens. U. S. Dept. Agr. Farmers Bul. 1506. 1926.
- Knowlton, R. H.  
Hookworm infestation among troops: Treatment with oil of chenopodium. Jour. Amer. Med. Assoc. 72:701-703. 1919.
- Lambert, W. V.  
Natural resistance to disease in the chicken. Jour. Immunol. 23:229-260. 1932.
- McCoy, O. R.  
Immunity reactions of the dog against hookworm (*Ancylostoma caninum*) under conditions of repeated infection. Amer. Jour. Hyg. 14:268-303. 1931.

Weaver, C. E.

A study of the causes of mortality in groups of the Single Comb White Leghorn and Barred Plymouth Rock breeds of fowl: including a comparison between production and mortality. Fourth World Poultry. Cong. Rep. of Proc. 379-387. 1930.

## Date Due

[illegible]