THE RATE OF PASSAGE OF FOOD THROUGH THE DIGESTIVE TRACT OF THE HEN[1]

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REVIEW OF LITERATURE

The earliest recorded attempt to determine the time required for food to pass through the gastrointestinal tract of hens or other birds is probably that of Weiske, reported in 1878 (*9*).[2] After Weiske had fed 2 geese on dandelion leaves for 8 days, he abruptly changed the ration to barley grains, and within 3 hours and 25 minutes he found the barley grains in the excrement of the birds, swollen but otherwise little altered in appearance. Within 3 hours more, that is, about 6½ hours after the feed was changed, he observed that the excrement consisted entirely of residues of the barley with no green feed. After the geese had been fed grain only for several days, this ration was discontinued and green feed only was given. The green feed first appeared in the feces of one bird after 1 hour and 40 minutes and in that of the other after 1 hour and 45 minutes. After 3 hours and 30 minutes the excrement of both birds consisted almost exclusively of residues of the green feed, with only scattered bits of the barley kernels.

Recently a few rather extended efforts have been made to gather digestion data on poultry by methods similar to those used with human beings. T. G. Browne (*2*) determined the time required for food to traverse the tract of hens by a study of the droppings. In his early experiments he used small colored seeds, such as those of red millet and clover, but these he found unsuitable because of the difficulty of identifying them in the feces. Bread dough colored with magenta, aluminum powder, gentian violet, or methylene blue was tried; but the fluids of the digestive tract seemed to take the stain and carry it forward faster than the solids passed, thus staining everything on the way and leaving the original material behind. It was found, however, that fluids pass more rapidly through the canal than solids and that the rate of the passage varies directly with the quantity of fluid consumed. White and black oats were finally used and were found to be easily distinguishable in the feces. According to Browne's report, oats fed when the crop is empty appear in the feces within 5 to 6 hours, the time varying usually not more than an hour. The crop filled with oats empties within 18 to 20 hours. An entire meal of oats is passed within 27 to 28 hours. In two experiments in which birds were killed 20 and 10 minutes after they had begun to eat oats, a few oat grains were found in the gizzard. Retention of feed in the crop varies with the amount consumed, the more fluid portions passing out first. Liquids do not pass entirely through at once, although some portion passes immediately into the intestine. Liquids are not retained in the gizzard.

[1] Received for publication Jan. 11, 1927; issued June, 1927.
[2] Reference is made by number (italic) to "Literature cited," p. 770.

Kaupp and Ivey (*4, p. 10; 5*) used practically the method discarded by Browne. A mash colored by lampblack or a dye was fed, and the time at which the stain was last seen, together with that at which it first appeared in the droppings, was noted. Neither methylene blue nor gentian violet was found to be satisfactory, because these dyes seemed to cause constipation, which was followed by diarrhea. Lampblack gave more satisfactory results. From the averages of their results on two to six birds of each kind, the writers summarize their observations as follows:

> Digestive processes of the fowl are rapid. The greatest rapidity is shown in the laying and in the growing fowl, food passing on an average of 3 hours and 52 minutes in the case of growing fowls and 3 hours and 46 minutes in the cases of the laying hens. Next in activity comes the adult hen not in laying condition, averaging 8 hours, and then the broody hen required an average of 11 hours and 44 minutes.

The valuable bulletin of E. W. Brown on the subject of digestion in poultry (*1*) gives some data on the retention of food in the crop, which may be summarized as follows: 30 gm. of corn fed in the morning into the empty crops of each of two fowls weighing 3 pounds, 5 ounces had entirely passed into the gizzard within 11 hours and 30 minutes and 12 hours and 15 minutes; the same quantity of corn fed the following morning had passed into the gizzard within 13 hours, and 13 hours and 30 minutes; 35 gm. fed at night had entirely disappeared within 15 hours, and 15 hours and 30 minutes; 50 gm. fed at 2 p. m. disappeared in 24 hours, 15 minutes and 24 hours, 25 minutes. These observations are said to be typical of a large number made with several fowls. The period of retention of oats in the crop was essentially similar. The figures indicate that larger amounts of feed require a longer time to leave the crop and individual birds of equal weight show slight variations.

Schwarz and Teller (*7*) tested the retention of feed in the crop, using eight hens and feeding to them four different grains, namely, wheat, barley, maize, and oats. Before the experiments began the hens were allowed to fast for 24 hours. Thirty grams of the grain was then fed to them and no other feed was given during the experiment, though water was always at hand. The presence of grain in the crop was determined by palpation. At first the palpation test was tried once an hour, but after the fifth time once a half-hour. The time that the feed remained in the crop varied greatly between different individuals and even between different tests on the same bird; but in general when 30 gm. of grain was fed the crop emptied itself in about 11 to 12 hours. The average length of time for the four grains was: Wheat, 11 hours; barley, 10 hours, 50 minutes; maize, 11 hours, 50 minutes; and oats, 12 hours, 20 minutes. The actual variation observed was from 5 to 15 hours. So wide a variation in the individual figures detracts from the significance of the averages. While grain is in the crop it absorbs moisture and swells. The effect of this absorption was studied by removing wheat grains from the crop at the end of 4, 6, and 8 hours and comparing their weight with that of similar grains which had not been ingested. The gain in weight of wheat staying in the crop for 4 hours was 11.43 per cent; of that staying 6 hours, 32.69 per cent; and of that staying 8 hours, 36.71 per cent.

Quite recently Steinmetzer (*8*) has reported observations with Röntgen-ray apparatus. Uniform pellets were prepared from a

definite weight of the feed (groats) mixed with an equal weight of barium sulphate and a little water, the barium sulphate allowing the position of the feed at any time to be seen and to be photographed. The hens fasted for 24 hours before the experiments. At the time of the introduction of the pellets and immediately following, observations were made under the rays at first once in 5 minutes, then once in a quarter of an hour, and finally once an hour. Both the crop and the gizzard were visible when empty and their movements in response to the feeds could be watched. As the pills were dropped in, some of them slipped directly past the crop into the gizzard, though the majority remained in the crop for a time. All stopped for about 0.5 to 1 minute at about 1 to 2 finger-widths from the shadow of the gizzard and then slipped into the gizzard. This pause evidently indicated a short stop in the glandular stomach. In general, the passage of the feed from part to part was, in this case, quite rapid, as is shown by the following average figures of the intervals after feeding at which the food appeared in and disappeared from the segments.

Segment	Interval after feeding	
	First appearance of the food	Final disappearance of the food
Crop	0	2 hours.
Gizzard	0.5–1.0 minute	2 hours 15 minutes.
Small intestine	15 minutes	3 hours.
Large intestine	2 hours	4 hours.

The author thus summarizes his conclusions (*8, p. 505*):

> The passage of the food through the gastrointestinal canal of the cock is normally exceedingly rapid; in the case of the food used in our experiments in pill form, in 4 hours. The feed remains in the crop, the gizzard, and the large intestine for equal intervals of time (in our experiments an average of 2 hours), in the small intestine about half as much longer (in our experiments an average of 3 hours). The gizzard is without movement when it is in an empty condition, but begins rhythmic movements as soon as food passes to it. The glandular stomach was always found to be empty except for the short moments when from time to time portions of the food passed through it (0.5 to 1 minute). The behavior of the crop was peculiar. Although the attempt was made in all the experiments, no rule could be discovered as to when the pill would fall into the crop and when not.

Data obtained with these small amounts of treated feed in pill form are instructive, though they can not be applied directly to the conditions of practical feeding. One experimental series with twice the amount of feed gave about twice as long intervals.

In connection with a careful study of the movement and digestion of starch broth in the different parts of the digestive tract of pigeons, Mangold (*6*) noted that in the cloaca and throughout the length of the intestine, indigestible hulls of grain were always to be found, together with small stones from the gizzard, even after the pigeons had been fed only starch broth for 3 to 6 days. This fact indicates that such indigestible pieces may remain for a long time in the gizzard even in large amounts, to be passed later into the intestine.

In the experiments to be reported here, a study was made of the dry weight and the moisture content of the material found in the different segments of the digestive tract of hens at various intervals

after the ingestion of three types of feed in common use, namely, whole corn, ground corn, and ground corn combined with a protein concentrate.

PLAN OF THE EXPERIMENTS

After a fast of 60 hours, during which time water was accessible but not food or grit, hens were individually fed 50 gm. of the feed to be observed and were then kept in separate cages, without access to food, for different intervals of time. Any feed remaining uneaten after 30 minutes was force fed. In the first experiment water was kept before the birds after the feeding. In the second experiment 75 c. c. of water was given to each bird in connection with the feeding, 50 c. c. being mixed with the ground feeds and the rest being introduced into the crop by means of a pipette. For the whole-corn group, 75 c. c. of water was introduced by pipette after the feeding of the corn. At the end of the desired time the birds were killed, the digestive tracts immediately removed—care being taken not to disturb the contents—and the contents of the several segments placed in weighed evaporating dishes and weighed as promptly as possible. The sections selected were: (1) Crop and tubes down to the proventriculus, (2) gizzard and proventriculus, (3) small intestine from gizzard to caeca, (4) caeca, and (5) large intestine including cloaca. In the first experiment (4) and (5) were combined. The excreta were also collected, dried, and weighed.

The contents of each segment were dried at 105° C. and the moisture determined. To insure greater accuracy in finding the weight of the feed in the gizzard, the whole material from the gizzard was incinerated in the muffle and the stones were separated as completely as possible from the ash and their weight was taken as the weight of the grit. The dry weight of the contents minus the weight of the grit is given as the dry weight of feed in the gizzard.

RATE OF PASSAGE OF FOOD AS INDICATED BY THE WEIGHT OF DRY MATTER IN SEGMENTS OF THE DIGESTIVE TRACT AT VARIOUS INTERVALS AFTER FEEDING

EXPERIMENT 1: WHOLE CORN

In the first experiment 50 gm. of whole corn was fed to each hen and the birds were killed at intervals of 1, 2, 4, 7, 12, 15, 24, and 48 hours afterward and examined. For comparison, another hen was killed and examined in the same way after a fast of 60 hours following the usual green feeds. The weights of dry matter found are given in Table 1.

The data indicate that the corn left the crop rather rapidly at first and then more slowly while gizzard digestion was going on, more than 12 hours being required for it to pass entirely from the crop. In the hen which was killed at the end of one hour three corn kernels were found which had not yet reached the crop. From the data in Table 1 it seemed that by the end of 15 hours the amount of dry material in the crop, gizzard, and large intestine had returned approximately to a fasting level. The amount in the small intestine showed no regular change. The average amount in the small intestine was 3.87 gm. and in the large intestine, 1.36 gm.

TABLE 1.—*Weight of dry matter in sections of the digestive tract and in the excreta of hens fed whole corn; experiment 1*

Hours after feeding	Weight in grams of contents of—					Weight of feces (grams)	Remarks
	Crop	Gizzard		Small intestine	Caeca and large intestine		
		Dry matter	Dry matter not grit				
1	37.66	16.84	8.54	3.50	1.26	0	Much whole corn in tubes, as well as crop; 6 whole kernels in gizzard.
2	34.88	22.31	9.18	4.84	1.49	0	1 whole kernel in gizzard.
4	29.21	16.41	6.14	4.14	2.13	2.81	Much water in crop; 1 whole kernel in gizzard.
7	19.25	24.21	12.81	4.49	2.50	4.07	4 whole kernels in gizzard.
12	22.21	31.77	10.38	2.92	1.26	4.54	25 whole kernels in gizzard.
15	1.87	16.60	6.72	4.97	1.36	6.88	Crop showed only secretion; no whole kernels in gizzard.
24	.04	15.93	5.14	2.88	.84	11.99	No appearance of corn anywhere.
48	.03	12.79	5.84	2.52	1.15	18.24	No appearance of corn.
60 (control)	.45	18.25	9.94	4.56	.29		Straw in crop; grass in gizzard.
Average				3.87	1.36		

EXPERIMENT 2: WHOLE CORN, GROUND CORN, AND GROUND CORN PLUS TANKAGE

In Experiment 2 the hens were fed whole corn, ground corn, and a mixture of ground corn and tankage in the proportion of 4 to 1. The experiment was carried out as before with the exception of the intervals allowed after feeding and before killing the birds. In order to obtain more complete information on the later periods of digestion without multiplication of birds, it was decided to obtain data for the time at which the last of the feed left the crop and at intervals of 1, 2, 3, and 4 hours thereafter. The time at which the crop emptied was judged by external manipulation, and the hens were killed accordingly. This method of estimating the condition of the crop did not prove satisfactory for the kind of study desired. Hence the data will be considered entirely with regard to the interval after feeding and without regard to the time after the crop appeared to be empty. The weights of dry matter obtained in experiment 2, arranged on that basis, are given in Table 2.

In a consideration of this larger collection of data, the great irregularity in the results is at first most striking. Wide variations among the individual birds occur which can not be attributed to the difference in the intervals which elapsed after feeding. For instance, one bird of the whole-corn group had 34 kernels (small ones) in the crop after 23 hours, and one of the ground-corn group had 5 gm. of dry matter in the crop at the end of 35 hours. This last amount is nearly the same as was found in a hen of the same group after 12 hours. One factor which partly explains the irregularities and at the same time complicates the interpretation of the data is the uncertainty as to the amounts of the secretions present. When a crop contains nothing but its own secretions it may show nearly 2 gm. of dry matter. We have no means of judging the quantity of secretion present in the other sections of the digestive tract. After the longer periods of digestion the secretions probably make up larger proportions of both the dry matter and the moisture present.

TABLE 2.—*Weight of dry matter in sections of the digestive tract and in the excreta of hens fed whole corn, ground corn, and ground corn and tankage; experiment 2*

WHOLE CORN

Hours after feeding	Weight in grams of contents of—						Weight of feces (grams)	Remarks
	Crop	Gizzard		Small intestine	Caeca	Large intestine		
		Dry matter	Dry matter not grit					
11.3	0.56	8.42	7.85	4.04	.....	[a] [b] 0.65	3.05	Crop 2 whole kernels. Gizzard 15 whole kernels.
12.8	.45	11.41	6.10	3.91	1.21	.43	6.00	Crop 1 whole kernel. Gizzard 3 whole kernels.
15.4	.....	7.02	[b] .24	1.64	.63	.39	5.27	Crop 1 whole kernel. Gizzard no whole kernels.
19.7	.91	9.74	6.84	2.57	.63	.89	4.22	Crop no whole kernels. Gizzard no whole kernels.
20.2	.76	19.02	8.19	2.09	.18	.26	6.01	Crop 1 whole kernel. Gizzard 5 whole kernels.
21.1	.....	10.03	4.94	2.05	[c]	.23	4.94	Crop no whole kernels. Gizzard 2 whole kernels.
21.1	.....	13.22	3.39	1.37	.78	.20	4.28	Crop no whole kernels. Gizzard no whole kernels.
23.3	7.08	16.54	4.87	2.40	.73	.19	3.77	Crop 34 whole kernels. Gizzard 2 whole kernels.
Average	.....	.....	6.03	2.51	.69	.37	.....	

GROUND CORN

11.8	4.33	8.98	6.23	5.08	0.59	0.57	3.06
13.5	3.73	20.60	5.46	3.53	1.66	1.03	7.87
15.0	2.72	10.28	4.84	2.17	.66	.25	4.05
16.1	14.14	12.64	4.78	3.34	.78	.89	1.54
18.5	.63	11.88	5.33	2.52	.38	.14	5.38
34.8	4.97	16.82	7.91	3.35	.71	.90	7.04
Average	.....	.....	5.76	3.33	.80	.63	.....

GROUND CORN AND TANKAGE

11.6	2.71	13.72	6.64	5.53	0.34	0.38	5.87
13.2	2.58	17.72	5.53	4.23	.33	[c]	5.47
19.4	.39	15.48	7.36	3.86	.77	.74	.99
20.5	1.25	10.12	4.86	2.26	.68	.48	7.12
23.2	.23	20.20	5.36	1.97	.51	[c]	4.90
24.2	.86	9.82	6.17	2.24	.34	.67	6.24
25.1	.37	15.40	5.90	4.45	1.00	1.22	3.90
26.1	.90	10.66	3.58	3.84	.39	[c]	4.71
Average	.....	.....	5.68	3.55	.55	.70	.....

[a] Large intestine + caeca. [b] Not included in the average. [c] Lost.

Some interesting and significant facts are brought out if we consider not individual birds but the conditions found during periods of several hours each. In Tables 3 and 4 the data of experiments 1 and 2, respectively, have been arranged to permit of such a study. The periods selected are those covered by the hours 1 to 4 (experiment 1), 5 to 10 (experiment 1), 11 to 14 (experiments 1 and 2), 15 to 21 (experiments 1 and 2), 22 to 28 (experiments 1 and 2), and more than 30 (experiments 1 and 2).

TABLE 3.—*Average weight of dry matter in sections of the digestive tract of the hens during successive periods after feeding; feed, whole corn; experiment 1*

Hours after feeding	Weight in grams of contents of—			
	Crop	Gizzard	Small intestine	Caeca and large intestine
1–4 [a]	33.9	8.0	4.2	1.6
7	19.3	12.8	4.5	2.5
12	22.2	10.4	2.9	1.3
15	1.9	6.7	5.0	1.4
24	.04	5.1	2.9	.8
48	.03	5.8	2.5	1.1
60 (control)	.5	9.9	4.6	.3

[a] 3 birds; in each of the other cases, 1 bird.

TABLE 4.—*Average weight of dry matter in section of the digestive tract of hens during successive periods after feeding; feed, whole corn, ground corn, and ground corn and tankage; experiment 2*

Hours after feeding	Weight in grams of contents of—														
	Crop			Gizzard			Small intestine			Caeca			Large intestine		
	Whole corn	Ground corn	Corn and tankage	Whole corn	Ground corn	Corn and tankage	Whole corn	Ground corn	Corn and tankage	Whole corn	Ground corn	Corn and tankage	Whole corn	Ground corn	Corn and tankage
11–14	[a] 0.5	[a] 4.0	[a] 2.6	[a] 7.0	[a] 5.8	[a] 6.1	[a] 4.0	[a] 4.3	[a] 4.9	[b] 1.2	[a] 1.1	[a] 0.3	[b] 0.4	[a] 0.8	[b] 0.4
15–21	[a] .8	[c] 5.8	[a] .8	[d] 4.7	[c] 5.0	[a] 6.1	[d] 1.9	[c] 2.7	[a] 3.0	[e] .6	[e] .6	[a] .7	[d] .4	[c] .6	[a] .4
22–28	[b] 7.1		[e] .6	[b] 4.9		[c] 5.3	[b] 2.4		[e] 3.1	[b] .7		[e] .6	[b] .2		[a] .9
35		[b] 5.0			[b] 7.9			[b] 3.4			[b] .7			[b] .9	

[a] 2 birds. [b] 1 bird. [c] 3 birds. [d] 5 birds. [e] 4 birds.

From a consideration of these tables, representing the two experiments, the following conclusions seem to be justified:

Crop. All whole corn leaves the crop by the end of 12 to 15 hours. Ground corn leaves the crop more gradually, with the result that when ground corn is fed a much longer time is required for the crop to become empty. Ground corn and tankage mixed in the ratio of 4 to 1 leave the crop more slowly than whole corn but more rapidly than ground corn alone.

Gizzard. The amount of dry matter in the gizzard in addition to the grit is larger when there is feed in the crop than when there is none, but otherwise it does not vary greatly. Nor does it vary with the three types of feed used.

Small intestine. The amount of dry matter in the small intestine is the same for the three feeds, and is somewhat higher during the first 15 hours after feeding than it is later.

Large intestine and caeca. The amount of dry matter in the large intestine and the caeca probably does not change very much during digestion, though it may rise somewhat 5 to 10 hours after feeding. (See Table 1.) The figure for the control hen of experiment 1 indicates that it may fall markedly during a prolonged fast.

MOISTURE IN THE DIGESTIVE TRACT OF HENS

The data collected reveal some interesting facts with regard to the degree of moisture present in the different sections of the digestive tract of the hen. Table 5 shows the percentages of moisture found in experiment 1 and Table 6 those found in experiment 2.

TABLE 5.—*Percentage of moisture in the contents of sections of the digestive tract of hens fed whole corn; experiment 1*

Hours after feeding	Percentage of moisture in the contents of—			
	Crop	Gizzard	Small intestine	Caeca and large intestine
1	23.2	43.9	84.7	77.7
2	17.9	35.9	86.4	83.1
4	49.9	36.8	85.0	82.4
7	38.7	47.8	83.2	79.6
12	20.6	32.4	85.1	80.9
15	52.8	46.1	82.0	81.9
24	95.1	34.5	82.5	92.9
48	95.0	44.7	83.9	86.7
60 (control)	74.5	47.7	76.8	76.1
Average		41.1	83.3	82.4

TABLE 6.—*Percentage of moisture in the contents of sections of the digestive tract of hens fed whole corn, ground corn, and ground corn and tankage; experiment 2*

WHOLE CORN

Hours after feeding	Percentage of moisture in the contents of—				
	Crop	Gizzard	Small intestine	Caeca	Large intestine
11.3	69.7	57.3	82.6	[a] 80.2	
12.8	67.6	47.6	82.2	69.0	79.2
15.4		54.6	75.0	80.3	86.2
19.7	80.1	58.2	84.4	79.5	77.7
20.2	88.6	45.4	85.1	77.2	82.6
21.1		43.4	86.8	[b]	80.1
21.1		34.9	82.6	71.1	81.5
23.3	54.4	40.8	84.0	70.9	72.0
Average		47.8	82.8	74.7	79.9

GROUND CORN

11.8	61.4	56.6	82.2	69.7	77.0
13.5	60.2	31.1	83.9	73.2	67.6
15.0	62.3	50.4	82.4	78.5	78.6
16.1	53.5	48.4	80.5	69.5	74.6
18.5	78.5	39.5	83.3	79.9	75.9
34.8	61.5	46.5	85.8	80.5	77.4
Average		45.4	83.0	75.2	75.2

GROUND CORN AND TANKAGE

11.6	67.2	47.0	80.9	78.1	78.7
13.2	74.2	34.4	83.2	76.8	[b]
19.4	68.9	43.4	86.8	80.8	85.0
20.5	65.6	46.4	84.5	71.7	81.2
23.2	91.3	30.9	80.1	80.9	[b]
24.2	74.6	54.9	82.6	79.8	82.1
25.1	77.7	45.3	81.6	77.5	82.6
26.1	74.7	41.7	81.8	82.4	[b]
Average		43.0	82.7	78.5	81.9

[a] Caeca+large intestine; not included in the average.

[b] Lost.

TABLE 7.—*Amount of water in the crop and gizzard, and ratio of moisture to dry matter not grit in gizzard*

Hours after feeding	Water in—		Ratio of moisture to dry matter not grit in gizzard
	Crop (grams)	Gizzard (grams)	
EXPERIMENT 1: WHOLE CORN			
60 (fast)	1.3	16.7	1.7 : 1
1	11.3	13.2	1.6 : 1
2	7.6	12.5	1.4 : 1
4	[a]29.1	9.5	1.6 : 1
7	12.1	22.2	1.7 : 1
12	5.8	15.2	1.5 : 1
15	2.1	14.2	2.1 : 1
24	.8	8.4	1.6 : 1
48	.6	10.3	1.8 : 1
EXPERIMENT 2: WHOLE CORN			
11	1.3	11.3	1.4 : 1
13	.9	10.4	1.7 : 1
15	[a]2.2	8.4	[b]35.1 : 1
20	3.7	13.6	2.0 : 1
20	5.9	15.8	1.9 : 1
21	----	7.7	1.6 : 1
21	----	7.1	2.1 : 1
23	8.5	11.4	2.3 : 1
EXPERIMENT 2: GROUND CORN			
12	6.9	11.7	1.9 : 1
14	5.7	9.3	1.7 : 1
15	4.5	10.5	2.2 : 1
16	16.3	11.9	2.5 : 1
19	2.3	7.8	1.5 : 1
35	8.0	14.6	1.8 : 1
EXPERIMENT 2: GROUND CORN AND TANKAGE			
12	5.6	12.2	1.8 : 1
13	7.4	9.3	1.7 : 1
19	.9	11.9	1.6 : 1
21	2.4	8.8	1.8 : 1
23	2.4	9.0	1.7 : 1
24	2.5	12.0	1.9 : 1
25	1.3	12.7	2.2 : 1
26	2.7	7.6	2.1 : 1

[a] Much visible water. [b] Very little food residue.

The quantity of moisture in the crop is very variable, and in these experiments shows no relation to the type of feed eaten or to the interval after feeding. In experiment 1, where water was kept before the birds all of the time, the amount in the crop may have been affected by the time after drinking. In some cases water was distinctly evident in the crop, either as water drunk or as secretion. In the other sections, aside from the gizzard, the percentage of moisture remained nearly constant. In the gizzard the moisture content was rather variable, though less so than in the crop. An inspection of Tables 5 and 6 shows strikingly that the percentage of moisture in the gizzard is not a reflection of that in the crop. For example, two birds in experiment 1 each showed 48 per cent moisture in the gizzard, but the amount in the crops of the same birds varied as widely as from 75 to 39 per cent; one bird of the corresponding group in

experiment 2 which had 45 per cent moisture in the gizzard, showed 89 per cent in the crop. The same lack of uniformity in moisture content of crop and gizzard is apparent if one considers the actual amount of moisture in these organs instead of the percentages. The amount of moisture in the crop seems to be absolutely independent of its other contents and that in the gizzard is usually about 1.5 to 2 times the amount of dry matter not grit present (Table 7).

The percentages of moisture present in the several sections of the digestive tract may be summarized thus: (1) In the crop an indefinitely variable amount; (2) in the gizzard about 30 to 60 per cent (the general average for the four groups was 44.2 per cent); (3) in the small intestine about 82 to 86 per cent (the average in each group was 83 per cent); (4) in the caeca 70 to 80 per cent (the general average for three groups was 76.4 per cent); and (5) in the large intestine 75 to 85 per cent (the general average for three groups was 78.9 per cent). The average percentage in the caeca and large intestine of the hens in experiment 1 was 82.4 per cent. The percentage was remarkably constant in the small intestine. As was to to be expected, the small intestine showed the highest percentage generally and the large intestine next. The moisture content of the caeca was slightly lower than that of the large intestine. The moisture content of the gizzard was distinctly low.

GRIT IN THE GIZZARD OF HENS

E. W. Brown (*1*) undertook a study of the utilization of sand by poultry. Comparisons were made of the SiO_2 consumption and excretion, and in some cases the gravel found in the crop and gizzard was weighed and examined. With free access to gravel the amount of both the ingestion and excretion varied widely with the individual birds and with the type of feed. The values were considerably higher on an oat diet than on a corn diet. Under such conditions the excretion sometimes reached 6 gm. of sand per day; but when no grit was available, the excretion fell to a low figure.

T. G. Browne (*2*), performing experiments in which sand and shot were mixed with the food when the normal amount of grit was otherwise provided, found that this excess sand and shot appeared in the feces in the 5-hour interval usual for food. On the other hand, he found the gizzard rarely if ever free from sand and pebbles even after the birds had been without access to grit for six weeks.

A few observations on the amount of grit in the gizzard were made by Buckner and Martin (*3*) in connection with a study of the formation of bone and egg shell from different mineral sources. After eight months the lot receiving nothing but grain and tankage showed 12.6 gm. of grit in the gizzard.

Kaupp and Ivey (*4*, *5*) made similar observations, reporting grit present in the gizzard even after a year without opportunity for renewal, one hen showing 5.89 gm. of grit after 365 days. The birds still appeared healthy, indicating that the retained grit was sufficient to grind the feed.

All of these observers have found grit constantly present in the gizzard, but in very different quantities. Their work also gives evidence that grit may normally be found in all sections of the digestive tract and in the excreta. It appears, however, that when there is no opportunity for the chicken to pick up grit, whatever is in the gizzard is retained there for a long time.

In the experiments reported here no attempt was made to estimate the amount of grit or sand in any portion of the tract except the gizzard. The probable presence of sand is, however, one of the factors contributing to the complexity of the problem and may explain in part the irregularities of the results obtained. In the gizzard the grit makes up so large and so variable a part of the total dry matter that a rough determination of the amount was made by ashing at low red heat the total contents of the gizzard, sifting out with a 40-mesh sieve the fine powdery ash, and weighing the residue as grit. The weights so obtained are given in Table 8. The birds had all been without access to grit for 60 hours previous to the beginning of the experiment.

TABLE 8.—*Grit content of the gizzard of hens used in experiment 1 and experiment 2*

Experiment 1		Experiment 2					
Whole corn		Whole corn		Ground corn		Corn and tankage	
Hours after feeding	Grit (grams)	Hours after feeding	Grit (grams)	Hours after feeding	Grit (grams)	Hours after feeding	Grit (grams)
60 (fast)	8.31	11	0.57	12	2.75	12	7.08
1	8.30	13	5.31	14	15.14	13	12.19
2	13.13	15	6.78	15	5.44	19	8.12
4	10.27	20	2.90	16	7.86	21	5.26
7	11.40	20	10.83	19	6.55	23	14.84
12	21.38	21	5.09	35	8.91	24	3.65
15	9.88	21	9.83			25	9.50
24	10.80	23	11.67			26	7.08
48	6.95						
Average	11.16		6.62		7.77		8.47

Table 8 shows a rather wide variation in the amount of grit in the gizzards of the hens. In one case there was as little as 0.57 gm. and in another case as much as 21 gm.; but in general the amount ranged from 3 to 15 gm. No connection was observed between the amount of grit present and any other factor or condition.

SUMMARY

Determinations have been made of the amount of dry matter contained in the various segments of the digestive tract of hens at different intervals after the ingestion of 50 gm. of whole corn, ground corn, or a mixture of ground corn and tankage in the ratio of 4 to 1.

The results indicate a wide variability in the rate of passage of the food through the hen. In most cases, however, the whole corn had left the crop by the end of 12 to 15 hours. The ground corn remained in the crop distinctly longer than the whole corn and somewhat longer than the mixture of corn and tankage. The amount of dry matter in the other sections of the digestive tract did not differ notably for the three kinds of feed used. The amount of dry matter in the gizzard in addition to the grit was larger while food remained in the crop than later, and to a less extent the same was true of the small intestine. Otherwise the amount of dry matter in the intestines was fairly constant.

The percentage of moisture in the contents of the crop showed a wide variation, apparently independent of the kind of feed eaten and of the time after feeding. The percentage of moisture within the gizzard was low and rather variable, being about 30 to 60 per cent, with an average of 44.2 per cent. The amount was not a reflection of the amount in the crop, but was usually about one and one-half to two times that of the dry matter not grit present. The percentage of moisture within the small intestine was high and remarkably constant at about 82 to 86 per cent, with an average of 83 per cent. That in the caeca was about 70 to 80 per cent of the total contents, with an average of 76.4 per cent; and that in the large intestine was about 75 to 85 per cent, with an average of 78.9 per cent.

The amount of grit found in the gizzard varied widely, the usual range being from 3 to 15 gm. No connection was observed between the quantity of grit present and any other factor or condition.

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