STUDIES ON GIZZARD ULCERATION IN CHICKENS

by

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REVIEW OF LITERATURE

This paper consists of data and an analysis of those data as derived from a series of experiments designated primarily to contribute to the solution of the general problem of gizzard ulceration in chickens.

Dam (1929) according to Cheney (1937) first reported the observation of ulcers apparent in the lining of the chicken gizzard. Ringrose et al (1930) and McFarlane et al (1931) also reported the observation of this condition in chicks maintained on experimental diets. Since these early reports many investigators have taken up a study of the factors involved in the occurrence, prevention or cure of this disease.

Stedman (1936) defines a disease as, "an abnormal condition of the body or any of its parts," and an ulcer as, "a lesion of a cutaneous or mucous surface caused by a molecular disintegration of the superficial parts, attended usually by more or less suppuration."

Jungherr (1935) on the other hand states that, "ulcerated gizzard can not be called a definite disease but constitutes a post-mortem lesion." This early opinion however, has since been reversed and the condition is now quite generally thought to be due to a nutritional deficiency and is considered as a nutritional disease. Cheney (1937) reports that chickens which possess gastric ulcers also show a condition of hyper-

acidity. "The cause of the ulcers and the hyperacidity is apparently the lack of a dietary factor which has a specific effect on the resistence of the gastric mucosa." Such a view is in accord with Stedman, op. cit., in his definition of a peptic ulcer - "an ulcer of the mucous membrane of the stomach or duodenum, caused by the action of the gastric juice upon a portion where the nutrition has been interfered with in some way."

Fogelson (1931) has reported that relief from symtoms of peptic ulcer in dogs has been obtained from the feeding of mucin. He explains this relief as due to the mucin coating the ulcer and protecting it against the proteolytic action of the gastric secretion and also because of its high combining power with free acid, it unites with sufficient free HCL to neutralize it and to prolong the rate of dialysis of pepsin through the protective mucin layer. Bird et al (1938) suggest that the reported activity of bile and bile compounds may be related in part to the mucin content of these products and the same theory may hold in regard to chondroitin.

Crandall et al (1937) in the feeding of chondroitin sulfuric acid to Eck fistula dogs noted in addition to weight gains definite changes in appetite and activity in favor of such dogs over the controls. They further report that, "Kim and Ivy have observed that mucin prevents ulcers and greatly reduces weight loss in biliary fistula dogs."

Crandall and Roberts (1933) also have reported that,

"the local action of mucin is a factor in promoting the healing of peptic ulcer, but a definite state-

ment on this point is impossible until the role of the various amino sugars can be determined. It is highly possible that the administration of large amounts of glucuronic acid, a substance of considerable biologic importance, may be beneficial in a manner not yet clearly understood."

More recently, Almquist and Meechi (1941) have reported the ineffectiveness of both mucin powder and glucuronic acid in the control of gizzard erosions of the chick gizzard lining.

Almquist (1938) reported the influence of bile acids on the erosions of the chick gizzard lining stating that certain components of bile when added to the diet, protect against erosion and lesions of the gizzard lining. Substances tested were whole bile, commercial dried bile tablets, vacuum concentrated whole beef bile, cholic acid, deoxycholic acid, sodium glycocholate and sodium taurocholate. This work was confirmed by Bird et al, op. cit. On the other hand Emery and Schnitker (1939) have concluded that desiccated ox bile can not be considered as a specific for peptic ulcers.

Cheney (1940) reporting on the effect of cinchophen in the production of peptic ulcers in chicks states that, "feeding of cinchophen to chicks produces gizzard lesions with the characteristics of peptic ulcers." The cinchophen feeding was not started until 5-7 days after the feeding of the special diets which themselves were started 3-14 days after hatching. It is quite possible that the lesions were already there at hatching time and that cinchophen may merely have aggravated the condition due to liver damage.

Almquist and Stoketad (1937) have reported, "Presence or absence of gizzard erosions or of the gizzard factor in the diet has no appreciable effect on the growth of chicks."

In their work on the anti-hemorrhagic vitamin, Almquist and Stoketad (1936) have reported that extensive erosion of the gizzard lining was commonly noted but its occurrence was not closely correlated with the incidence of the hemorrhagic disease. They have concluded that, "Gizzard erosion is not a portion of the hemorrhagic syndrome, but is a separate deficiency disease which may be corrected by a new fat soluble factor found in the saponifiable fraction and probably vitamin in nature." In later work Almquist (1937) reported this factor to be fat soluble, destroyed by ethyl alcohol and unstable to heat. On the other hand, Bird et al (1936) indicate this factor not to be fat soluble. They were able to prepare a gizzard factor solution by treating fresh pork lung with 0.3 per cent NaOH and then acidifying to a pH of 4.5. The gizzard factor potency appeared in the precipitate resulting when the NaOH solution was acidified to pH 4.5.

Tesmiro (1937) in attempting to isolate bile acids from dog fish muscle, obtained a crystalline, hygroscopic substance (dacryorrhetin) which had the power when injected intraperitoneally in doses of 3.0 mg. per 100 gm. of body weight to produce ulceration of the stomach of the guinea pig in 3 hours.

Almquist and Stoketad (1937) have stated that the best practical sources of the anti-gizzard erosion factor yet found are fresh and dried greens and wheat bran. Halpin et al, and

others, loc. cit., have reported it to be present in bile compounds, wheat midds, oats, wheat, alfalfa, cartilage, lung and other miscellaneous products.

Brown and Embleton (1932) have isolated an aspergillus fungus, proving highly infectious, from chicks affected with ulcerated gizzards. From this premise, the use of copper sulphate undoubtedly developed as a means of treatment, since it is well known that copper sulphate has an antagonistic power against the growth and development of certain fungus organisms.

Cover (1939) states that chicks showing gizzard lesions often possessed gall bladders showing marked distention. Other workers have indicated bile or bile compounds to possess beneficial action in the prevention of these gizzard lesions. On the premise that the distention of gall bladders suggested a failure of bile passage, Lansing and Miller (1940) reported the ability to produce a hemorrhagic condition of the gizzard in six adult chickens by ligation of the bile ducts. They suggest biliary dysfunction as a contributing cause of observed gizzard ulceration in chicks.

Previous to this report Lansing et al (1939) in observations of day old chicks reported, "Of the 600 chicks fully 75 per cent had gizzards which were not normal." ...."The presence, in every abnormal gizzard examined, of blood cells in the secreted lining or of blood clots between the lining and the glandular layer is evidence that hemorrhage, either slight or pronounced, is an immediate cause of gizzard erosion." Referring to the type considered as erosion wherein fissures and

small holes were found in the lining immediately above the reddish-brown accumulations, they state. Approximately 45 per cent of all the abnormal gizzards were of this type.

Almquist and Forster (1940) report that, a chick diet adequate for normal health and growth was rendered, in effect, deficient in vitamins A, G, K and the gizzard factor by the addition of an adsorbing charcoal.

Mount (1939) lists the most important pathological changes observed in chicks affected with gizzard lesions as follows:

1- Hemorrhages at the junction between the gizzard proper and the proventriculus.
2- Roughening and pigmentation of the horny layer.
3- Exfoliation.
4- Areas of necrosis of the horny layer.
5- Gizzard erosion or ulceration
6- Ulceration of the secretory layer.
7- Hemorrhages within or below the horny layer.

While gizzard lesions of poultry were first observed in chickens, they have also been observed in other domesticated as well as wild birds. The following listing gives, according to the writers knowledge, the type of bird and original worker or workers to be credited with the fact of having first observed and reported on this condition.

Chickens	:	Dam, H (1929)
Pigeons	:	Bird, H. R., O. L. Kline, C. A. Elvehjem, E. B. Hart and J. G. Halpin (1936)
Turkeys	:	Poppenheimer, A. M., F. Gottlieb and E. Jungherr (1939)
Quail	:	Tepper, A. E. (this report)
Pheasants	:	Tepper, A. E. (this report)

In attacking this general problem it was deemed advisable to study, (1) the incidence of the disease as existing in the various regions of the United States, (2) its practical impor-

tance from the standpoint of its effect on growth, livability and efficiency of feed consumption in growing chicks, (3) its time of origin, and factors influencing this origin, (4) changes taking place in the severity of lesions in growing chicks when fed various diets and (5) the effect of diet fed to breeding birds on the prevention or cure of this disease in day old chicks. During the course of investigation a theory of origin of gizzard ulceration was developed and several experiments were planned and carried out to test its validity.

PROBLEM ONE

A SURVEY OF THE INCIDENCE OF GIZZARD LESIONS IN NEWLY HATCHED CHICKS THROUGHOUT VARIOUS REGIONS OF THE UNITED STATES

Procedure: In order to determine the relative incidence of gizzard lesions in day old chicks throughout the various sections of the United States a survey was started in October 1939. Chicks or hatching eggs were secured from twelve states in various regions of the country. When hatching eggs were received they were immediately incubated at the University of Maryland and examination of gizzards in the resulting chicks was made on the twenty-second day following the initial setting date. The gizzards were scored as indicated in Fig. 1.

Discussion: Table I presents a summary of the observations as made according to specified breeds. A total of 1737 day old chicks were examined from 62 different sources. Evidence is presented to show the considerable range in "gizzard scores" both within specified breeds as well as between various

FIGURE I

METHOD OF SCORING GIZZARD LESIONS

Condition	Score
Normal	0
Slight Hemorrhage 1 - 2 small areas	1
Severe Hemorrhage More than 2 small areas	3
Slight Erosion 1 - 2 small crater lesions	2
Definite Erosion Few small or 1 large crater lesion	4
Severe Erosion Many small or large areas of lesions	5

hatchery sources. Of a total of 87 different lots of chicks examined (lots variable in number) a range in scores was observed from 0.2 to 4.6 points per chick.

Table II presents a similar summary according to state of origin. It indicates an average incidence of "gizzard score" of 2.4 for all chicks so examined. Although a considerable variation in the incidence of gizzard lesions is apparent, not one of the lots examined was found free from the disease.

Of the 1737 chicks examined 460 chicks were observed to have normal gizzards leaving 1277 or 74 percent affected. This agrees quite closely with the observations of Lansing et al., (1939).

PROBLEM TWO

TO INVESTIGATE THE INCIDENCE OF GIZZARD LESIONS IN DAY OLD PHEASANTS AND QUAIL

Procedure: In the study of the prevalence of gizzard lesions in day old chicks as observed from various sources throughout the United States, the question arose as to the possibility of birds other than chickens being subject to this same nutritional disease. A review of the literature indicated that only chickens, pigeons and turkeys had been reported as having these lesions.

Discussion: Accordingly, 32 day old quail chicks and nine pheasant chicks were procured through the courtesy of the Gwynnbrook State Game Farm and subsequently examined. Two of the quail and one of the pheasant chicks were observed to have

TABLE I

Gizzard Lesions as Observed in Day Old Chicks by Specified Breeds

Breed	Number of Chicks Examined	Number of Hatcheries Represented	Range in Scores	Average Score per Chick
Crossbreeds	290	10	1.2 - 2.8	1.56
Barred Plymouth Rocks	357	15	0.2 - 2.7	1.38
New Hampshires	138	5	1.5 - 3.0	1.98
Rhode Island Reds	64	2	1.9 - 2.2	2.05
W. Plymouth Rocks	120	3	0.8 - 3.9	2.34
S.C.W. Legborns	623	21	1.3 - 4.6	2.49
Mixed	155	6	1.9 - 4.4	2.93
Total	1737	62	0.2 - 4.6	

Table II

Gizzard Lesions as Observed in Day Old Chicks by Specified States

STATE	No. of Chicks Examined	Average Score per Chick
Kansas	20	4.6
Michigan	150	3.5
Missouri	125	3.1
Iowa	75	2.7
South Carolina	71	2.3
Washington	209	2.1
Utah	85	2.1
New Hampshire	160	1.9
Maryland	452	1.9
Indiana	201	1.8
Alabama	78	1.7
Texas	23	1.6
	1757	2.4

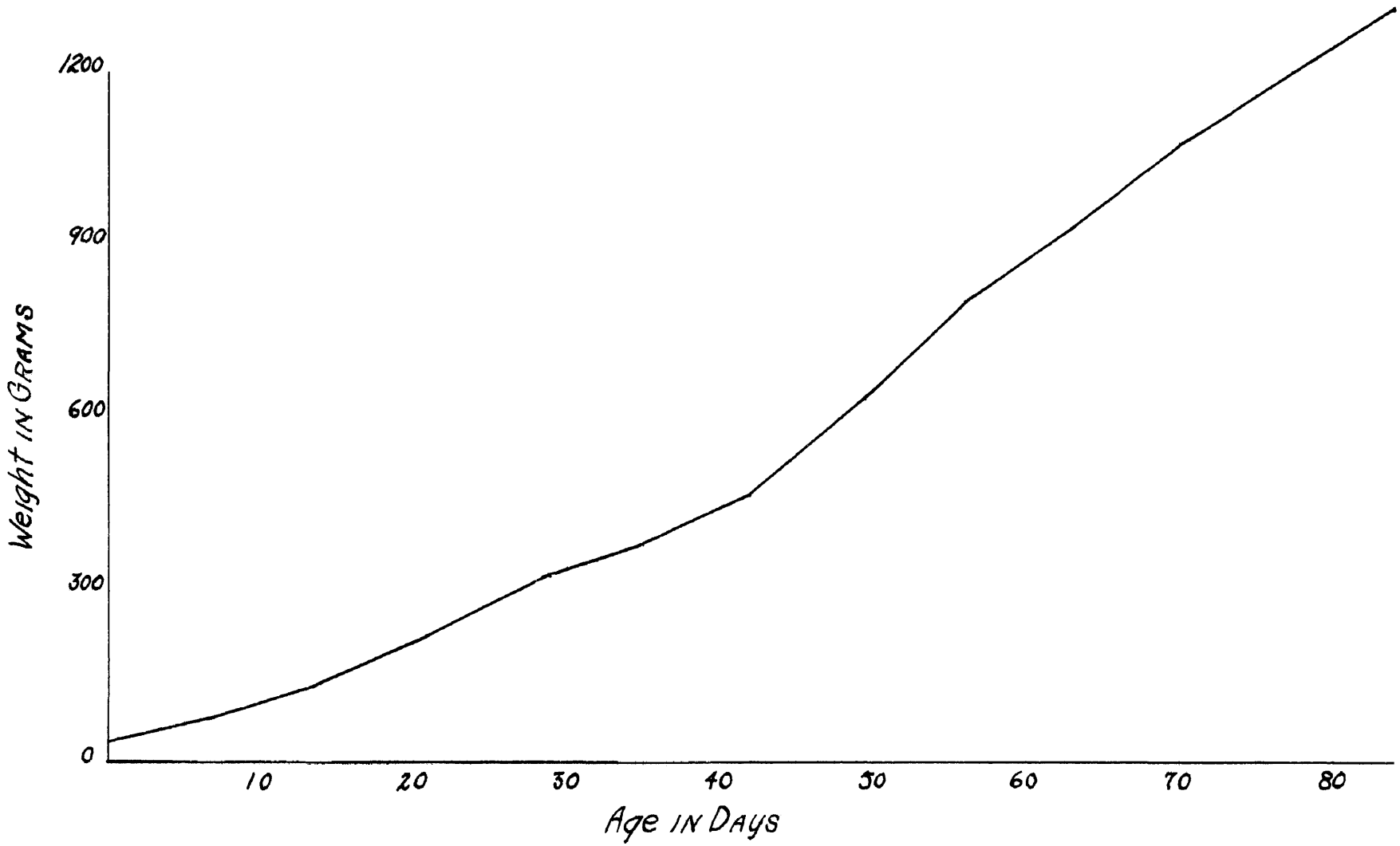

Figure 2 - Growth Chart for New Hampshires

Day Old Gizzard Score - 1.7

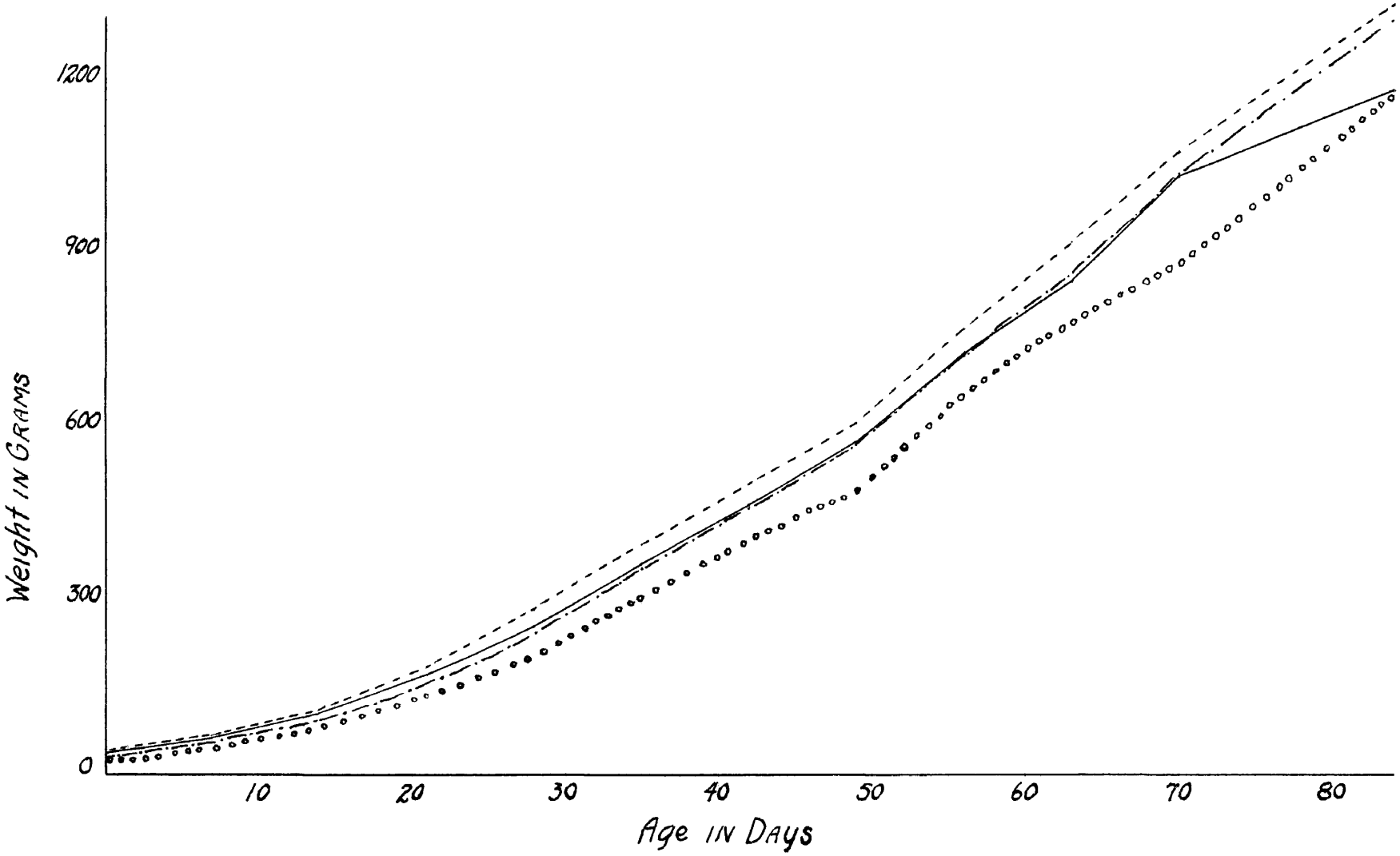

Figure 3 - Growth Chart for Barred Rocks

Day Old Gizzard Score
— Group 4 - 2.2
---- Group 7 - 2.8
—·— Group 9 - 2.3
oooo Group 11 - 1.9

hemorrhages in the gizzard lining similar to those noted in chickens. This seems sufficient evidence, though more observations would be desirable, that both quail and pheasants are similarly subject to the nutritional disease, gizzard ulceration. The breeders producing these chicks were managed in confinement and fed a commercial game bird ration.

PROBLEM THREE

A STUDY OF THE RELATIVE SEVERITY OF GIZZARD LESIONS IN DAY OLD CHICKS AND THE EFFECT OF THIS INCIDENCE ON SUBSEQUENT GROWTH, LIVABILITY AND EFFICIENCY OF FEED UTILIZATION.

Procedure (Test 1). Twelve lots of fifty chicks each, of various breeds including Barred Plymouth Rocks, S. C. W. Leghorns, New Hampshires and Crossbreds were secured from six different hatcheries operating in Maryland and New England. All chicks were received during the third week of October 1938. From each lot so received, 50 chicks were immediately killed and gizzards examined for the presence of gizzard lesions. A relative gizzard score was thus established for each lot of chicks based on the severity of these lesions. The method of scoring used is shown in Figure 1. The remaining 20 chicks were placed under electric floor brooders and carried to an age of 12 weeks. Throughout the brooding period all groups were managed similarly and fed the Maryland Station Mash—on all mash feed, ad lib. (see Fig. 6). No supplements of any kind were added. Weekly recordings of weight and feed consumption were made through-

out the brooding period.

Procedure (Test 2). A similar procedure was followed in Test 2 with the 12 lots of chicks being secured from eight different Maryland and New England hatcheries. Seven of the twelve lots consisted of cross breeds while five were Barred Plymouth Rock chicks. Combining both tests, chicks were received from twelve different hatcheries.

Discussion. There is presented in Table III-A detailed data covering the actions as recorded for all 24 lots of chicks. The high and the low weight groups according to the average weight attained at twelve weeks of age have been underlined. By following these particular groups it will be noted that the crossbred group 1 of Test 2 attained the greatest average weight of approximately three and one-third pounds. The Leghorn group 6b of Test 1 was lightest in weight, averaging about two and one-quarter pounds. Similarly, the heaviest group was most efficient in feed required per pound of gain (3.37) and the lightest group least efficient with an efficiency factor of 4.25.

So that we may more easily trace the relation of average "gizzard score" to average weight at 12 weeks, this table has been broken down by breeds. Table III-B shows these relations for Crossbreeds. The group 5b (underlined) indicates the lowest weight group with an average chick score of 1.7. There is a considerable variation in the relation of "gizzard score" to average weight at 12 weeks. A positive 100 per cent relation would have arranged group 5b at the top of the

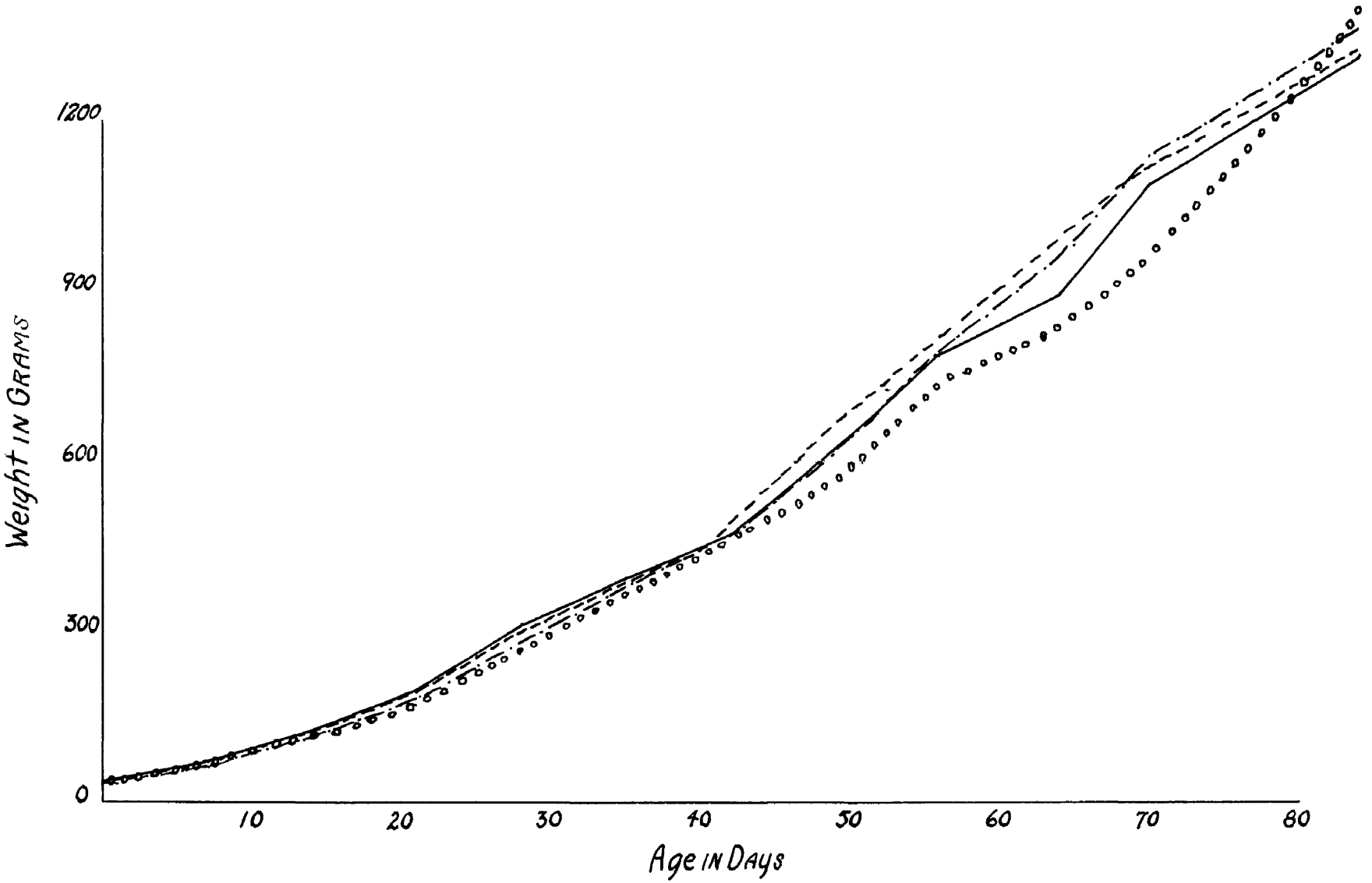

Figure 4 - Growth Chart for Cross Breeds

Day Old Gizzard Score -

—— Group 2 - 2.5

---- Group 3 - 2.6

—·— Group 5 - 2.1

oooo Group 10 - 1.9

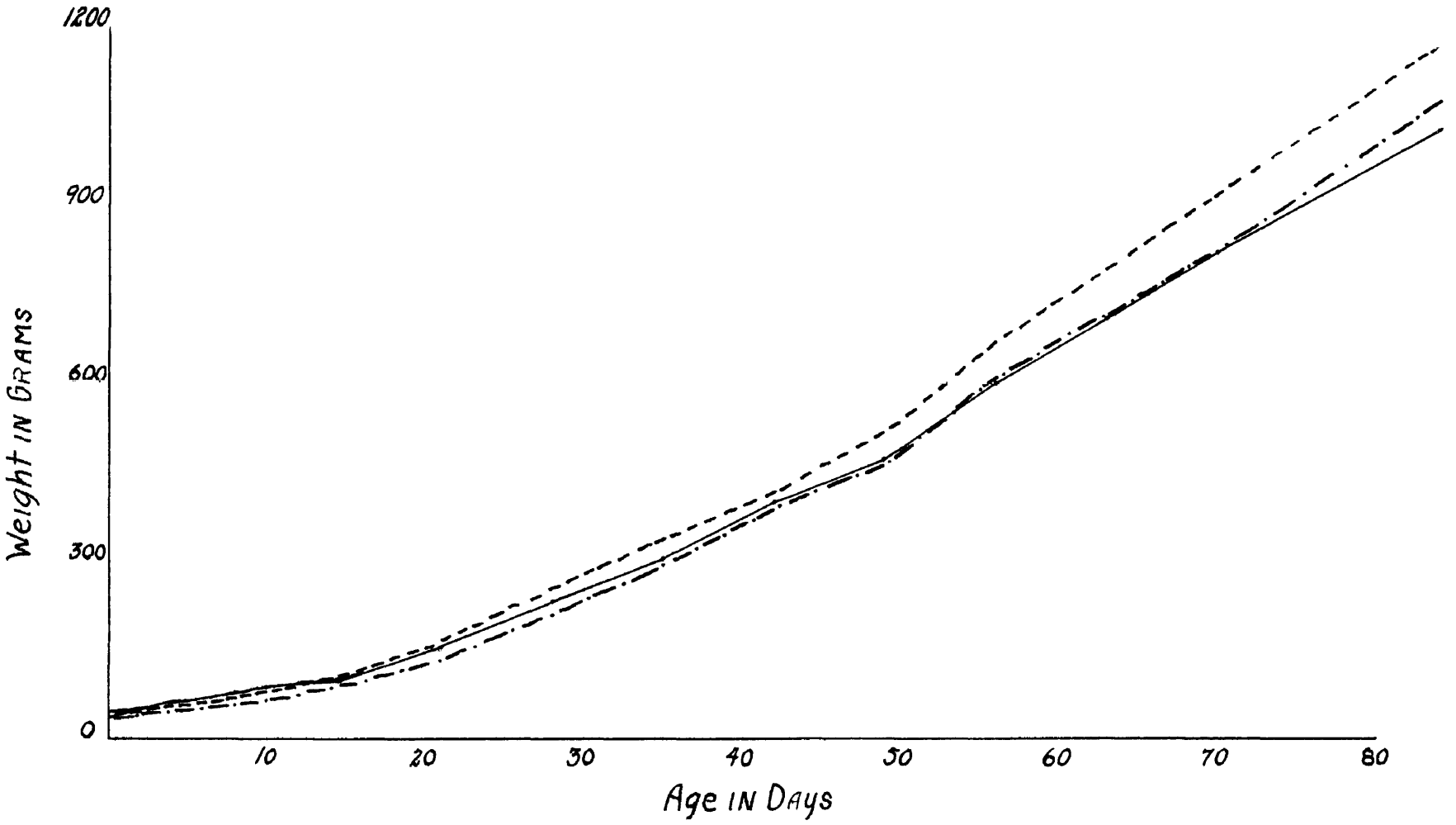

Figure 5 - Growth Chart for S.C.W. Leghorns

Day Old Gizzard Score -

—— Group 6 - 3.2

---- Group 8 - 2.6

—·— Group 12 - 1.7

table, that is if severity of gizzard lesions as day olds definitely restricted subsequent growth rate. On the other hand, four other groups having much more severe "gizzard scores" exceeded this group in weight. Two of these four were also more efficient in feed utilization.

One might assume that those having the lower "gizzard score" should have the highest feed efficiency. Only one of the groups below the dotted line having relatively low "gizzard scores" is more efficient than any of the others above the line.

Figures 2, 3, 4, and 5 present by graphic means, the growth data of Test 1.

Turning to Table III-C we note a somewhat similar non-relationship of average "gizzard score" and average weight at 12 weeks of age among Barred Plymouth Rock chicks. The group lowest in "gizzard score" is also among the low weight groups; whereas the group having the highest "gizzard score" is actually the highest in weight. This group is also the most efficient from the standpoint of feed utilization.

In Table III-D showing records of the three S. C. W. Leghorn groups the lowest weight group happens also to have the highest "gizzard score." However, Group 5a which shows a "gizzard score" of 2.6 has a much greater average weight than Group 1a with a "gizzard score" of 1.7.

FIGURE SIX

THE MARYLAND STATION MASH

Ingredient	Pounds
Yellow Corn Meal	25.0
Wheat Bran	15.0
Wheat Flour Middlings	15.0
Pulverized Heavy Oats	15.0
Alfalfa Leaf Meal (Dehyd.)	5.0
Soy Bean Oil Meal (Exp.)	5.0
50% Meat Scrap	7.5
Dried Skim Milk	7.5
55% Fish Meal (8% Dried)	5.0
Fulv. Limestone	1.0
Salt	0.5
Manganese Sulphate	0.012
Cod Liver Oil (85 D per gm.)	1.0
Total	102.512

TABLE

Relation of Severity of Gizzard Lesions in

Group No.	Breed	No. Chicks Examined	No. Chicks Breeded	Mortality to 12 weeks	Ave. Gizzard Score (1 day old)
					TEST 1
1	B.R.	20	30	2	1.6
2	B.P.R.xM.H.	20	30	1	2.5
3	B.P.R.xM.H.	20	30	0	2.8
4	B.P.R.	20	30	0	2.1
5	B.P.R.xM.H.	20	30	0	2.2
6	S.C.W.L.	17	30	0	2.7
7	B.P.R.	20	30	2	2.7
8	S.C.W.L.	13	30	2	2.6
9	B.P.R.	20	30	1	2.2
10	B.P.R.xM.H.	20	30	0	1.9
11	B.P.R.	20	30	1	1.9
12	S.C.W.L.	20	30	3	1.7
					TEST 2
1	B.P.R.xM.H.	20	30	2	1.4
2	B.P.R.xM.H.	20	30	2	1.5
3	B.P.R.xM.R.	20	30	3	1.2
4	B.P.R.	20	30	0	2.4
5	B.P.R.xM.H.	20	30	10	1.7
6	B.P.R.	20	30	4	1.7
7	B.P.R.	20	30	3	2.0
8	B.P.R.	20	30	3	1.9

III-A

Chicks to subsequent Growth Rate

Ave. Weight at 12 weeks (gms.)			Lbs. Feed per lb. Gain	Mortality
Males	Females	Both		
1354.6	1240.7	1297.6	3.80	2
1380.0	1177.0	1278.5	3.80	1
1438.5	1158.3	1298.4	3.77	0
1243.0	1151.0	1197.0	4.93	0
1486.2	1206.5	1337.3	3.52	0
1086.9	934.5	1010.7	4.26	0
1489.0	1233.5	1361.5	3.50	2
1282.8	1039.1	1150.8	4.31	2
1402.5	1187.6	1295.0	3.65	1
1572.5	1244.8	1408.5	3.40	0
1211.4	1122.5	1166.8	3.97	1
1198.0	948.5	1073.7	4.10	3
1658.8	1337.5	1498.1	3.37	2
1492.1	1260.3	1376.7	3.49	2
1571.9	1372.5	1472.2	3.43	3
1206.6	1042.3	1124.4	3.78	0
1301.6	970.0	1130.8	3.73	10
1263.6	1143.6	1208.6	3.97	4
1198.5	983.6	1094.5	4.08	3
1161.2	935.7	1048.4	4.23	

TABLE
(Cont

Relation of Severity of Gizzard Lesions in

Group No.	Breed	No. Chicks Examined	No. Chicks Brooded	Mortality to 12 weeks	Ave. Gizzard Score (1 day old)	
9	B.P.R.xH.R.	20	30	3	1.2	
10	B.P.R.xH.L.	20	30	0	1.3	
11	B.P.R.	20	30	1	0.3	
12	B.P.R.xH.I.R.	20	30	4	1.4	

III-A
ued)

Chicks to subsequent Growth Rate

Ave. Weight at 12 weeks (gms.)			Lbs. Feed per lb. Gain	Mortality
Males	Females	Both		
1388.0	1174.7	1270.8	3.79	3
1393.3	1104.6	1198.9	3.98	0
1214.2	963.5	1088.8	3.90	1
1497.5	1244.6	1371.0	3.86	4

Relation of Severity of Gizzard Lesions in Crossbred Chicks to Subsequent Growth Rate

Group No.	Ave. Gizzard Score (1 day old)	Ave. Weight at 12 Weeks (gms.) Males	Females	Both	Feed Efficiency Factor
3a	2.8	1435.5	1132.2	1283.8	3.77
2a	2.5	1380.0	1177.0	1278.5	3.80
8a	2.2	1450.2	1206.5	1337.3	3.58
10a	1.9	1572.5	1244.6	1408.5	3.40
5b	1.7	1301.6	970.0	1135.8	3.73
12b	1.5	1492.1	1258.3	1375.7	3.45
1b	1.4	1458.8	1337.5	1398.1	3.37
11b	1.4	1407.5	1344.6	1371.0	3.36
10b	1.3	1385.3	1104.6	1199.9	3.58
3b	1.2	1571.9	1371.5	1472.[illegible]	3.49
9b	1.2	1385.0	1174.7	1279.8	3.72
Average	1.7	1458.5	1202.5	1330.4	3.65

Table III-6

Relation of Severity of Sinusitis Lesions
Barred Plymouth Rock Chicks to Subsequent Growth
Rate

Group No.	Ave. Sinusitis Score (1 day old)	Ave. Weight at 12 Weeks (gms) Males	Females	Both	Feed Efficiency Factor
7a	3.7	1400.5	1.53.5	1361.6	3.50
4b	2.4	1206.0	1043.3	1174.4	3.76
6a	2.0	1401.5	1137.6	1295.0	3.65
4a	2.1	1243.0	1131.0	1187.0	4.02
7b	2.0	1125.5	923.6	1024.5	4.00
8b	1.8	1161.8	936.7	1048.4	4.13
11a	1.9	1221.4	1102.3	1166.8	3.97
6b	1.7	1368.6	1148.6	1208.6	3.97
11b	0.8	1214.4	963.5	1081.0	4.08
Average	1.8	1258.0	1076.4	1167.2	3.98

TABLE III-D

Relation of Severity of Gizzard Lesions
in S.C.W. Leghorn Chicks to Subsequent Growth Rate

Group No.	Ave. Gizzard Score (1 day old)	Ave. Weight at 12 Weeks (gms.)			Feed Efficiency Factor
		Males	Females	Both	
6a	2.7	1086.9	934.5	1010.7	4.25
8a	2.6	1262.5	1038.1	1150.8	4.31
12a	1.7	1122.9	949.5	1073.7	4.10
Average	2.3	1102.7	974.0	1078.4	4.22

PROBLEM FOUR

THE TIME OF ORIGIN OF GIZZARD LESIONS IN THE DEVELOPING CHICK

General: Although various investigators have indicated that gizzard lesions have been found as early as eighteen days of embryonic development, no one, to my knowledge, has as yet investigated and reported on the time in embryonic life at which this abnormality of the gizzard lining actually develops. The establishment of this point seems desirable in that it may be of aid in the guidance of further investigational work on the cause and prevention of this disease.

Lillie (1927) has reported that the simple, tubular glands of the gizzard begin to form about the thirteenth or fourteenth day, and the lining of the gizzard is simply the hardened secretion of these glands. According to Calhoun (1933) this horny layer is about three-fourths as thick as the glandular layer adjacent to it. The tubular glands are located in the tunica propria and open into the bottom of crypts in the epithelium of the mucous membrane.

Procedure: Seventy-five hatching eggs were incubated for the production of assay material. At the period of fourteen days of incubation all eggs were candled for fertility and the infertile eggs removed. At the age of fourteen days and continuing daily until hatching time five to seven live embryos were removed from the shell and their gizzards examined under the dissecting microscope (15x) for the occurrence of the formation of gizzard lesions. At each examination

a test of the clotting time of the blood was conducted by means of the capillary tube test.

Discussion: The following discussion is presented in the form of periodic observations:

Nov. 5, 1940 (fourteen days) - All gizzards appear about the size of a pea, with a light flesh colored tinge. Each gizzard as opened contained a milk-white substance. The internal lining appears very smooth throughout but a few of the larger folds and crevices are apparent. There was no visual evidence whatsoever, of any hemorrhage apparent on any of the five gizzards examined. Some green pigment was observed and seemed to be bile, either in the form of a small clot near the intestinal opening or mixed with the milk-white contents.

Nov. 6, 1940 (fifteen days) - Not much visible change in size. The inner lining of the organ has assumed a slight yellow tinge. No hemorrhagic areas were visible. Blood vessels covering the outer coat of the organ appear more numerous and full. Coagulation time of blood was 8 minutes and 15 seconds.

Nov. 7, 1940 (sixteen days) - The inner surface of gizzard appears somewhat more yellowish in color. On viewing a crescent section one is able to indistinctly separate between horny layer and muscular layer. No evidence of any hemorrhage is apparent. The milk-white contents still persist and extend into the proventriculus. By capillary tube test the blood clotted in six minutes.

Nov. 8, 1940 (seventeen days) - Very little change of a visible nature has taken place. The lining which was first observed on the fifteenth day is much more distinct in outline. It appears to be about ½ mm. in thickness. The cellular layer is taking on a pinkish cast as contrasted with the yellow color of the horny layer. No hemorrhage spots were visible. The coagulation time for five samples average 2 minutes and 30 seconds.

Nov. 9, 1940 (eighteen days) - Intermediate, smaller folds of the lining are starting to form and the alternate hills and valleys are more apparent. No evidences of hemorrhage or erosion on the surface of lining are noticeable. In every gizzard examined there was contained in the milk-white material, a small clot of green pigment which was assumed to be bile. The average clotting time was 2 minutes and 15 seconds.

Nov. 10, 1940 (nineteen days) - This stage shows the yolk being drawn into the body of the chick. The folds of the gizzard lining are now quite definite in form and cover the entire surface. The thickness of the lining has increased to approximately one-third millimeter. No visible evidence of hemorrhage or erosion is present. The clot of green pigment is still apparent and located at the point of attachment of the intestine. The average blood clotting time on five embryos was 2 minutes and 10 seconds.

Nov. 11, 1940 (twenty days) - The yolk at this stage is within the body of the chick but the navel is quite

swollen and shows a slight protrusion. The shell of two of the eggs had been pipped while the others had merely pierced the inner membrane with beak open to the air cell. The milk-white substance within the gizzard has turned to a light yellow color. HEMORRHAGE SPOTS ARE PLAINLY VISIBLE. These are not located on the surface of the lining but rather between the lining and the glandular layer. The coagulation time of blood was 1 minute and 15 seconds.

Nov. 12, 1940 (twenty-one days) - Six embryo gizzards from chicks that had just broken out of the shell were examined. The gizzard had emptied to a large extent of the yellowish substance noted in the previous observation. The presence of hemorrhagic areas under the gizzard lining was noted in five of the gizzards. These areas, however, have now turned a brownish color in contrast to the bright red color noted in the previous examination. The blood coagulation time was 30 seconds.

A review of the above observations indicates that the hemorrhagic lesions occurr on the twentieth day of incubation. It is further suggested that the cause of the hemorrhage has been overcome previous to the twenty-first day, a clot has formed and turned brownish in color due to oxidative changes. New lining which is being continually produced by the tubular glands immediately underneath the hemorrhage will cause pressure on the clot, forcing it outward. This will eventually cause a rupture (erosion) in the lining and later be healed by the replacal of new lining.

If one peels off the lining over these hemorrhagic areas, the hemorrhage clot is also peeled off with the lining and shows it to be attached to the underside of the lining. The cellular structure underneath appears normal and no evidence of a hemorrhagic condition in this underlying tissue is apparent.

It seems quite possible that with the drawing of the yolk into the body cavity of the chick, this increased concentration of organs within the relatively limited space of the body cavity, exerts an increased blood pressure. This increased blood pressure, for the moment, is too much for the normal resisting power of the capillaries and a hemorrhage takes place. Shortly thereafter, however, an adjustment in the blood flow occurs, capillaries strengthen and hemorrhage ceases. This is then followed by the normal oxidative changes in the existing blood clot.

Whether these assumptions have any practical basis will be discussed in a later problem.

PROBLEM FIVE

THE RISK OF CHICK GALL BLADDERS AND THEIR RELATION TO OBSERVED GIZZARD LESIONS

Introduction: Cover (1939) has recently reported from his studies on ulcerated gizzards in chickens that the gall bladders of chicks affected with gizzard lesions were often distended or enlarged. Lansing and Miller (1940) report this to suggest a failure of bile to pass through the bile duct into the duodenum. They further report an apparent confirm-

ation of this assumption from cholecystographic examination of one to six day old and three week old chicks.

Klipe (1915) concluded according to Meehan (1931) that during foetal life the liver normally has the property of letting the bile pigments escape into the circulation direct, instead of passing them into the intestine, but that it normally loses this faculty at birth, and if it does not do so, icterus neonatorum results.

Accepting for the present the above reports, an occlusion of the bile duct should normally cause an increased size or weight of the organ over those having a non-occluded bile duct. It seems logical to assume that if a failure of the bile to pass through the bile duct into the duodenum is related to severity of gizzard lesions, this can be indicated by a study of the weight of these organs as related to the observed gizzard score, even though there may be some direct loss of bile into the circulation from the bladder.

Procedure: Thirty-seven day old crossbred chicks were individually weighed, killed and their gall bladders and gizzards removed for analysis. In the removal of the gall bladder it was pealed away from the liver tissue and cleaned of all adhering connective tissue. It was weighed immediately in order to minimize the effect of drying. After the gall bladder was weighed, the gizzard was removed and opened for a determination of gizzard score.

Discussion: A review of table IV indicates there to be no relationship between size or weight of gall bladder and

the severity of gizzard lesion observed.

The weight of chicks used on test varied from 29 gms. to 47 gms. The weight of the gall bladders in these chicks varied from 13 mgs. to 89 mgs., whereas the gizzard scores varied from 0 to 7 (severe hemorrhage plus definite erosion).

The range in weight of gall bladders for those chicks showing no gizzard lesions was approximately as wide and of the same range as those chicks showing more severe lesions. Accordingly, the original assumption, that a distention and increased weight of the gall bladder would indicate an obstruction of the bile duct and would be reflected in the presence of more severe gizzard lesions, was not substantiated.

PROBLEM SIX

THE RELATION OF COAGULATION TIME OF BLOOD OF DAY OLD CHICKS TO THEIR GIZZARD LESION SCORE

Procedure: The method followed was a modification of Lee and White's method as given by Smith, Clough and Clough (1938). The modification consisted of a direct heart puncture of the day old chick and the withdrawal of 0.5 cc. of blood into a 2 cc. syringe which had previously been washed with physiological salt solution.

Twelve day old chicks as produced from battery managed layers, artificially inseminated, were used for the test. In the determination of coagulation time a record was maintained of the exact second when blood first entered the syringe until it had clotted within the glass tube into which it was passed from the syringe. As soon as the tube could be inverted with-

TABLE IV

OBSERVED GIZZARD SCORES AS RELATED TO GALL BLADDER WEIGHT OF DAY OLD CHICKS

No. Chicks	Ave. Weight	Gizzard Score	Range in Weight of Gall Bladders
7	35.6 gm.	0	14 - 70 mg.
10	37.9 "	1	15 - 89
-	-	2	-
17	37.2	3	13 - 85
-	-	4	-
2	35.5 '	5	45 - 62
-	-	6	-
1	40.0	7	55.0

out loss of blood, coagulation was assumed to have occurred. After the withdrawal of blood the chicks were killed and their gizzards examined for presence or absence of lesions.

Discussion: Table V presents the results of the coagulation time and the comparable gizzard score as observed in the examinations of the respective chick gizzards.

TABLE V

THE RELATION OF COAGULATION TIME OF BLOOD AND OBSERVED GIZZARD SCORE IN DAY OLD CHICKS

Chick No.	Coagulation Time	Gizzard Score
1	1:10 min.	3
2	1:12 "	3
3	1:10 "	3
4	1:15	3
5	2:00	3
6	1:10 "	1
7	1:15	0
8	2:30 "	3
9	1:30	3
10	1:20	3
11	1:20 "	1
12	1:10 "	0

It will be noted from the above table that the time of coagulation varied from one minute ten seconds to two minutes thirty seconds. In no case was the time prolonged above nor-

mal. Since those chicks which showed most severe gizzard lesions had a blood coagulation time similar to those showing absence of gizzard lesions it is concluded that the coagulation time of blood bears no relation to the severity of observed gizzard lesions.

PROBLEM SEVEN

THE RELATION OF THE METHOD OF INCUBATION TO THE INCIDENCE OF GIZZARD LESIONS IN THE RESULTANT CHICKS

Procedure: Eighty-three hatching eggs produced by pullet breeders fed the regular maryland station mash were divided into two groups of 38 and 45 eggs each. Those of Group One were placed under broody hens and naturally incubated, whereas those of Group Two were artificially incubated in a forced draft cabinet incubator. On the twenty-second day of incubation all chicks so hatched were removed, killed and their gizzards examined for the presence of gizzard lesions. Eggs used in this test were selected from the total production secured from breeders one day previous to their incubation.

Three broody hens were selected on May 9, 1940 and on the following day 14 eggs were placed under one of these. On May 14, 12 eggs were placed under each of the other hens, making a total of 38 eggs to be incubated under natural conditions. Also on May 14, 45 eggs were placed in the forced draft machine for the production of chicks by the artificial

method.

A total of twenty chicks were secured by the natural method and twenty-four by the artificial method. On the twenty-second day of incubation they were removed, killed and their gizzards examined for the presence of gizzard lesions.

Discussion: The gizzards of the naturally incubated chicks showed four normal and sixteen affected or an average gizzard score of 1.8. All lesions were limited to the presence of hemorrhages. The gizzards of the artificially incubated chicks showed under macroscopic examination, five normal and nineteen affected with an average score of 1.9. Two gizzards showed the presence of slight erosions while the rest were limited to a hemorrhage condition.

Since somewhat similar gizzard lesions were observed in the gizzards of both naturally and artificially incubated chicks it is concluded that the method of incubation bears no relation to the occurrence of gizzard lesions in day old chicks.

PROBLEM EIGHT

THE EFFECT OF INCREASING AND DECREASING BLOOD PRESSURE ON THE TIME OF ORIGIN AND SEVERITY OF GIZZARD LESIONS IN EMBRYONIC AND DAY OLD CHICKS

Procedure: Two hundred S. C. W. Leghorn hatching eggs were incubated up until the fourteenth day from which time observations were made daily until hatching date of the macroscopic appearance of the lining of the gizzard in the developing embryos. Five live embryos were used for each ex-

amination. Since through Problem 4 it was observed that hemorrhages originate on the twentieth day of development, the time at which the yolk sac is also drawn into the body cavity of the chick, this yolk intake is assumed to cause an increased blood pressure within the embryo and may possibly be related to the occurrence of hemorrhages in the gizzard lining. It was therefore deemed advisable to cause an increased blood pressure within the embryo previous to the normal intake of the yolk sac, in order to study its effect on the hemorrhage origin.

Twenty live embryo containing eggs at the age of sixteen days were injected with ½ cc. of adrenalin hydrochloride 1:1000 by placing this solution within the air sac of the egg. On the eighteenth day of incubation these injected embryos were examined to note the effect of this drug on the formation of hemorrhages in the gizzard. A group of twenty uninjected embryos and twenty injected with physiological saline solution were maintained as controls.

Conversely, to the above, it was thought advisable to attempt to reduce blood pressure and also to attempt a strengthening of the capillary walls which, in turn, might tend to offset the bursting pressure exerted by the blood on the thin walled capillaries of the gizzard.

Accordingly, on the sixteenth day of incubation, 1 cc. of l-ascorbic acid (2mg. per cc.) was injected into twenty eggs containing live embryos and later examined at hatching time to note its effect on the development of hemorrhages.

A control group of ten embryos was injected with physiological saline and used for comparison. Twenty live embryos at nineteen days of age were injected with ½ cc. digitalone (a purified extract of digitalis) and twenty were injected with 1 cc. histamine dihydrochloride (0.4mg. per cc.). These latter two injections, being given just previous to the intake of the yolk might tend to reduce or offset the possible increase due to the absorption of the yolk. The eggs were allowed to hatch and then examined for the presence of gizzard lesions.

Conclusions: The daily observations of the condition of the gizzard lining in the developing embryos indicated a similar series of changes to be taking place as already discussed in Problem 4. The hemorrhagic appearance was again noticeable on the twentieth day of incubation.

The twenty embryos injected with adrenalin hydrochloride were examined on the eighteenth day and all were observed to contain hemorrhages under the gizzard lining and somewhat similar to those normally encountered. Hemorrhages were noted in other parts of the body as well. Plate 2 illustrates the appearance of these hemorrhages as contrasted with an open (A) and non-opened (B) normal gizzard. It was conclusively demonstrated that an increased blood pressure will result in the formation of hemorrhages in the gizzard capillaries.

Since the dosage given was obviously too strong, a further test was instituted whereby graded dosages of ½ cc. of

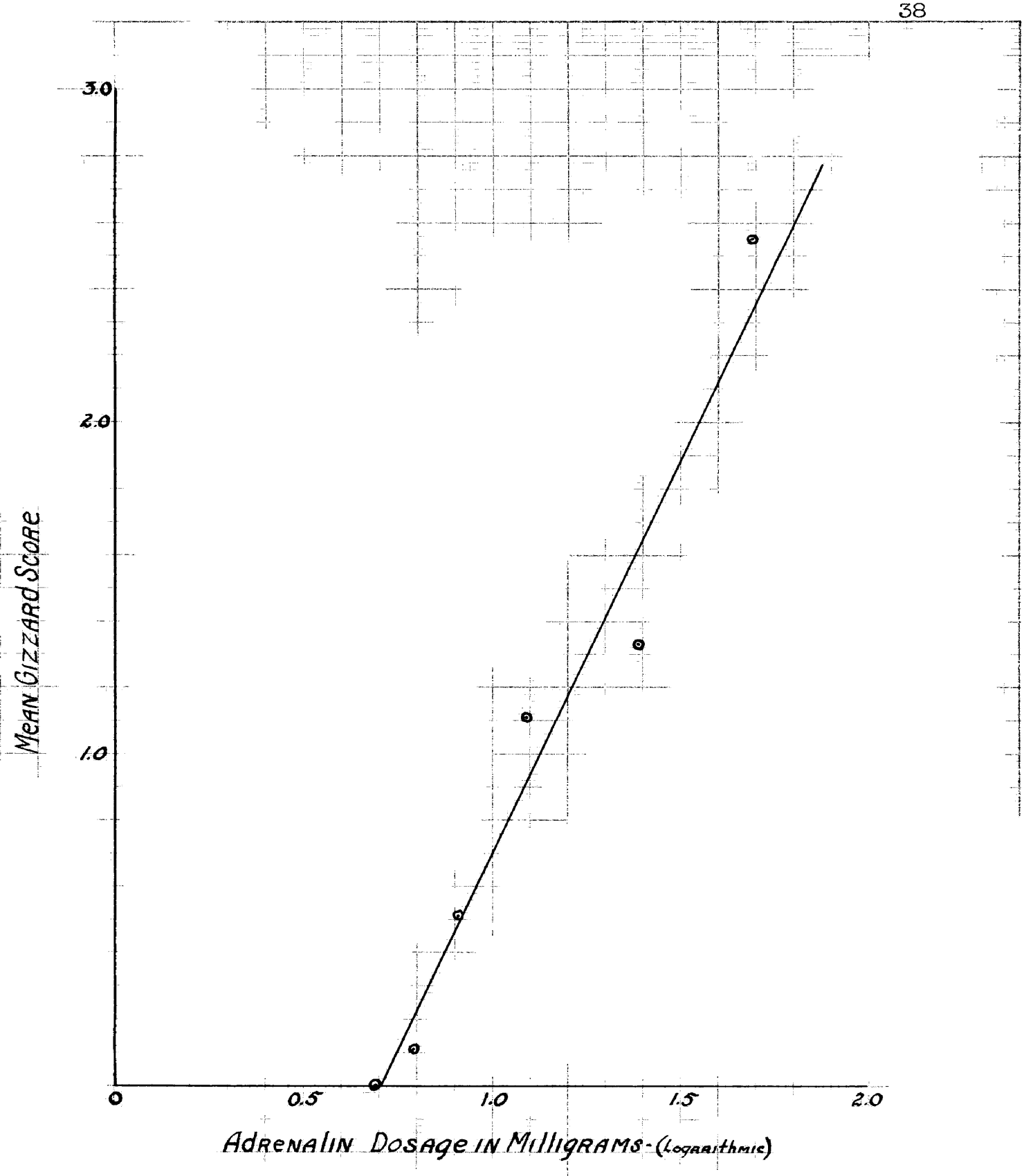

Figure 7- The Effect of Increasing Blood Pressure on the Severity of Gizzard Lesion

each of the following dilutions were used; 1:1000, 1:2000, 1:4000, 1:8000, 1:8000 and 1:10,000. Figure 7 illustrates the results procured. The logarithmic value of each dosage used plotted against the mean glycemi score observed, indicates rather close relationship between the two factors. Hemorrhages resulting from the injections of the lower dilutions were limited solely to the gizzard tissue.

All injections of histamine dihydrochloride, Vitamin C and digitalone were unsuccessful in that no differences were encountered in the severity of lesions as observed at hatching time over the injected or non-injected controls.

PROBLEM NINE

THE RELATION OF AGE OF YOLK TO THE INCIDENCE OF HEMORRHAGE IN THE GIZZARD LINING IN DAY OLD CHICKS

Introduction: It was previously demonstrated that the injection of adrenalin hydrochloride into fertile eggs will produce hemorrhage in the gizzards of eighteen day old embryos. This, in itself, seems to imply that some physiological mechanism occurring "normally" at about the twentieth day causes an increased blood pressure. Those chicks with strong capillaries are able to take care of this increase, while others with weakened capillaries are unable to withstand the sudden increase of blood pressure and a hemorrhage results.

Working on this proposition it is quite conceivable that

the larger the yolk which is taken into the body cavity by a chick during the hatching period, the greater will be its effect on raising of the blood pressure. The greater the pressure which is set up, the more severe will be the gizzard lesion observed following hatching.

Procedure: Two hundred day old chicks were taken from the incubator as soon as the hatch was completed and were weighed individually. Each chick was then killed, without loss of blood, the yolk removed and the body reweighed. The difference in weights was taken as the weight of the yolk removed. The gizzard of each chick was then examined and scored according to severity of lesion present.

Discussion: The range in weight of chicks examined varied from 29 to 52 grams, the yolk weight from 1.5 to 12 grams and the gizzard score from 0.0 to 8.0. The relationship between the weight of the yolk and the observed scores is plotted in Figure 8.

A calculation of the standard errors for two arbitrary groups was made. The first group included those having yolk weights of 5 grams or less while the second group included those over 5 grams in weight. In both cases the standard error was ±.13. The mean gizzard score of the first group was 2.18, that of the second group 2.73 with a difference of 0.55. The standard error of the difference was ±.18. The results indicate quite definitely that yolk also as taken into the body cavity of the developing chick is at least a contributing factor in increasing the severity of gizzard

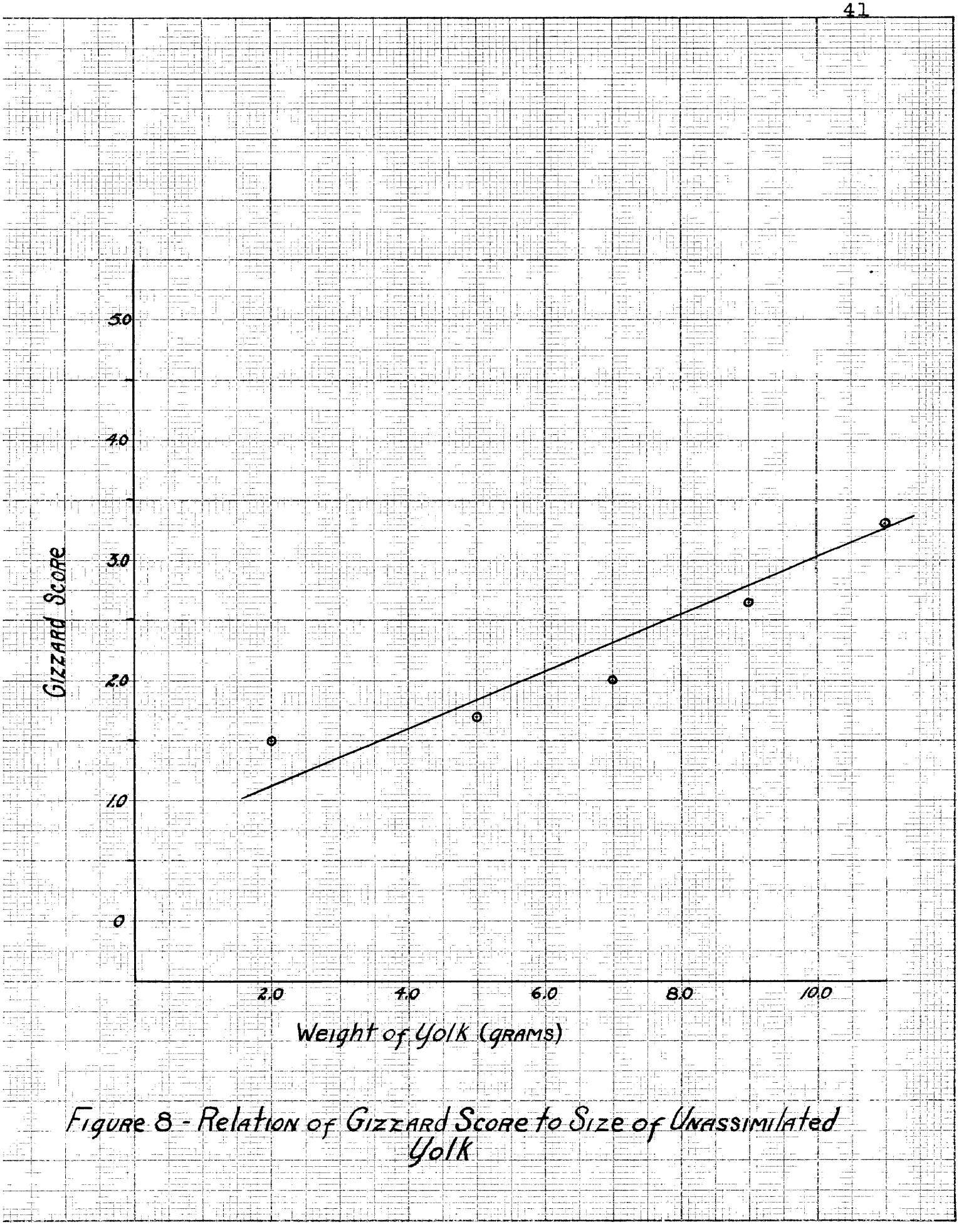

Figure 8 - Relation of Gizzard Score to Size of Unassimilated Yolk

lesions in day old chicks.

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THE INFLUENCE OF THE INITIATION OF PULMONARY RESPIRATION AT VARIOUS STAGES OF YOLK INCLUSION WITH THE BODY CAVITY OF THE INCIDENCE OF GIZZARD LESIONS IN CHICK EMBRYOS.

Introduction: Previous studies have indicated that lesions in the gizzards of developing chick embryos appear on the twentieth day of incubation. This period coincides with three important physiological changes occurring during embryonic development.

These changes are (1) the drawing-in of the yolk sac and its contents into the body cavity of the chick, (2) establishment of pulmonary respiration and (3) the establishment of pulmonary circulation with the accompanying withdrawal of blood from the allantoic vessels. All three of these changes can conceivably result in an increased blood pressure. Should the capillary walls in the gizzard be weak, this increased pressure may result in the hemorrhage which is apparent on the twentieth day of incubation.

It has been shown that an increased blood pressure will cause hemorrhages in the gizzard tissue immediately underneath the gizzard lining, and that large yolks taken into the body cavity of the developing embryo may also be a contributing factor in the severity of gizzard lesions.

Procedure: In order to further study the effect of pulmonary respiration on this problem fifty-three fertile

eggs containing live embryos on the nineteenth day of incubation were used. These eggs were candled, the outline of the air cell clearly marked by pencil and an opening approximately one half inch square was cut through the shell exposing the inner membrane under the air cell. These eggs were then placed within a glass topped incubator and observed continuously from the stage of 457 hours up to 501 hours of incubation.

As soon as the chicks beak broke into the air cell space the time was recorded on the egg shell and after a certain period of time the eggs were removed, embryo killed and its glands examined for the presence of lesions. The first fifteen embryos were examined for lesions fifteen minutes following the appearance of the beak into the air cell space. The next seven were allowed a period of one hour before examining, the remainder being allowed a period of two to three hours. A record of the stage of yolk inclusion within the body cavity of the chick was also made.

Discussion: Table VI presents these observations as made. Since all of these embryos examined had established pulmonary respiration it seems apparent that this, in itself, is not a direct quantitative factor of gland hemorrhages. There appears to be a conditioning effect produced by the stage of yolk inclusion within the body cavity. The more complete the yolk inclusion, the greater was the chance of hemorrhage.

It was further deemed desirable to examine a series of

embryos which, on the twenty-second day of incubation, were still alive, had not broken their way into the air cell but did show a complete inclusion of the yolk within the body cavity. But such an observation it would be possible to differentiate between the relative effectiveness of the two factors as causative agents.

An examination of fifty such embryos showed normal gizzards in forty-six and slight hemorrhage in but four. This appears as circumstantial evidence that the inclusion of the yolk, in itself, is not the sole conditioning factor for the occurrence of hemorrhages in the gizzard lining. It seems quite probable that all three of the above mentioned factors are cumulative in their effect.

TABLE VI

RELATION OF INITIATION OF PULMONARY RESPIRATION AT VARIOUS STAGES OF YOLK INCLUSION IN THE BODY CAVITY OF THE CHICK TO THE INCIDENCE OF GIZZARD LESIONS

Stage of Yolk Inclusion	Observed	
	Hemorrhage	Normal
All inside cavity	10	5
Three-fourths inside	4	13
One-half inside	0	21

PROBLEM ELEVEN

THE RELATION OF THE INGESTION OF SAND BY GROWING CHICKS TO SUBSEQUENT GROWTH AND LIVABILITY OF CHICKS AFFECTED WITH GIZZARD LESIONS

Introduction: During the course of our investigations on Ulcerated Gizzard disease an opinion was expressed by an interested observer that the ingestion of sand by growing chicks probably was a contributing cause of mortality and poor growth with chicks likewise affected with gizzard lesions as day-olds. Some 40 million broiler chicks are raised on the Del-Mar-Va peninsula yearly, and a large part of these chicks are allowed free access to beach sand as a litter within the pens or in the open yards fronting the houses, upon which the chicks range. Since a considerable trouble has been experienced with ulcerated gizzards in this area, the assumption was made that this sand may possibly be detrimental to the securing of optimum results in the broiler chicks so raised.

Procedure: In order to secure a definite answer to this question two hundred Rock-Red crossbred chicks were divided into five lots of thirty-five chicks each. The remaining twenty-five chicks were killed as day-olds and their gizzards examined for the presence of gizzard lesions. A relative "gizzard score" was thus established and assumed to be applicable to each of the five lots.

Group 1 was fed the Maryland station Mash and served as a control. Groups 2, 3, 4 and 5 were fed the same type of

each supplemented with 2.5, 5.0, 10.0 and 20.0 per cent, by weight, of beach sand, respectively. All chicks were managed in growing batteries throughout the course of the experiment.

On the periods of 3 days, 1 week, 2 weeks, and 3 weeks of age, four chicks from each group were removed, killed and their gizzards examined to note the influence of sand on the severity of the observed gizzard condition. In this selection of chicks the two highest and the two lowest weight chicks were used.

Body weight and feed consumption records were maintained weekly.

Discussion: The average initial "gizzard score" for the twenty-five day-old chicks examined was 8.0 points. The method of scoring is shown in Figure 1. Table VII shows the relative average gizzard scores secured by examination of the gizzards at periodic inspections for all groups. It will be noted that the apparent severity of gizzard lesion seems to increase throughout the examination periods. These increases in observed severity are, however, not regular and likewise are not at all closely associated with the amount of sand ingested by the chicks. Thus, at the 3 day examination Group 8 receiving 2.5 per cent beach sand held the lowest "gizzard score," at 1 week Group 4 receiving 10.0 per cent had the lowest gizzard score, at 2 weeks Group 8 was lowest, and at 3 weeks Groups 1 and 8 both held similar "scores."

This apparent increasing severity is quite similar to our previous observations. During the first three or four

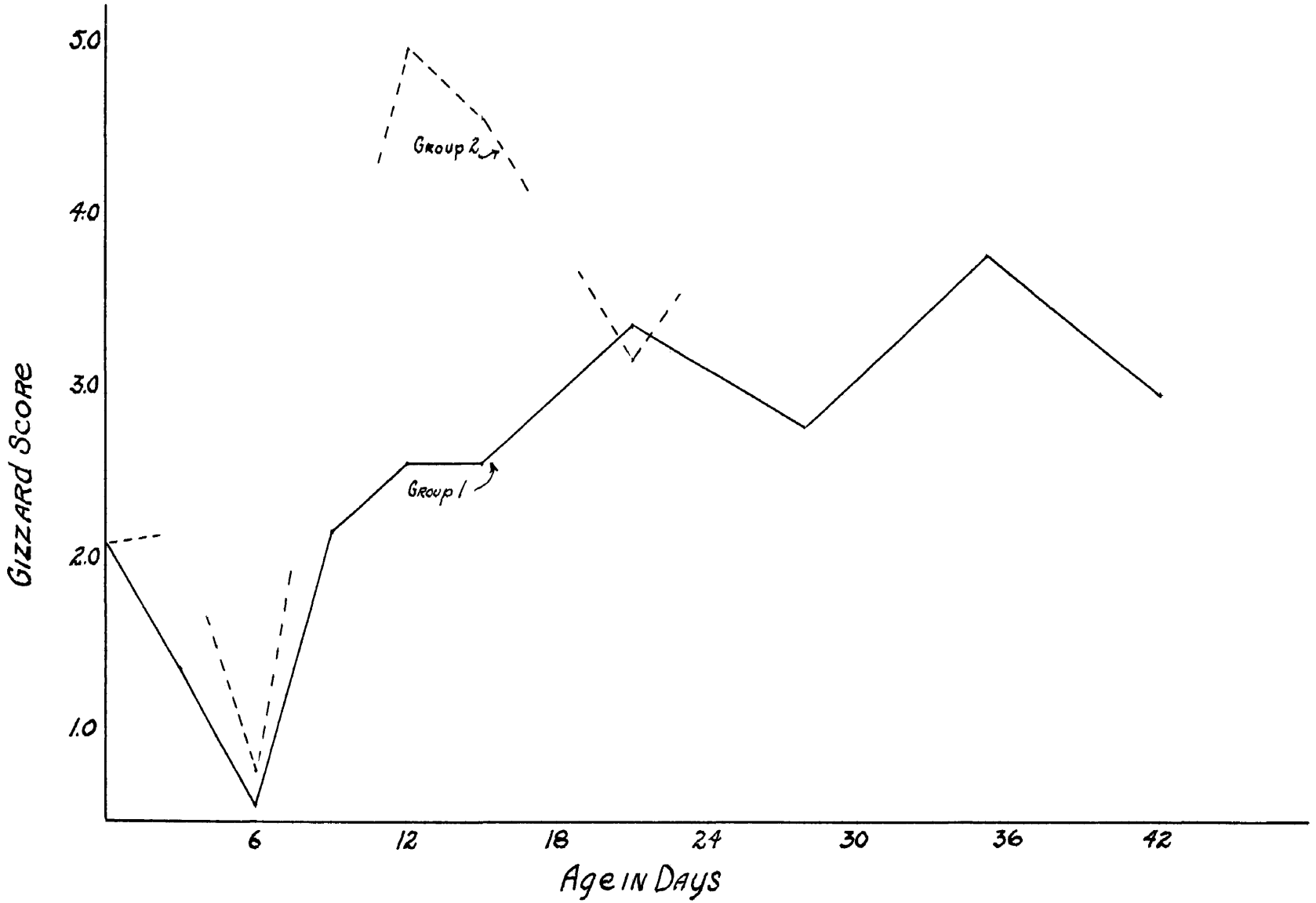


Figure 9 - Changes in Gizzard Lesion Severity in Growing Chicks as Effected by Diet

weeks the affected lining sloughs off and is replaced by a normal lining. This normal lining is replaced at the bottom of the opened craters or crevices in the old split lining and eventually the older affected areas are replaced with normal lining. Undoubtedly, the movement and grinding of the feed within the gizzard causes this sloughing of the affected lining.

In order to check on the relative consumption of sand by these examined chicks, the contents of all gizzards were washed out thoroughly into a glass container and grit present in the contents separated by washing and floating out of the feed material. The contents were then dried thoroughly in an electric oven at 100° C. and the combined sand from the four gizzards weighed. The results obtained are shown in Table VIII. Although the relative amounts recovered in the gizzards from the respective groups are not exact as compared with the amounts incorporated within the feed, they are, however, quite similar.

Tables IX and X indicate, respectively, the average body weights and feed consumption per chick by weekly periods up to 6 weeks of age. In regard to Table IX, no significant differences in body weight are apparent. Group 3 receiving 20.0 per cent sand averaged to weigh the heaviest at six weeks followed in order by Groups 2, 1, 5, and 4. Although Table X indicates a close relation between total weight of feed consumed and per cent of sand contained in the feed, if we review Table XI containing figures for feed consumed where-

in the percentage sand contained has been eliminated from totals we find an entirely different relation. Thus Group 1 receiving no sand actually consumed more feed than did any of the sand-fed groups. It is also of considerable interest to observe the average efficiency figures in this same table. Thus Group 1 receiving no sand is less efficient than either of Groups , 3, or 5.

Throughout the six weeks period only one chick died. This occurred in Group 2 at 1 week of age and upon examination was found to have severe hemorrhage and ulcers in gizzard lining. The lungs were congested and the cause of death considered to be pneumonia.

PROJECT THREE

TO INVESTIGATE THE IMPORTANCE OF COPPER SULPHATE AND OF A NUTRITION FACTOR IN ANTI-GIZZARD EROSION FACTOR IN THE TREATMENT OF SUCH LESIONS.

Procedure: Previous work at the Maryland Agricultural Experiment Station has indicated that copper sulphate is of doubtful benefit in the treatment of gizzard erosions in chicks. It seemed desirable to reinvestigate the action on chicks of a diet adequate in the gizzard erosion factor with and without the supplemental addition of copper sulphate as dry powder in the mash or as a solution mixed with the drinking water.

Accordingly, three groups of 30 day old chicks of mixed breed were placed in electrically heated batteries on October 20, 1939 and maintained in those batteries to an age of three weeks. Group One received the Maryland Station mash without

TABLE VII

RELATIVE AVERAGE GIZZARD SCORES BY STATED PERIODS

Period	Group 1	Group 2	Group 3	Group 4	Group 5
3 days	0.85	0.0	0.5	0.7	0.7
1 week	1.00	1.5	2.2	0.0	1.7
2 weeks	1.7	2.7	2.5	1.5	0.7
3 weeks	2.7	3.0	4.0	4.3	2.7

TABLE VIII

BLACK MOLD RECOVERED FROM GIZZARDS OF FOUR CHICKS FROM EACH GROUP AT STATED PERIODS. -(GRAMS)

Period	Group 2		Group 3		Group 4		Group 5	
	Total	Average	Total	Average	Total	Average	Total	Average
1 week	—	—	—	—	—	—	0.074	2.287
2 weeks	0.960	0.240	2.936	0.734	4.776	1.194	12.256	2.564
3 weeks	1.404	0.351	3.505	0.880	6.120	1.530	10.750	2.689

TABLE IX

AVERAGE BODY WEIGHT IN GRAMS BY WEEKS
PERIODS FOR ALL GROUPS

Group	Week						
	Initial	1	2	3	4	5	6
1	41.6	63.7	93.6	137.9	207.4	327.0	393.4
2	41.7	64.6	103.4	149.4	221.5	310.9	400.3
3	41.4	67.9	108.1	147.8	201.0	296.5	370.4
4	41.1	69.8	111.6	143.7	200.5	278.5	363.3
5	40.6	67.8	112.3	156.5	206.1	303.4	408.6

TABLE X

AVERAGE FEED CONSUMPTION IN GRAMS
BY STATED PERIODS FOR ALL GROUPS.

Group	Week						
	1	2	3	4	5	6	Total
1	80.9	91.4	136.0	170.3	261.9	262.5	1002.0
2	80.3	97.8	100.9	161.8	225.8	267.5	929.5
3	86.3	96.9	127.8	157.8	251.4	296.9	1017.2
4	82.5	105.1	130.2	171.8	242.9	350.2	1038.7
5	85.4	119.8	156.2	209.8	274.8	330.2	1176.0

AVERAGE WEEKLY GAIN, FEED CONSUMED (POUND) AND EFFICIENCY OF FEED CONSUMPTION FOR GROUPS. (GRAMS)

Group	1			2			3			4			5			6			Total		
	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain	Gain	Feed Consumed	Feed: Gain
1	22.1	50.6	2.3	31.4	91.4	2.8	43.3	136.0	3.2	69.5	179.3	2.6	110.0	281.9	2.5	56.4	282.8	5.0	341.8	1032.0	2.9
2	29.7	69.05	2.1	39.0	94.77	2.4	46.0	136.19	2.9	78.1	157.76	2.0	89.3	218.21	2.4	89.5	290.32	3.1	389.6	906.29	2.3
3	26.4	53.43	2.0	40.3	92.06	2.3	39.7	121.41	3.0	53.2	149.91	2.8	95.5	238.83	2.5	82.9	312.66	3.7	338.0	968.29	2.8
4	28.7	56.3	1.9	41.7	94.6	2.3	32.2	117.2	3.6	56.9	154.82	2.7	77.8	218.61	2.8	85.0	298.18	3.4	322.2	929.51	2.8
5	26.6	44.32	1.9	45.1	95.68	2.1	43.2	124.06	2.8	70.6	167.04	2.4	77.3	219.36	2.8	105.1	288.64	2.7	327.9	940.00	2.8

supplement. Group Two was fed a similar mash but supplemented with 0.25 per cent copper sulphate in powder form. Group Three also received the Maryland station mash and in addition the drinking water was supplemented with 0.05 per cent copper sulphate. These supplements were continued for the first ten days only.

At the age of 3, 5, 7, 10, 14 and 21 days of age five representative chicks from each lot were removed and their gizzards examined to note the severity of lesions present and possible indications of any healing process taking place. A random selection of 12 day old chicks from the total lot were also killed and their gizzards examined to note the incidence of lesions present at the start.

Discussion. All chicks were weighed at weekly intervals and these average weights are reported in Table XII. It will be noted that Group Two showed a slightly higher average weight than did the other groups, but this group at the three week period had no Leghorn chicks in its midst whereas Group One had three. It is possible that this variation in breed may have influenced the average weight. However, the variation between groups is not excessive.

Table XIII shows the observed gizzard scores by stated periods and it is noticed that the severity is in direct order 1, 2 and 3 by groups.

In the examination of gizzards it was quite apparent that the feeding of copper sulphate as a dry powder in the mash caused a thickening and softening of the gizzard lining

followed by some exfoliation. This lining also appeared a lighter yellow color than that observed in the chicks from the other two groups. In Group One at the age of ten days a definite appearance of a new lining was noted in a few chicks at the base of a crater lesion. The hemorrhage spots in these cases were no longer visible. This would seem to indicate a definite healing process as taking place.

TABLE XII

AVERAGE WEIGHT RECORDS ALL GROUPS AT STATED PERIODS IN GRAMS PER CHICK.

Group	Week Initial	1	2	3
1	38.1	64.3	106.0	158.0
2	39.3	71.0	112.0	176.0
3	40.9	58.3	95.0	164.0

TABLE XIII

INCIDENCE OF GI LESION SCORES BY STATED PERIODS

Group	Classed Score by Age in Days 1	3	5	7	10	14	21	Ave.
1	2.5	1.4	0.16	1.4	3.0	1.3	1.45	1.39
2	2.6	1.2	0.50	2.5	1.0	1.3	3.3	1.63
3	2.5	3.2	2.75	1.16	0.83	2.3	3.0	2.39

PROBLEM THIRTEEN

THE OCCURRENCE OF AND CHANGES TAKING PLACE IN THE GIZZARD LESIONS OF GROWING CHICKS AS INFLUENCED BY VARIOUS RATIONS.

Introduction: Early reports by Almquist (1936) and Bird, et al (1936) as well as others have indicated various ingredients to have a curative effect on gizzard lesions during a subsequent growing period. Since these workers did not report the severity of lesions in the day old chicks at the start of the feeding trial, some question may be advanced as to the true curative effects produced.

It has further been reported that when growing chicks are fed a well balanced diet there appears to be no significant relation between the incidence of gizzard lesions in the day old chicks and their subsequent growth, livability and feed consumption. This then implies that chicks fed a "poorly" compounded diet may suffer during the subsequent growing period in any or all three of the previously mentioned measures as a result of the continued presence of severe lesions.

It therefore was deemed desirable to trace the occurrence of and changes taking place in the gizzard lesions of chicks fed various "protective" and "non-protective" diets.

Procedure: Four hundred and twenty-five day old S.C.W. Leghorn male sexed chicks were divided into eight groups of fifty chicks each for feeding trials. The remaining twenty-five chicks were killed as day olds and examined for the presence of gizzard lesions. A relative gizzard score was thus established and applied as an average initial score for each

of the above mentioned groups.

Throughout the experimental period of six weeks, at the daily periods of 3, 6, 9, 12, 15, 21, 23, 33 and 45, five chicks were removed at random from each group. These were killed and their glandular examined for the presence and severity of lesions.

The notations used in this text are outlined in Table 14.

Discussion: Figures 1 and 10 show the trend of glandular scores observed for the first five groups. Groups 6, 7, and 8 suffered extremely high mortality, not considered related to the problem and are therefore not presented. It will be noticed that all groups showed a definite drop in observed severity of lesions as of the sixth day, after which a decided increase occurred, followed by a general levelling out.

Observations as early as the sixth day showed evidence of deposition of new glandular lining. On the ninth day it was observed that the ridges of lining containing hemorrhages were splitting and causing a very roughened condition of the lining. On the twelfth day severe exfoliation was noticeable, especially in Group 2. Plate 3 illustrates this observed condition.

On the twenty-first day, examination showed the presence of severely swollen glandular linings in all groups. This lining was light yellow in color, of pulpy condition and easily torn. Following the twenty-first day there was a reduction of this swollen lining condition in Group 1 but others groups were more variable in the appearance of severity. See one

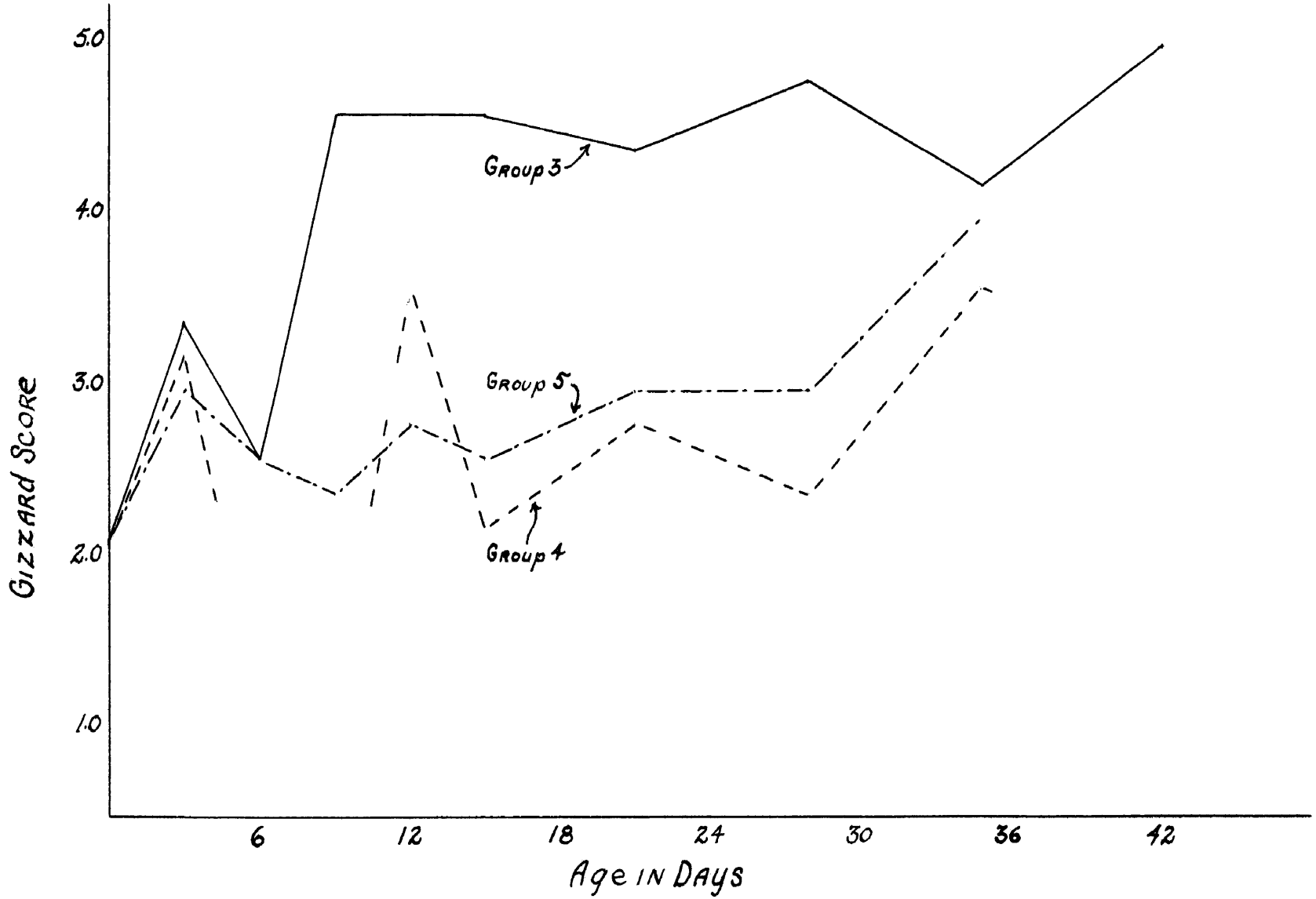


Figure 10- Changes in Gizzard Lesion Severity in Growing Chicks as Effected by Diet

TABLE 14

[illegible] (Table 1:

Ingredient	Group							
	1	2	3	4	5	6	7	8
	pounds							
Yellow corn meal	65	70	68	78	57.5	5.0	5.0	6.0
Wheat bran	15							
Wheat bran (cooked 110° for 24 hrs.)						5.0	5.0	5.
Wheat flour middlings	15				28			
Ground hard oats	15							
Alfalfa leaf meal	5.0	5.0				5.0	6.0	5.0
Meat scraps	7.5	7.0						
Fish meal	7.0	5.0						
Fish oil	5.0							
Crude casein						18	18	18
Dextrinized corn starch						57	[illegible]	56.5
Brewer's yeast			1			[illegible]		
Soybean oil meal	6.0	11						
Wheat germ oil								
Calcium carbonate		0.5	1					
Tricalcium phosphate			1					
Salt 1						5.0	5.0	5.0
Sodium chloride	0.5	0.5	1					
Cod liver oil	1	1	1		-			-
Sodium glycocholate					2.5			0.5
Manganese sulphate	.012		.015	.01	.012			

of the roughened condition of the linings following the fifteenth day it was rather difficult to distinguish, in many cases, the presence of small erosions.

A comparison of the scores as observed and presented in Figures 9 and 10 indicate quite generally that a well balanced diet aids in the reduction of gizzard lesion severity. Also good growth and low mortality was maintained regardless of the presence of gizzard lesions. In contrast, a poorly balanced diet showed higher gizzard scores, poor growth and higher mortality throughout the experimental period.

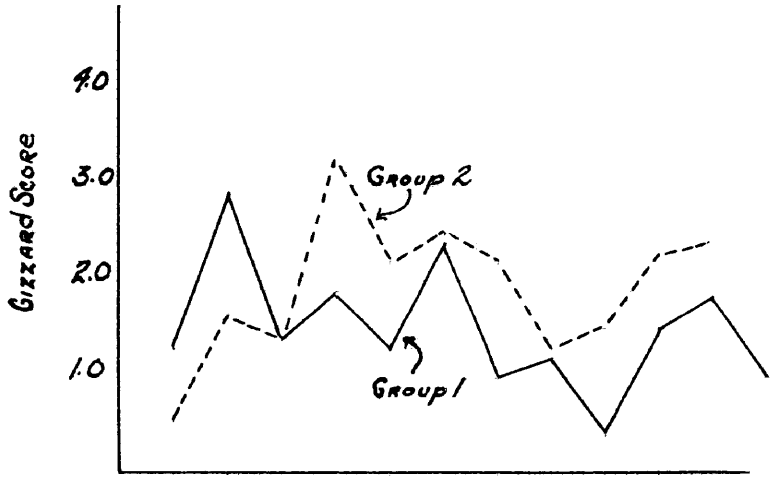
Group 4 and 6 supplemented with whole ground oats and sodium glycocholate, respectively, showed less severe gizzard lesions than did Group 3 indicating some protective value from these supplements. Feed consumption and growth of the chicks receiving sodium glycocholate were both low as compared to that of Group 3 or Group 4.

PROBLEM FOURTEEN

THE EFFECT OF ARTIFICIAL LIGHT RATION OF LAYING POPULATION ON THE INCIDENCE OF OVARIAN LESIONS OBSERVED IN CHICK CRIPPLING

Introduction: It is quite generally accepted that, in the response of mature female chickens to light, the rays of light act through the eye and cause a stimulation of the anterior pituitary gland, resulting in an increased production of gonad stimulating hormone. This gonad stimulating hormone in turn, acts upon the ovary to stimulate it to increased production of mature yolks. As a consequence, there is de-

A



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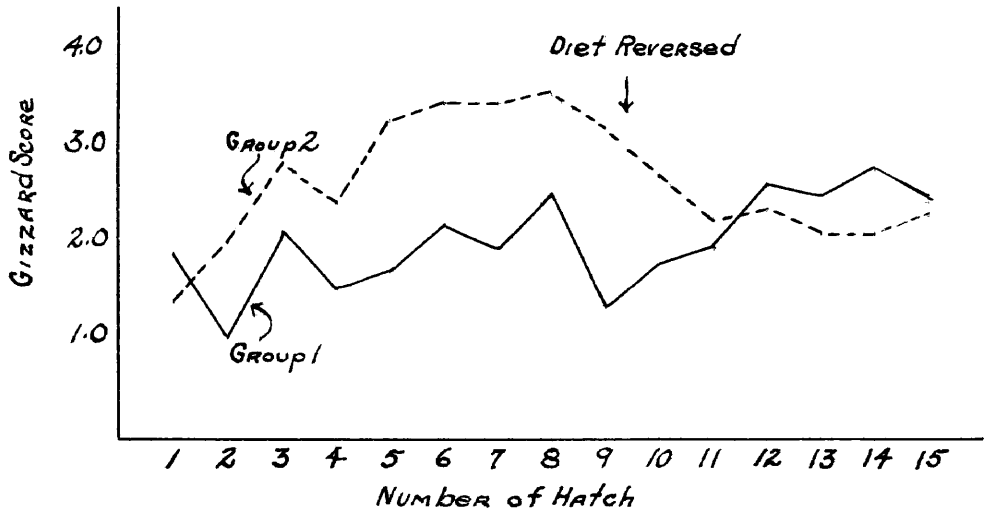

Figure 11 - The Effect of Feeding Breeders a Ration Composed Largely of Anti-Gizzard Erosion Active Ingredients on the Severity of Gizzard Lesions in their Day Old Progeny

veloped a tendency to increased rate of lay during this period of light application. Since birds were available at this Station which were receiving variable light rations, it was deemed desirable to study the effect of this light ration on the incidence of gizzard lesions in chicks produced from such birds.

<u>Procedure:</u> On the basis of the above statements, two groups of New Hampshires were used. Group One received a continuous twenty-four hour light ration and Group Two was restricted to a six hour light ration per twenty-four hour day. All birds were fed the Maryland Station mash. Representative lots of eggs from each group were incubated and upon hatching, the chicks were examined for the presence or absence of gizzard lesions.

<u>Discussion:</u> In Test One twenty-seven chicks were hatched and examined from Group One showing a total gizzard score of 62 or an average of 2.30 per chick. From Group Two twenty chicks were hatched showing a total score of 47 or an average gizzard score per chick of 2.35. A second hatch for both groups was conducted with Group One showing a total score of 11 for five chicks or an average of 2.20. Group Two showed a total score of 37 for fifteen chicks or an average of 2.47 points.

The grand average of these two tests showed the chicks from Group One to have an average gizzard score of 2.28 while Group Two gave an average score of 2.40.

The differences observed do not appear significant and

it is concluded that the light ration received by breeders has little or no influence on the incidence of gizzard lesions observed in their resulting offspring.

PROBLEM FIFTEEN

THE EFFECT OF FEEDING BREEDERS A RATION COMPOSED LARGELY OF ANTI-GIZZARD EROSION ACTIVE INGREDIENTS ON THE SEVERITY OF LESIONS IN TENTH DAY OLD PROGENY.

Introduction: On the basis of the reported literature it seems probable that suitable rations can be formulated which would represent (1) a ration well fortified in the anti-gizzard erosion factor or factors and (2) a ration supposedly deficient in this factor or factors. The assumption was made that by feeding such rations to breeding birds, the resultant day old chicks hatched from the eggs laid by these two groups of birds would vary markedly in the observed incidence of gizzard lesions. An attempt was therefore made to substantiate or invalidate this premise.

Procedure: Test 1 - Thirty New Hampshire yearling females and four barred Plymouth Rock males were divided into two groups of fifteen females and two males each. Group 1 was fed a ration composed of 5½ pounds ground whole oats, 15 pounds wheat bran, 15 pounds wheat middlings, 4 pounds alfalfa leaf meal, 5 pounds meat scraps, 4 pounds fish meal, 1 pound gurbay (vitamin G concentrate), 1 pound salt, 8.5 pounds ground limestone, 1 pound cod liver oil and 0.012 pounds manganese sulphate. Group 2 was fed a ration composed of 68 pounds ground yellow corn, 10 pounds corn gluten

meal, 15 pounds dried skim milk, 1 pound salt, 2 pounds ground limestone, 3 pounds steamed bone meal, 1 pound cod liver oil and 0.012 pounds manganese sulphate.

Group 1 was allowed free use of a grass range adjacent to the house but Group 2 was kept confined. This procedure was followed since green grass has also been reported to have anti gizzard erosion activity. Both groups received oyster shell ad. lib.

Following an adjustment feeding period of two weeks all eggs laid were pedigree hatched each week for a period of twelve weeks (July 9 - Sept. 24). On the twenty-second day of the incubation period all chicks hatched were killed and their gizzards examined for the presence and severity of lesions.

Procedure: Test 2 - This was similar to that of Test 1 with the exception that fifty S.C. Brown Leghorn females and four males were used and divided into two pens of equal numbers. The birds were fed for an adjustment period of eight weeks previous to setting any eggs. The first hatch occurred December 2 and the last April 14, 1941 with a total of fifteen hatches.

On February 12, between the ninth and tenth hatches, the rations were shifted so that Group 1 was then receiving the deficient ration and Group 2 the fortified ration. It was further deemed desirable to alter the deficient ration so as to eliminate the steamed bone meal. Thus, 2 pounds of tricalcium phosphate and 1 pound of corn gluten meal were added to

replace this product.

Discussion: Figure II presents the respective results procured from the two tests. Chart "A" gives the results of Test 1 and " those of Test 2. A review of this figure indicates that it is possible to reduce the severity of gizzard lesion incidence in day old chicks by an adjustment of the diet fed to the breeders. Further, when reversal of the diet given these two experimental groups was made, similar reversal in the severity of gizzard lesions observed in the resultant day old chicks occurred. In as much as this reversal took place immediately and gizzard lesions were not completely eliminated from the chicks produced by breeders fed the protective diet, it appears that the diet is only partially protective in its nature.

Combining these results with those secured in Problem 13 gives additional assurance that oats do have a protective value against the production of severe gizzard lesions in day old chicks.

GENERAL DISCUSSION OF PROBLEM

Introduction: These studies have revealed that the disease is extremely widespread throughout the country and it appears safe to say that probably 75 percent of all day old chicks hatched are affected. However, under a good feed and management program it seems to have no effect on growth, livability or efficiency of feed consumption. Chickens, turkeys, pigeons, pheasants and quail have been found subject to the disease.

The initial lesion occurs as a minute or large hemorrhage immediately under the lining of the gizzard and is visible on the twentieth day of incubation. With a continued secretory action of the glands within the tunica propria of the gizzard tissue, this hemorrhage is forced outward, made subject to mechanical action of the gizzard and is finally ruptured. The ruptured or eroded area may undergo exfoliation and revert into the commonly seen gizzard erosions or ulcerative areas which are still visible at twelve weeks of age.

Several years ago it was suggested that the cause of origin was due to an absence of a dietary factor, probably vitamin in nature. The work herein reported offers confirmation to this report. It further indicates that an increased blood pressure within the vascular system of the developing chick on or about twenty days of age is the indirect cause of this hemorrhage.

As yet there is no known specific cure for the disease but on the other hand there are certain substances which,

when incorporated within the diet of chicks or of breeding birds producing such chicks, will aid in reducing the severity of lesions present. Fresh and dried greens, wheat and its products, oats, cartilage and associated bile compounds all appear to have some protective value.

Methods of treatment by the use of copper sulphate have not been found effective.

Although initially thought to be of a serious threat to the well being of growing chickens, evidence has been accumulated that it is of very little economic importance.

Origin and Cause: Lansing and Miller (1940) have reported that "Hemorrhage, either slight or pronounced, is an immediate cause of gizzard erosions." The writer is in accord with this statement and offers the following additional comment.

As reported in Problem 4 the hemorrhagic lesions occur on the twentieth day of incubation. These hemorrhagic areas are visible as red spots or lines but after hatching, the lesions are observed to be brown in color. This, it is believed, is due to normal oxidative changes. The hemorrhage has ceased, a clot has formed and the original hemoglobin has been oxidized and broken down to the brown pigment, hematohilin.

Since the tubular secretory glands in the tunica propria of the gizzard are continually active new lining is being produced. Thus the clot is continually being forced outward and, subject to mechanical action within the gizzard, will result in a rupture (erosion) in the lining which is eventually healed by the replacement of new lining. If one peels

off the lining over these hemorrhagic areas, in the gizzards of day old chicks, the hemorrhagic clot is also peeled off with the lining and is found immediately underneath. When this procedure is followed with gizzards from older birds having been fed a well balanced diet, it is noticed that eroded areas are based with a new lining. The macroscopic appearance of the tissue immediately beneath the eroded areas is normal and undifferentiated from the adjacent tissue.

Cover (1939) observed that chicks showing gizzard lesions often possessed gall bladders showing marked distension. Following this observation Lansing and Miller (1940) reported the ability to produce a hemorrhagic condition of the gizzard in six adult chickens by ligation of the bile ducts. They suggest biliary dysfunction as a contributing cause of observed gizzard ulceration in chicks.

The writer, working on the hypothesis that occlusion of the bile duct would cause its distension and increased size, proceeded to relate the size or weight of gall bladders of day old chicks to their observed gizzard scores. The results indicated no relationship between size or weight of gall bladder and the severity of gizzard lesion observed.

Some investigators originally attributed the cause of origin as due to a deficiency of Vitamin K. However, in 1937 Almquist and Stokstad indicated its lack of association. In studies by the writer, the coagulation time of blood was found to bear no relation to the severity of observed gizzard lesions in day old chicks, the coagulation time of blood was

quite uniformly rapid but the gizzard scores varied markedly.

In order to determine the cause of hemorrhage, Problems 8, 9 and 10 were instituted. Injections of adrenalin hydrochloride into live embryo containing eggs at sixteen days of incubation resulted in the production of hemorrhages on the eighteenth day. Thus by increasing the blood pressure, hemorrhages within the gizzard alone, could be produced earlier than they normally occur in the disease, and of a similar nature.

The evidence, that blood pressure exerted on the capillaries of the gizzard was a controlling factor, led the writer to investigate the physiological processes occurring on or about the twentieth day of incubation.

Previous to the twentieth day the body cavity of the developing embryo is relatively free of congestion. The lungs are unexpanded, the yolk sac and contents are outside the cavity and a large part of the vascular system is also outside the body in the chorio-allantois and the yolk sac.

Normally on the twentieth day, (1) the yolk sac and its contents are drawn into the body of the chick, (2) the chick forces its beak into the air cell and shortly thereafter the lungs are expanded due to the start of pulmonary respiration, and (3) the blood from the allantoic vessels is withdrawn into the systemic and pulmonary vascular system and the allantoic vessels are cut off.

All three of these factors will tend to cause an increased pressure to be built up within the body cavity and be reflected

in an increased blood pressure.

The results of Problem 9 indicated quite conclusively that the greater the size of yolk taken into the body cavity of the chick the greater would be its effects on the production of hemorrhage in the gizzard. That this is not the sole causative agent for the increase in blood pressure and subsequent gizzard lesion was demonstrated in Problem 10. A group of embryos, which on the twenty-second day of incubation were still alive, had not broken their way into the air cell but did show a complete inclusion of the yolk within the body cavity, were examined. Evidence is presented to show that the inclusion of the yolk, in itself, is not the sole conditioning factor for the occurrence of hemorrhages in the gizzard lining.

Evidence is also presented to show that the establishment of pulmonary respiration without the inclusion of yolk within the body cavity is not the sole conditioning agent. However, with the establishment of pulmonary respiration, the more complete the yolk inclusion, the greater was the chance of hemorrhage.

Undoubtedly, a combination of all three of these changes is necessary for the expression of a full effect on increasing blood pressure. Should the capillary walls in the gizzard be weak, through absence or deficiency in the anti-gizzard erosion factor, this increased pressure may result in the hemorrhage which is apparent on the twentieth day of incubation.

Occurrence: The disease is extremely widespread as in-

dicated by the results of a survey conducted by the writer and reported in Problem 1. Chicks or hatching eggs were secured from twelve states in various regions of the country and from sixty-two different sources. When hatching eggs were received they were immediately incubated and an examination of the gizzards in the resulting chicks was made on the twenty-second day following the initial setting date. The results indicated the disease to be common throughout the territory covered with 74 per cent of the chicks examined - 1737 - showing some stage of the disease. This agrees quite closely with the results reported by Lansing, et al (1939) in their examination of 600 chicks.

The writer has examined, since this original survey, nearly 3000 chicks and embryos as contained in experimental lots of variable numbers from 5 to 50. Although a considerable variation in the incidence of gizzard lesions was apparent not one of the lots examined was found free of the disease.

Treatment and Cure: The writer wishes to state at the outset that there is, as yet, no known specific cure for the disease. From the standpoint of practical treatment, in the field, many poultrymen have made use of copper sulphate dissolved in the drinking water or as a dry powder mixed in the mash. The work of the writer, as reported in Problem 12, indicates that the effectiveness of either of these treatments, in addition to the feeding of a well balanced diet, is questionable. The untreated chicks grew just as favor-

ably as did the treated ones and at the end of the three week trial showed a lower gizzard score. It appears doubtful that this method of treatment is of any value. Almquist and Keechi (1941) have also reported copper sulphate as ineffective.

Under a good feed and management program there appears to be no definite relationship between the incidence of gizzard lesions in chicks as day olds and subsequent growth, livability, and efficiency of feed utilization of these chicks to 12 weeks of age.

The method of incubation bears no relation to the occurrence of gizzard lesions in day old chicks.

The light ration received by breeding birds has little or no influence on the incidence of gizzard lesions observed in their offspring.

A large number of substances and common feed ingredients have been reported to have protective value in the treatment of gizzard erosions in the growing chicks. These include whole bile, commercial dried bile tablets, vacuum concentrated whole beef bile, cholic acid, deoxycholic acid, sodium glycocholate, sodium taurocholate, fresh and dried greens, wheat bran, oats, wheat, cartilage, lung and other miscellaneous substances. Cholesterol, phytosterol, alpha tocopherol, phytol, glucuronic acid, gum arabic, agar, choline, creatine, aloin, mucin powder, linoleic acid, dried stomach lining, butter, whole milk powder, yellow corn and others have been reported as being ineffective.

As reported in Problems 13 and 18, the writer confirms the reported protective values of oats and sodium glycocholate when fed to growing chicks. Evidence is also presented to show that the incidence of gizzard lesions in day old chicks can be reduced by feeding the breeding birds a diet composed largely of oats in contrast to one containing a relatively large quantity of yellow corn meal. The fortified diet as used in Problem 14 contained several ingredients which have been reported as being "protective", whereas the diet fed to Group 2 was purposely made "non-protective." The results of the gizzard examinations on the resultant chicks are presented in Figure 11 and indicate that though "protective," the diet did not completely eliminate the incidence of gizzard lesions. The severity of existent lesions could be reduced by dietary control and this would lend support to the statement of Almquist and Stokstad (1936) that gizzard erosion "is a separate deficiency disease."

CONCLUSIONS

1 - Under a good feed and management program there appears to be no definite relationship between incidence of gizzard lesions in chicks 6 day olds and subsequent growth, livability and efficiency of feed utilization of these chicks to 12 weeks of age.

- Furthermore, under such a system of feeding and management growth, livability and efficiency of feed utilization will remain normal.

- There is an apparent wide variation in the severity of gizzard lesions in day old chicks produced in different hatcheries but in no case was any hatchery found to produce chicks free from this disease.

4 - The disease is widespread throughout the country as evidenced by a survey of 37 lots of chicks from different regions of the United States involving 1757 day old chicks which showed 7% per cent affected.

- The locality of origin of the chicks examined does not appear to be closely related to gizzard score.

6 - The use of copper sulphate, either as a dry powder mixed with the mash or as a solution mixed with the drinking water, is ineffective in the treatment of gizzard ulceration.

7 - Pheasants and quail chicks were found to be subject to the disease.

- The method of incubation, artificial versus natural, bears no relation to the occurrence of gizzard-lesions

in day old chicks.

9 - The ingestion of beach sand up to an amount of 20.0 per cent by weight of the total feed consumed is not harmful to subsequent growth and livability of chicks up to six weeks of age.

10 - There is apparently no definite relation between the ingestion of sand up to 20.0 per cent of the total feed consumed and the severity of observed gizzard lesions.

11 - The light ration received by breeding birds has little or no influence on the incidence of gizzard lesions observed in their resulting offspring.

12 - The coagulation time of the blood from chicks affected with gizzard lesions is normal and is not related to the severity of observed lesions.

13 - There appears to be no relation between the size or weight of gall bladders in day old chicks and the severity of gizzard lesion observed.

14 - The initial lesion occurs as a minute or large hemorrhage immediately under the lining of the gizzard and is visible on the twentieth day of incubation.

15 - Increasing the blood pressure of 16 day old embryos through injections of adrenaline will cause the formation of hemorrhages in the gizzard capillaries on the eighteenth day and result in a lesion similar to those observed "normally" on the twentieth day.

16 - Yolk also as taken into the body cavity of the developing chick is a contributing factor in increasing the

severity of gizzard lesions in day old chicks.

17 - The establishment of pulmonary circulation, respiration and the inclusion of the yolk sac and its contents into the body cavity of the developing embryo appear to be cumulative in their effect upon blood pressure and related to the severity and occurrence of gizzard lesions in day old chicks.

18 - A well balanced diet containing oats, alfalfa leaf meal, wheat products and certain other feed ingredients reported to have "protective" value when fed to growing chicks will aid in the cure and reduction of gizzard lesion severity as contrasted with a poorly balanced diet composed largely of the "non-protective" foods, such as corn, milk and soybean oil meal.

19 - Confirmation is given to the reported "protective" values of oats and sodium glycocholate when fed to growing chicks.

20 - It is possible to reduce the severity of gizzard lesions in day old chicks by an adjustment of the diet fed to breeding birds

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DESCRIPTION OF PLATE ONE

#1 - Normal

#2 - Slight erosion and hemorrhagic area in lower left corner

#3 - Slight hemorrhage in lower right corner

#4 - Definite erosion in upper left corner

#5 - Severe hemorrhage and two crater lesions in lower right

#6 - Large crater lesion in upper right, small erosions below

#7 - Severe hemorrhage in lower right corner

#8 - Crater lesions upper left, hemorrhagic area lower right

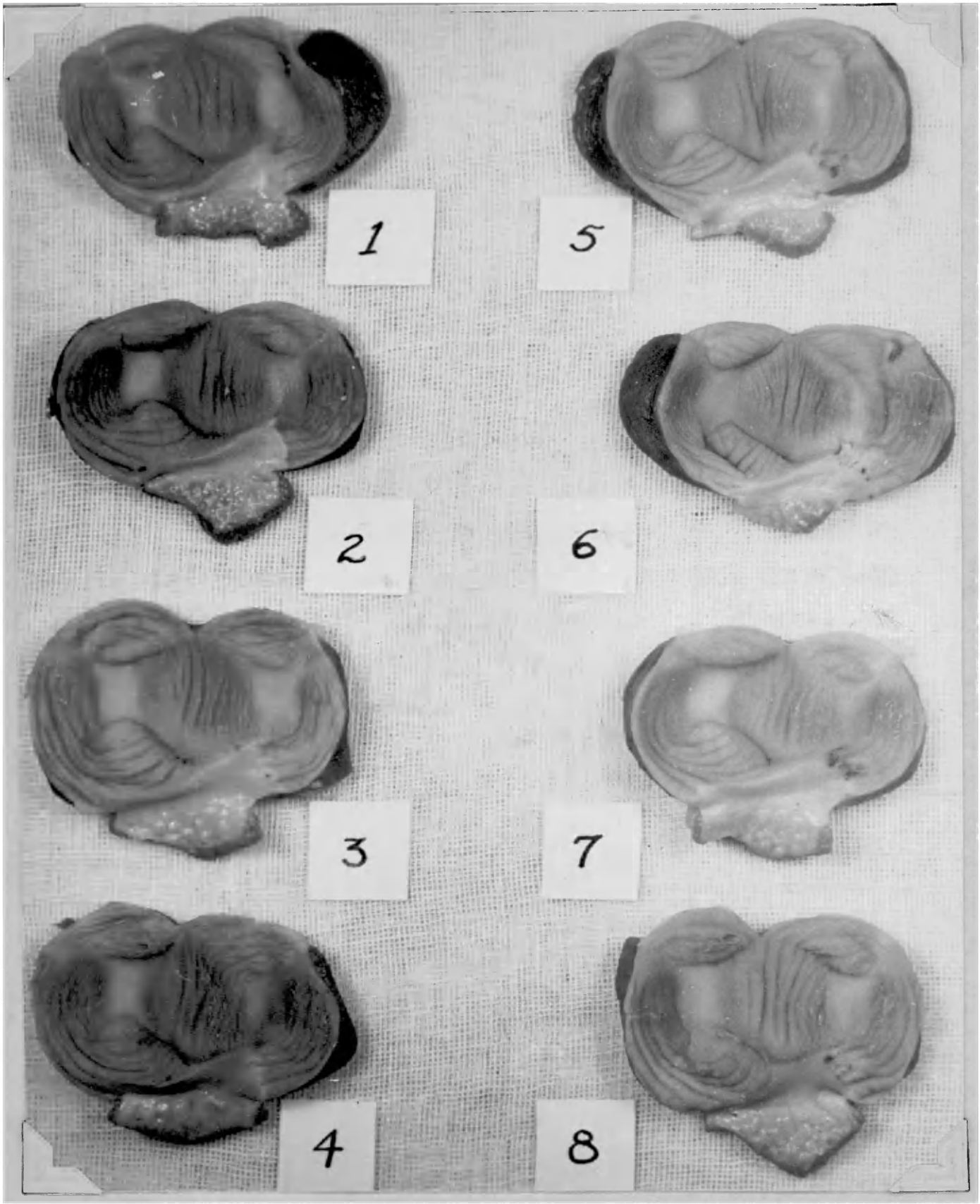

Plate One - Variable Degrees of Observed Dietary Lesions.

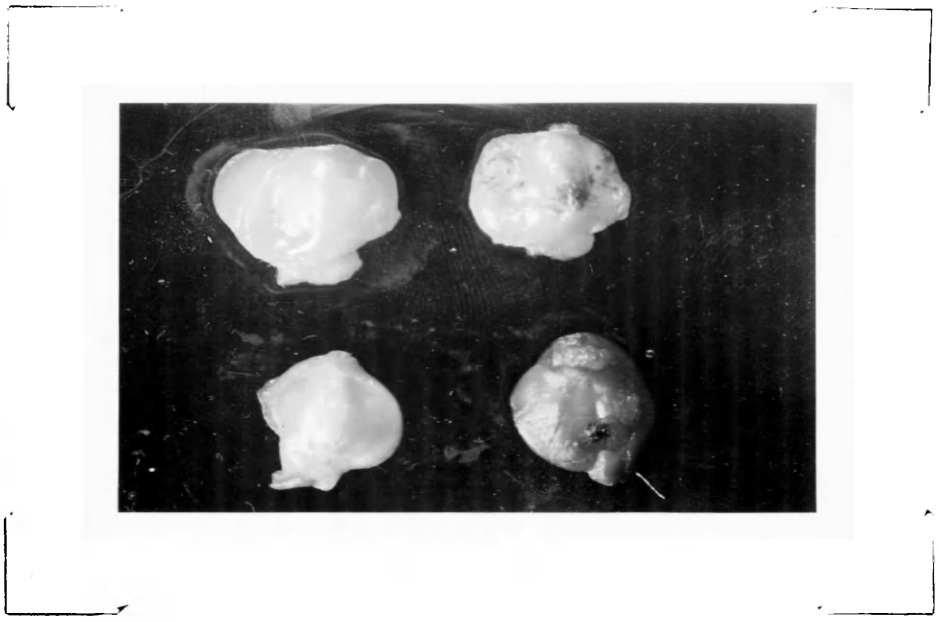

Plate Two - Hemorrhages Produced in the Blastoderm through the Injection of Adrenalin into Eggs at 48 Days of Incubation

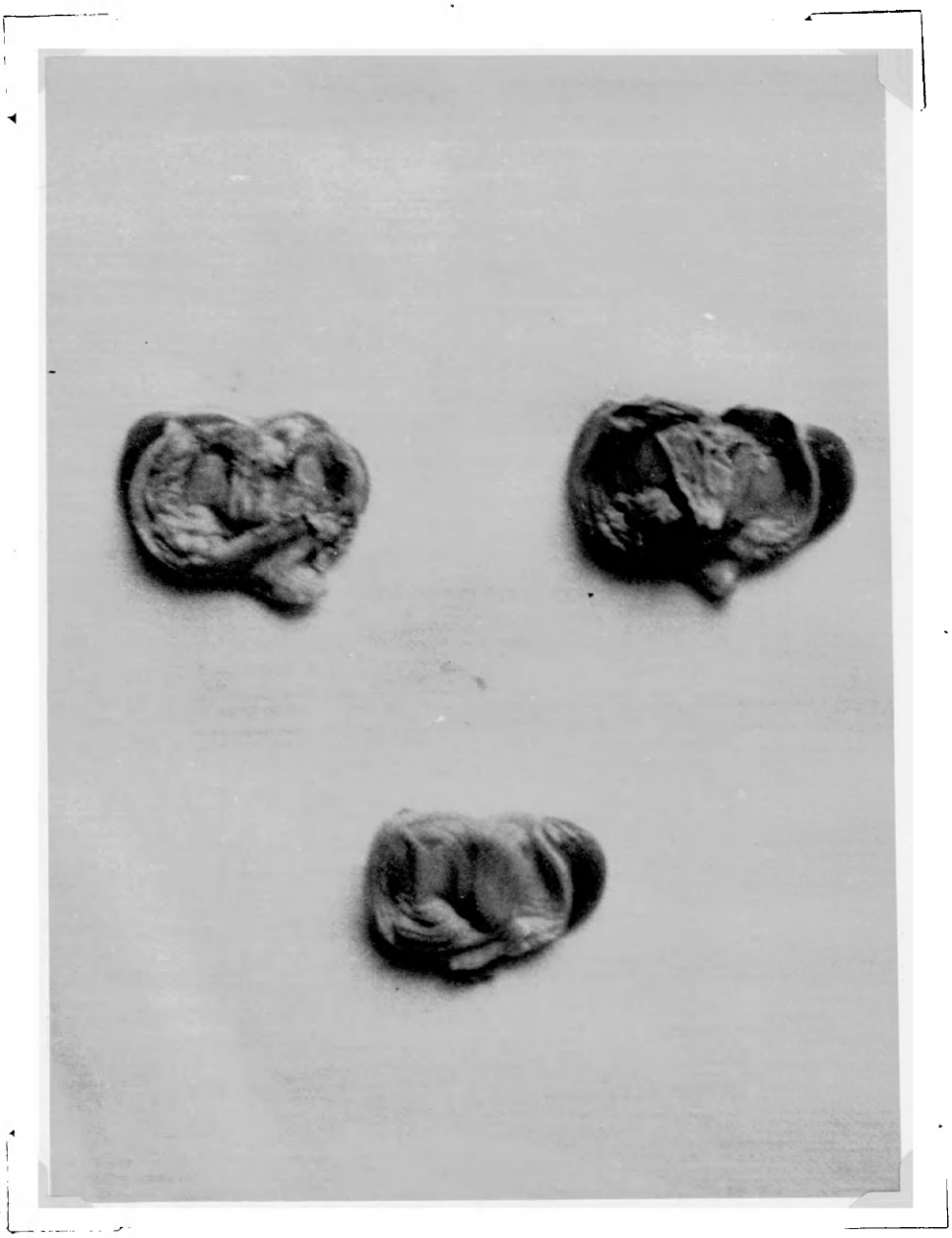

Plate Three - Severe Exfoliation of Gizzard Lining