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SOME OBSERVATIONS ON THE DIGESTIVE SYSTEM OF THE FOWL.

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FOWLS have a very active digestion and, if allowed, will partake of several small meals a day, their appetite appearing to return as soon as there is the least accommodation in the crop for more food. As compared with that of mammals the alimentary canal is relatively short, and the passage of food material through it is relatively rapid ; nevertheless the digestive process is so active, and the assimilative process so rapid, that the co-efficients of digestion of the ordinary foods consumed are little if any below those in other domesticated animals.

The co-efficients of digestion and the chemical changes which the ordinary foods undergo in their passage through the alimentary canal of poultry were studied as far back as the year 1843, and later by Voit, Kalugin, Peterhof, and others, but it was not until 1904 that E. W. Brown undertook this task on anything like an elaborate scale (*U.S.A. Dept. of Agric Bulletin* 56, 1904).

Although much valuable information has since been published in this connection, there is a vast amount of very necessary knowledge to be yet acquired, but along a somewhat different line of investigation, viz., in regard to the functions of certain digestive organs and the passage of foods and fluids along the alimentary tract in these animals. It is true that the digestive process in them is to a large extent similar to that in mammals, especially as far as the functions of the liver, pancreas, and intestine are concerned, but the rôle played in this process by certain other organs, particularly the crop, proventriculus, gizzard and, last but not least, the cæcal tubes, is by no means thoroughly understood. With the object of ascertaining certain facts and thereby arriving at some conclusions in this connection I recently conducted several experiments with fowls.

One of the chief difficulties encountered in the earlier stages of these experiments was to discover some food material which could be recognised in the fæces after having passed through the alimentary canal. Most foods undergo such transformation during digestion that they give no indication whatever of their presence in the fæces.

Several attempts were made with the smaller coloured seeds, such as red millet and red clover seed, but these became altered beyond recognition even in the first part of the intestine. Several experiments were also carried out with dough made from bread and coloured with different colouring agents, viz., magenta, aluminium powder, gentian violet, and methylene blue, but in these cases I came to the conclusion that the fluids in the alimentary canal became stained with these agents and were carried outwards faster than the solids, staining everything on their way and leaving the original coloured food behind. This proved later to be actually the case, for it was found that the time required for the coloured material in these cases to pass through the alimentary canal and appear in the fæces did not coincide with that required by oats in later experiments, the latter requiring a longer period. Furthermore, it was afterwards proved that fluids pass more rapidly through the canal than solids, and that the rate of passage varies directly according to the quantity of fluids consumed.

White and black oats were later used, and it was found that their husks could be easily recognised and distinguished in the fæces, so that they proved suitable for experiments of this kind.

Observations made in the course of experiments with several fowls proved that oats fed to hungry fowls (crop empty) will appear in the fæces five to six hours afterwards. Variations may occur with different fowls and also with the same fowl at different times, but, provided conditions are normal, these variations are so slight as to be almost negligible, rarely exceeding one hour. Quoting from the record of an experiment typical of nine carried out on nine different fowls with similar results: A hen in perfect health had been fed entirely on bread and meal for two days preceding the experiment. At 10 A.M. crop empty; now fed on white oats, which were eaten voluntarily until the crop became moderately full; all food then withheld. At 2 P.M. three droppings containing no oat husks had been passed. At 3 P.M. a fourth dropping containing a few white-oat husks. At 5.30 P.M. two more droppings, both rich in white-oat husks, were found in cage; crop now about half its original size. At 10 P.M. two additional droppings found, both rich in white-oat husks; crop still containing a small quantity of oats. Next morning at 9 A.M. crop perfectly empty; one dropping made during night, also rich in white-oat husks. Now fed on black oats, which were eaten voluntarily till crop became moderately full, when all food was withheld. At 12.30 P.M. two droppings passed since feeding, both containing some white-oat husks. At 1.50 P.M. a third dropping found, containing a mixture of white and black-oat husks. At 3 P.M. a fourth dropping containing black-oat husks only. At 5.30 P.M. another dropping had been passed containing black-oat husks only; crop now about half its full bulk. At 9.30 P.M. one additional dropping found, black-oat husks only; crop still containing a small quantity of oats. Next

morning at 9.15 A.M., crop perfectly empty, and two droppings passed during the night, both containing black-oat husks only. During experiment the hen was allowed free access to water.

As already stated, several experiments had been previously carried out with coloured dough made from bread, and it now transpired that the coloured material in these cases appeared in the faeces in a shorter time than in the case of oat husks.

Quoting from records of two of these experiments, each of which is typical of four carried out with similar results:—

(1) Healthy fowl, crop empty, forcibly fed at 9.30 A.M. on very soft dough, deeply stained with magenta, until crop became moderately full. First magenta-coloured dropping passed at 12.30 P.M.; crop now only slightly smaller than immediately after feeding. The droppings were magenta-stained for thirty hours after feeding, and the crop was empty after twelve hours.

(2) Healthy fowl, crop empty, forcibly fed until crop became moderately full, at 9.30 A.M., on moderately firm dough, containing only a small proportion of fluid and deeply stained with magenta. First magenta-coloured droppings passed at 1.45 P.M. Droppings were magenta-stained for thirty-six hours after feeding, and the crop contained a small quantity of dough after twelve hours.

It may be worthy of note here that fowls are averse to eating any material of a soft doughy nature, always preferring oats or other dry foodstuffs, but in no case of any foodstuff do they eat so ravenously and fill the crop to such a degree as when feeding on grain, particularly oats.

Other experiments were carried out with coloured fluids with a view to ascertain certain facts regarding the rate of the fluids along the alimentary tract:—

(1) Fowl, crop empty, drenched at 9.30 A.M. with 2 ounces of a solution of methylene blue. The fluid could now be felt in the crop, where apparently a large proportion had been retained. At 11.30 A.M. first blue-coloured dropping passed, and crop now somewhat smaller. Crop became empty eight hours after drench. Two other similar experiments carried out with similar results.

(2) Fowl, crop empty, drenched at 9.30 A.M. with 1 ounce of methylene blue solution. First blue-coloured dropping passed between 12.5 and 12.20 P.M. Crop became empty four and a half hours after drench. Three other similar experiments carried out with similar results.

(3) Fowl, small quantity of oats in crop, drenched with 2 ounces methylene blue solution at 3 P.M.; destroyed half an hour afterwards and *post-mortem* examination made. One and a half ounces of blue-coloured fluid in crop, mucous membrane and contents of alimentary canal stained blue as far back as the middle of the intestine. One other similar experiment carried out with similar result.

In reviewing all the above experiments the following deductions may be arrived at:—

(1) The shortest period in which oats will pass through the alimentary canal and appear in the faeces is about five hours, but a portion may be delayed in the crop as long as eighteen to twenty hours.

(2) The crop filled with oats will completely evacuate itself in about eighteen to twenty hours.

(3) An entire meal of oats (crop full) will pass through the alimentary canal in about twenty-seven to twenty-eight hours.

(4) Foods in solution or in a very soft condition will pass through the alimentary canal faster than dry foods, that is, bulk for bulk.

(5) The time required for moderately firm dough made from bread to pass along the alimentary canal and appear in fæces is little, if any, shorter than in the case of oats; but, since fowls do not normally fill the crop with food of this nature to such a degree as when feeding on oats, it seems probable that, bulk for bulk as compared with oats, less of this food would be voluntarily consumed in a given period, in case the animal was confined to feeding on the one or the other.

(6) Fluids pass along the alimentary canal faster than solids, and a portion reaches the intestine very soon, probably almost immediately after being swallowed, while the remainder is retained in the crop to be gradually passed on later.

(7) The rate at which fluids pass along the alimentary tract varies directly according to the quantity consumed.

(8) If a large drench of fluids (2 ounces) be administered, these will usually appear in the fæces after about two hours.

The Mouth and Pharynx.

Speaking generally for the animal kingdom, salivary glands are developed in a degree corresponding to the extent of the changes which the food undergoes in the mouth and the length of time during which it is there detained. The fowl offers no exception to this rule, for true salivary glands are absent, and the food undergoes no mastication in the mouth, being simply hurriedly gulped into the œsophagus. In some birds, however, salivary glands, though usually of a rudimentary type, are present, and in a few they are well developed, as, for example, in the woodpecker, in which the sublingual glands are very large, extending from the angle to the symphysis of the jaw.

On microscopical examination of sections from the wall of the mouth and pharynx of the fowl it is seen that the submucosa is rich in mucous glands, particularly in the roof and floor of the pharynx. The secretion from the pharynx is fairly profuse and is normally swallowed, but when the swallowing ceases immediately after death a small quantity is then seen to collect in the pharynx as a clear slimy fluid. It has no action in converting starch into sugar.

The Œsophagus.

The œsophagus in the fowl is relatively wide and very dilatable, and its wall is very thin. It is capable of such dilation that a sponge larger than a hen's egg can, without difficulty, be passed through it into the crop. Its structure resembles that in mammals, and throughout its length there are mucous glands scattered in its mucous membrane beneath the epithelium. During swallowing the bolus of food passes along it very slowly, and I have frequently

observed that when a fowl is allowed to gulp dry foodstuff, such as bread crumbs, a mass of this material may collect and become lodged some distance down the tube, causing here a swelling in the neck; this may remain for some minutes or even for hours, preventing the bird from feeding during its delay.

The Crop.

The crop in the common fowl, as compared with that in other birds, is well developed. In fruit- and insect-eating birds no such organ is present, while in most of those of the flesh-eating type a somewhat analogous structure is placed in the upper part of the neck below the lower jaw. In the pigeon the crop is remarkable in that it is double, consisting of a pouch on each side of the œsophagus, and its wall is rich in glands which secrete a copious fluid, so that the food in this bird is not only retained here but thoroughly macerated before being passed to the digestive organs proper. In the fowl it is simply a dilatation of the œsophagus, having exactly the same structure and containing only a few mucous glands, similar to those in the œsophagus and most numerous in the neighbourhood of its openings. In reality it is nothing more or less than a reservoir for food, and it plays the same part to the gizzard as a hopper to the mill; it receives the food as it is swallowed and supplies it to the gizzard in small successive quantities as required.

It would appear that a fairly profuse secretion is poured out by the glands in its wall, for a piece of sponge as large as a hen's egg passed into it through the œsophagus becomes saturated with fluid in less than half an hour. But when it is considered that these glands are comparatively few there is little reason to doubt that a large proportion of this fluid has been swallowed from the secretions of the glands of the pharynx, mouth, and œsophagus. This fluid has no action in converting starch into sugar, and apparently only serves to moisten the food and thus facilitate its passage into the proventriculus.

The contents of the crop are always acid in reaction, but this may be accounted for by a certain amount of fermentation which the food may here undergo, although Klug states that he found in this organ traces of acid and pepsin derived from the proventriculus. It is very unlikely, however, that anything in the nature of gastric digestion takes place here, since the food has not yet been subjected to any mastication or grinding process. Furthermore, food which has been detained in the crop for hours never shows any indication whatever of having undergone any digestive change.

If no digestive products are here produced, and since the lining of this organ is of the squamous and stratified type of epithelium, it is only reasonable to assume that the crop does not function as an organ of absorption; in fact there is every reason to believe that little or no material becomes absorbed here. Some authors state that in cases of poisoning by common salt a large proportion of this material becomes absorbed by the crop, but when it is considered that fluids pass to the intestine very rapidly, and that

the toxic symptoms in these cases do not manifest themselves for some hours after the consumption of the salt, there can be no doubt that at least a large proportion of the toxic material is absorbed by the intestine.

The period of retention of food in the crop obviously varies according to the extent to which the crop is filled, and to a lesser extent according to the rate of digestion and the character of the food consumed.

The full crop steadily diminishes in size until it is entirely empty, so that there is evidently a uniform flow of food material from the crop to the gizzard. But in the case of grain or other hard foodstuff it seems probable that the rate of this flow is regulated by the capacity of the gizzard to deal with the material it receives, for the mechanism of the crop is such that if grain and soft food be mixed the latter will pass to the gizzard faster than the former. The contents of the crop are not subjected to any churning or mixing movements, but are simply squeezed and pressed together, with the result that in the case of a meal of mixed food the softer material has a tendency to be expressed from that which is harder and coarser and be thus forced upward toward the point of exit, to leave the crop at a faster rate. It is now apparent that if two or more foods of a meal be of the same consistence and be fed separately, they will not mix to any marked degree in the crop, and will to a large extent pass out of the crop in the order of their arrival; but if the foods be of different consistence, as oats and soft food, the harder and coarser will be the last to leave this organ.

The above conclusions were arrived at as the result of four experiments, a typical one of which is the following. A fowl was fed at 11 A.M. with two separate lots of soft dough made from bread, both richly mixed with oats and one coloured with magenta and the other with aluminium powder. Fowl destroyed at 5 P.M. same day. On *post-mortem* examination it was found that there was no mixing between the two lots of dough, although the greater part of the first consumed had left the crop. The greater part of the oats was still present, but the soft dough had for the most part been expressed from them, and they were placed chiefly towards the dependent part of the crop.

The Stomach.

Gastric digestion in birds differs very considerably from that of mammals, and the differences depend on the difference of plan on which the alimentary tract is constructed. Furthermore, the stomach varies considerably in structure in the different types of birds according as the diet is vegetable or animal. This organ consists of two parts, first the proventriculus, which is analogous to the true stomach in mammals, and second, the gizzard which in vegetable-eating birds acts as a grinding organ. In carnivorous birds the proventriculus is but faintly distinguished from the gizzard, which is comparatively small and whose walls have become thin and membraneous. The gizzard therefore has lost its crushing power in these flesh-eating birds, and may simply be regarded

as a membranous expansion of the proventriculus, free from secreting membrane and bearing close analogy in function with the left portion of the horse's stomach.

Granivorous birds have a small straight proventriculus which looks like a dilatation of the œsophagus and opens behind into the gizzard.

In the common fowl the proventriculus is fusiform in shape, and its wall is very thick owing to the presence in the submucosa of a thick layer of tubular glands which secrete an acid gastric fluid. When, however, the food comes into contact with this secretion it has not yet been crushed or comminuted; consequently it is incapable of being acted on by this fluid, which is powerless to dissolve cellulose membranes. Furthermore, the lumen of this organ is very small, and the food is evidently not delayed here on its course, for in no case did I find any material here, save a small quantity of mucus-like fluid. This secretion therefore evidently passes into the gizzard, or, what is more probable, into the duodenum, before it is allowed to exert its digestive action. An extract from the mucous membrane of this organ does not convert starch into sugar, but when allowed to act on albumen it has a marked digestive action.

The gizzard in the fowl is a highly muscular organ lined by a tough mucous membrane with a horny epithelium, but no true glands are present. Its contents are acid in reaction, and it always contains a quantity of gravel and sand and has for its function the crushing and grinding of food. As a grinding organ it is extraordinarily powerful, being capable of reducing hard grain to a fine state of division in a comparatively short time. It is stated by R. Meade Smith that short iron tubes capable of supporting 535 lbs. are completely flattened after passing through the gizzard of the turkey, but where particles of shot (lead) of various sizes were fed to fowls in my experiments I always found that these passed through the gizzard without undergoing any deformity whatever. The grinding process in this organ is brought about by the action of the muscles of its walls and the friction of its contained sand. It would appear that the motion of the gizzard contents is rotary, for when long pieces of grass or hay are present they are for the most part arranged in a circumferential fashion, and, again, Hunter believed the motion to be of this character as the result of the examination of hair balls derived from the hairs of caterpillars occasionally found in the stomach of cuckoos.

One is made very sensible of the action of the gizzard of the fowl by putting the ear to the side of the animal, especially a short time after oats have been consumed. A distinct grating sound indicative of the movements of particles of sand on one another can be heard, but this sound is not uniform in intensity, becoming more pronounced for two or three seconds at regular short intervals of about thirty seconds. It is here worthy of note that the heart sounds are very apparent and to some extent mask those of the gizzard.

By manipulation of the gizzard through the abdominal wall slight movements of apparent contraction and expansion can be made out, but these are not very apparent, being slow and deliberate

and only occurring at intervals of about thirty seconds, apparently coinciding with the periods of the most pronounced sounds. Tiedmann believed that the movements of the muscles of the gizzard are in some degree voluntary, having observed that when he placed his hand on the abdominal wall opposite this organ the motion suddenly stopped. This, however, I have not been able to verify, the movements apparently occurring at regular intervals irrespective of manipulation.

As already stated, the gizzard contents are acid in reaction, evidently due to the presence of secretion from the proventriculus, but it is most improbable that anything in the nature of gastric digestion takes place here, considering the character of these contents. They are always comparatively dry and coarse, and their dryness is such as to indicate clearly that very little gastric secretion or other fluid is here delayed; again, if this secretion exerts its action here it acts in a very dry medium as compared with gastric juice in mammals.

The sand and pebbles in the gizzard vary in amount, but it appears that they are rarely, if ever, entirely absent, even though the animal may not have had access to sand for a very long time. There is evidently some provision of nature whereby this organ is capable of retaining the necessary quantity for a considerable time in the absence of a further supply. One fowl under my observation was deprived of sand for six weeks, at the end of which period the gizzard contained a fair quantity of small pebbles. E. W. Brown records an experiment in a fowl where sand had been withheld for seven months, after which the gizzard was examined and found to contain ten particles of sand, which, however, appeared worn, having lost their sharpness. The same author also records experiments where fowls were deprived of sand for several months, and it was not until after the fifth month that they showed any signs of debility or deterioration. Although the gizzard has this power of retaining sand for a long time, yet it does not retard the passage through it of an unnecessary supply, for in two experiments (*see* Experiment No. 19 under *Cæcal Tubes*) sand and particles of shot (lead) that had been mixed with the food appeared in the *fæces* in the usual record time (five hours), and none were retained in the crop for an unduly long period. According to Brown, a fowl given free access to sand may pass as much as 6 grams daily in the *fæces*.

It would appear that the sand in the gizzard consists, at least to a large extent, of that which was last consumed, and that this is retained until a further supply takes its place; for in one experiment four small pebbles about the size of wheat grains were fed after being carefully examined, so that they could be afterwards recognised, and three of these were found in the gizzard one week afterwards, the fowl not having been allowed access to sand in the meantime.

The length of time required for any particular particle of food to reach the gizzard will obviously depend on the amount of material already in the crop, but if the latter be empty food will appear in the gizzard in a very short time after being fed, as demonstrated by the fact that in two experiments where the

animals were destroyed, one twenty and the other ten minutes after commencing to feed on oats, a few grains of the latter were found in the gizzard in both cases on *post-mortem* examination.

Fluids are not delayed in the gizzard, but rapidly pass through it to appear in the intestine very soon after being swallowed. (See experiments with coloured fluids, p. 14.)

The Intestine.

The intestines of birds are as a rule relatively to the size of the body shorter than those of mammals. In most birds of prey they are not more than twice the length of the body, but in granivorous birds they are considerably longer.

In the fowl the intestine is about six times the length of the body, and it is almost uniform in calibre and carries villi throughout. Its first 10 inches form a V-shaped loop called the duodenum, which embraces the pancreas. There is no division into large and small intestine, but it is customary to speak of that portion which extends from the openings of the cæcal tubes to the cloaca as the large intestine. This latter portion is straight and about 5 inches long. The bile and the pancreatic juice are poured into the termination of the duodenum, but the duodenal contents are always acid in reaction, doubtless due to the presence of gastric fluid from the proventriculus which has been carried back through the gizzard. Considering these last two facts, viz., that the duodenum undoubtedly contains gastric secretion and that the bile and pancreatic juice are poured into it only at its termination, there appears to be good reason to believe that it is chiefly in this part of the alimentary tract that the gastric juice exerts its digestive action on the newly ground food coming from the gizzard.

The digestive process in the intestine is very rapid but otherwise resembles that in mammals, the liver and pancreas performing the usual functions. This process is a continuous one, the crop acting as a reservoir and keeping up a continuous supply of food, never becoming entirely empty unless the animal is unduly deprived of food. In experiments where the crop was allowed to become empty the intestine soon became almost cleared of its contents, and the passage of fæces very soon ceased.

The Cæcal Tubes.

The cæcal tubes in most birds consist of two comparatively long tubes, which are as a rule well developed in vegetable feeders and which end blindly at their free extremities. They are symmetrically placed, and distinguished as right and left, and their posterior or fixed extremities open into the intestine a comparatively short distance in front of the cloaca. Their development varies in the different types of birds, and in some cases they are entirely absent.

In the fowl and also in the turkey they assume great importance because of the frequency of certain parasitic diseases, such as coccidiosis and worms, in which they are the chief seats of infection, and it is not improbable that they may play an important rôle in certain other infections not yet well understood. Furthermore, in

blackhead in turkeys, according to many authorities, these tubes not only harbour the causal parasites but also act as the primary seat of infection, the parasites first proliferating here and later invading the liver. In the fowl they are about 6 inches in length and are placed close along the side of the intestine, with which they lie in the abdomen in a coiled disposition, and to which each is attached throughout its length by a short mesentery containing blood vessels and nerves. In its posterior half each tube is relatively small, of a contracted appearance, and always devoid of contents, while its anterior half is markedly dilated and relatively thin-walled, and the mucous membrane is here raised into numerous folds. Histologically they closely resemble the intestines, but the glands are less numerous, the villi are very short or absent in the dilated portion, and there is a relatively large amount of lymphoid tissue in the mucous membrane, especially towards the junction of the tubes with the intestine. Their posterior extremities open into the intestine, one on each side, about 5 inches in front of the outer opening of the cloaca. These openings are directed backward, and each will admit an average-sized dog's catheter; overlying each is a small transversely placed fold of mucous membrane whose free edge is directed backward. These folds or valves almost meet above and below in the middle line, so as to form nearly a circular fold in the intestine. In the turkey these openings and valves are quite similar to those in the fowl, but are placed $5\frac{1}{2}$ to 6 inches in front of the outer opening of the cloaca.

On account of this anatomical arrangement it is an easy matter to pass a probe or fine catheter into either tube by directing it along the floor of the cloaca and intestine until five inches of its length have disappeared, when it can be recognised to have entered the opening. It is usually only possible, however, to pass the probe or catheter two or three inches beyond the opening, its progress being then arrested on account of the coiled disposition of the tube. Nevertheless in this way, with the aid of a suitable instrument, it should be possible to aspirate and inject these tubes in the treatment of the different parasitic affections to which they are subject. But a still more simple method of injecting them is to inject about 1 ounce of fluid through the cloaca into the termination of the intestine by the aid of an ordinary human enema syringe, and in this way the fluid is immediately driven along the entire length of the cæca apparently without resistance. The nozzle of the syringe is passed along the floor of the cloaca into the intestine, and it is preferable to inject slowly, using only a moderate pressure. Very often the injected fluid is not allowed to pass forward in the intestine beyond the cæcal openings, the intestine being here distinctly constricted, with the result that the two valves are often capable of entirely occluding its lumen when the fluid is forced forward against them.

Occasionally one or both cæca are found empty, but usually they contain in their dilated portions a certain quantity of material, which varies in character and quantity according to the character and quantity of the contents in the posterior part of the bowel.

When the contents of the large intestine are of their usual semi-solid character the material found in the cæcal tubes is always

homogeneous, pultaceous in consistence, usually of a brownish or chocolate colour, and always free from sand or grit; but if the contents of the large intestine be fluid or semi-fluid, as is often the case, so also are those in the cæca, and, furthermore, these two sets of contents are now so similar in every respect as to be almost indistinguishable. Here again the cæcal contents vary in quantity according as the large intestine is nearly full or empty, apparently increasing in amount as the fluid material in the large intestine increases.

These facts would suggest that the more fluid in character the contents of the large intestine the larger the proportion of these passing through the cæca, and therefore the greater the similarity between the material found in these tubes and that in the large intestine; and again, on the other hand, the more solid in character the contents in the large intestine the smaller the proportion of these passing through the cæca, and thus the more slowly the cæcal contents are formed and therefore the greater the difference in character between the material found in these tubes and that in the large intestine.

As a result of observations in experiments (*see* Nos. 15, 16, 17, 18, under Cæcal Tubes, p. 31) it would appear that this is actually what occurs, for in cases where the cæca were injected with methylene blue through the cloaca and the birds were destroyed after forty-eight hours, or even longer, the blue could be recognised in the cæcal contents only in those which had been previously passing normal semi-solid fæces and in which the cæcal contents were found to be of the characteristic pultaceous type; while in those cases in which the bird had previously been passing semi-fluid fæces, and in which the cæcal contents were found to be of the semi-fluid type, the blue had disappeared from the cæca in a much shorter time, even when the bird was destroyed and an examination made as soon as the passage of blue-coloured material with the fæces had ceased to be recognisable.

These observations indicate that although the cæca may retain fluids for only a short time they do not completely evacuate themselves frequently when they contain a quantity of material of the characteristic pultaceous type and when the contents of the large intestine are of the usual semi-solid character; and, again, they also indicate, on the other hand, that all the contents of these tubes are frequently evacuated and replaced by fresh material when those of the large intestine are of a fluid or semi-fluid nature. If any further proof be necessary that the characteristic pultaceous material usually found in the cæca is here retained for a considerable period, it is that this material is only exceptionally found in the contents of the large intestine or in the fæces. When daily examining all the droppings of individual fowl for weeks I occasionally met with a dropping consisting entirely of material of this nature and differing very markedly from other fæces passed directly before and after. Droppings of this type, however, did not appear at regular intervals, even from the same fowl, sometimes appearing at intervals of two or three days, and at other times at intervals of a week or longer, and it may be noted that the longer the interval the more solid and characteristic the material. The occasional

appearance of this material in the fæces would suggest that the cæca are only capable of evacuating themselves completely when contents of this nature collect in them to a certain extent. When it is considered that, if the contents of the large intestine be of their usual semi-solid character, the cæca do not frequently evacuate themselves completely, and their contents are only occasionally found in the large intestine or in the fæces, it appears quite reasonable to assume that in this case only a small proportion of the intestinal contents passes through them. Furthermore, this assumption is supported by the fact, as indicated in two of the experiments (*see* Nos. 7 and 10 under Cæcal Tubes, pp. 29 and 30), that coloured material may appear in the fæces before it has even entered these tubes. In fact, it was demonstrated by several experiments (*see* especially No. 19, p. 31) that the only type of material allowed to enter the cæca is fluids, so that the less fluid the character of the intestinal contents the smaller the proportion of these contents passing through them, and *vice versa*.

The question now arises as to how the pultaceous material usually found in the cæca is formed. As already stated, it disappears when the contents of the large intestine and fæces have been fluid or semi-fluid in character for some time, that is to say, when a relatively large proportion of material is passing through these tubes. It always differs very markedly from any of the intestinal contents, and thus gives no indication whatever of its source. On microscopic examination it is seen to consist chiefly of vegetable cells and masses of bacteria, but no large pieces of husks or fibres are present, such as are found in the intestinal contents. No one can deny that its direct source is the contents of the intestine; but, considering how it differs from these, it must be formed slowly and gradually, for it is most unlikely that these contents could undergo such a vast transformation in a short time. Moreover, methylene blue injected into the cæca can be recognised mixed with it, especially towards its centre, forty-eight hours, or even longer, after injection. There seems to be every reason for believing that this material is simply of the nature of a sediment from the fluids which normally pass through these tubes; that is to say, it consists of finely divided material carried into the cæca by fluids. This contention is further supported by the fact that I was unable to induce solids of any kind to pass into the cæca from the intestine, and in no case did these tubes contain any particle of solids resembling those in the intestine. To quote one of two experiments (*see* Experiment No 19 under Cæcal Tubes) which were carried out with similar results in this connection: A fowl was fed for two days before destruction on dough made from bread and mixed with sand and particles of shot (lead). The particles of sand varied from fine powder up to the size of wheat grains, and those of the shot were of various sizes. On *post-mortem* examination the cæcal tubes contained the usual homogeneous pultaceous material but no sand or shot, although the intestinal contents were rich in the former. Owen states that in grouse he always found the cæca filled with homogeneous pultaceous matter without any trace of heather buds, the remains of which were abundant in the fæcal matter contained in the ordinary tract of the intestine.

From the above evidence it is now apparent that only fluids, usually carrying with them finely divided material, are allowed to enter these tubes, and this is further demonstrated by the fact that when the intestinal contents become stained by giving colouring agents in the food no coloured solid particles are found in the cæca, but their mucous membrane and their pulaceous contents become stained only on the surface, and it is only after a time that the stain becomes mixed with the latter.

The proportion of the intestinal fluids which may pass through the cæca at any time is only a matter of conjecture; but, judging from the anatomical arrangements of the cæcal openings and the rapidity with which fluids pass through the intestine, in conjunction with the fact that coloured fluids may appear in the fæces before having entered these tubes, it seems almost certain that a considerable proportion of these fluids escapes the journey through the cæca. As already stated, their openings are directed backwards, and overlying each of them is a transversely-placed fold whose free edge is directed backwards, so that the fluids which enter them must necessarily take a retrograde course. Again, the bowel immediately in front of these openings possesses a distinct constriction, so that when the bowel contents have reached the openings the fluids are under a sudden relief of pressure as they escape into a wider portion of the intestine (the large intestine). These facts would suggest that the material which enters the cæca is in reality only of the nature of an overflow from the intestinal contents.

The question now arises as to the factors concerned in the passage of material into, along, and out of these tubes. Considering the fact that the intestinal contents at the cæcal opening have just escaped from a narrow into a larger portion of the bowel, it seems improbable that pressure plays any important part in this connection. It has just been pointed out that any material entering the cæca must take a retrograde course from the bowel, but it is most improbable that antiperistaltic movements occur in the large intestine for this purpose, although waves of this character can be produced by pricking this portion of the intestine immediately after death. These waves are continued forward into the cæcal tubes, and owing to the bowel contents being carried forward against the cæcal valves the latter now evidently become raised from their openings and stretch across the lumen of the intestine so as to occlude it, since some of these contents can now be seen through the bowel wall entering these tubes, while none can be seen passing forward in the intestine beyond this level. This would appear to be a feasible explanation of the mechanism by which the cæca are filled, but if this occurred normally, that is to say, if these tubes were normally filled by force during the time when their valves are forced open, all kinds of intestinal material, irrespective of its character, would no doubt be driven into them, so that their contents would always resemble closely those of the large intestine. That, however, is not the case, so that some other argument must be put forward in order to explain this phenomenon. There appears to be every reason to believe that the main factors concerned in the passage of fluids into and out of the cæca are the peristaltic movements of the tubes themselves. Movements of this character can be seen on

examination of these tubes immediately after the fowl is destroyed, but they become very pronounced if the tube be now pricked with a sharp pointed instrument. A slight wave is seen to pass from the site of the prick towards the blind extremity, and a very pronounced one passes in the opposite direction right to the intestine. In fact these waves are more pronounced than any which can be provoked in any part of the intestine by the same means. The pultaceous cæcal contents can now be seen through the thin wall of the tube moving to and fro along the dilated portion.

It is now not difficult to understand that the fluids in the intestine will be drawn into the cæca by suction produced by these peristaltic waves, and that the valves will then doubtless be drawn closely over the cæcal openings, so as to act as a filter and thus prevent any solid particles from passing in. It is almost certain, however, that it is only at certain periods (that is when fluid is present in the neighbourhood of the cæcal openings) that any material passes into these tubes, for the bowel at their openings is very often empty, at least at *post-mortem* examination, the contents of the large intestine, when present, being usually found towards the cloaca.

The fluids, or rather the unabsorbed portion of the fluids, are doubtless frequently expelled from the cæca, but the duration of their delay here is difficult to estimate, and it is very probable that it is not until they have been carried to and fro a number of times along the dilated portion of the tube that they are passed out. It may be that when the fluids are scanty, and little or none is coming in to take their place, they are retained here for a longer time to allow a larger portion to become absorbed.

As already indicated, the characteristic pultaceous material usually found in the cæca at the dilated portion is retained here for a considerable time, and, judging from the fact that one or both tubes may occasionally be found empty, and that occasionally a dropping is passed consisting entirely of material of this character, it is not unreasonable to assume that these tubes are only capable of completely evacuating themselves when this material has accumulated in them to a degree that causes a certain tension in their walls.

The time required for fluids, given by the mouth, to reach the blind extremities of the cæca varies directly according to the quantity of the fluids consumed. In experiments (*see* experiments under Cæcal Tubes) where 2 ounces of coloured fluids were drenched these were found to have reached the entire length of the tubes in from one and a half to two hours, whereas when only small quantities were administered or were mixed with the food (dough) they did not reach the blind extremities for three and a half to four hours or even longer. Again, the rate at which coloured fluids pass along these tubes apparently depends on the quantity present, for if the intestinal contents contain a large proportion of fluids the latter evidently reach the blind extremities very soon after entering the cæcal openings, whereas if the fluids be scarce and the intestinal contents be comparatively dry the stain is often found to have extended only a certain distance along the tubes three to four hours after administration, apparently only making slow progress in its course towards the blind extremities.

In considering the function of the cæca in the fowl one naturally turns to what is known about the degree of development and the function of these organs in other birds.

It would appear that in birds generally the development of the cæca is in proportion to the complexity of the food, yet there are certain exceptions to this rule which are difficult to reconcile on this basis. It is true that in most carnivorous birds the cæca are rudimentary or absent, while in most gallinaceous birds they are well developed; but, notwithstanding this, they are well developed in nocturnal birds of prey, such as the owl, where they are about 2 inches long, and in the pigeon, the parrot tribe, the lark, and certain other granivorous birds, they are rudimentary or absent. It indeed seems very difficult to explain why the cæca should be well developed in the owl and rudimentary or absent in other closely allied birds such as the hawk, which live on exactly the same type of food, or why these tubes should be absent in such a strictly grain-eating bird as the pigeon. Some authors maintain that the differences in the development of the cæca in different types of birds can be connected with certain differences in their habits of life, while others maintain that the degree of development is correlated to the quantity of food obtainable and the ease with which a new supply can be secured.

It should now be apparent that from a study of analogy on a general basis it is impossible to arrive at any definite conclusion regarding the function of the cæca in the fowl. If anything is to be inferred in this connection it is that the cæcal tubes in birds do not play any important special part in the digestive process, since they are well developed in some birds, while in others very closely allied in every respect they are rudimentary or absent.

In shape, in structure, and in the manner in which the contents are carried along them, the cæca in the fowl so closely resemble the intestine that it seems natural to regard them as miniature intestines, and as playing an accessory part to the intestine as regards function; their glands are poorly developed, their villi are long in the constricted portion, and the mucous membrane in the dilated portion, although almost devoid of villi, is raised into numerous ridges or folds, as if to increase the surface area. They are therefore suitably adapted for absorption, and this is doubtless their most important function. Their narrow portion, carrying the villi, would appear to be analogous to the small intestine in mammals, where nutrient material is largely absorbed, while the dilated portion, devoid of villi, would appear to represent the mammalian large intestine, where the absorption of fluids almost entirely takes place.

It has been shown that the more fluid in character the intestinal contents, the faster these pass through the intestine into the fæces and the greater proportion of these contents passing through the cæca.

These fluid contents, containing as they do a large proportion of suspended nutrient material, are doubtless hurried into the fæces before this material has had a sufficient opportunity to become absorbed; but, when it is considered that no sooner do these contents become of this consistence than the cæca become

more active and increase their function, as it were, by allowing a greater proportion, and it may be the greater part, of these contents to pass through them, thus enabling the nutrient material to be exposed to a larger surface area for absorption, it is not unreasonable to suggest that these tubes may serve to assist the intestine in the absorption of nutrient material which would otherwise have escaped with the fæces when the intestinal contents become fluid or semi-fluid in character. Again, it has been shown that when the intestinal contents are comparatively dry and the fluids are scarce the latter pass along the cæca comparatively slowly and are doubtless here delayed for a longer time than when fluids are plentiful, with the result that a larger proportion becomes absorbed. This would suggest that these tubes may also serve to conserve fluids when these are scarce in the body, by acting as reservoirs as well as organs of absorption for those fluids which would otherwise have escaped with the fæces.

It has already been explained that usually only a small proportion of the intestinal contents passes through the cæca, a fact which alone is a strong argument in favour of the contention that these tubes do not play a very important part in the digestive process. It may, of course, be argued that they may pour their secretions into the intestines to play there an important part in digestion, but if this were the case one would expect to find them opening into the first part of the intestine, and not as they do into its terminal part, where fæces of a normal character have already been formed, as an indication that the chief digestive and absorptive processes have been completed in the more anterior portion of the bowel.

The cæca are in marked contrast to the intestine in one respect, and that is that they usually retain material of a certain character for a considerable time, as already explained. This would appear to suggest that they absorb certain constituents which can only be extracted from the food after it has been subjected to the digestive process for a considerable time, but there are no facts that would go to support this contention, and, furthermore, material of this nature is not always found in these tubes.

Some authors state that the chief functions of the cæca in birds is to convert starch into sugar, but this has not been verified by more recent investigations, and the statements were apparently only based on the fact that in the pigeon these tubes are absent and the crop contains glands which were assumed to fulfil this function, and therefore compensate for the absence of the cæca. R. Meade Smith states that if the cæcal tubes of the duck be ligatured after the introduction of small fragments of cooked meat a large amount of clear alkaline fluid may be obtained although the morsels of meat have remained unaltered. This author also quotes an experiment carried out by the Bureau in which the cæca of chickens were ligatured with the result that the bird became affected with diarrhœa, lost flesh rapidly, and died from inanition. This result, however, in my opinion was only to be expected, seeing that the tubes were merely ligatured and left *in situ*. There is no doubt whatever that the holding up of their contents and the blocking of the circulation in their walls, caused by ligation,

would be quite sufficient to render them active seats of toxin production, thus giving rise to a general toxæmia sufficient to account for these results. In this connection there is every reason to believe that had the cæca been completely and carefully removed the chickens would have suffered little if any inconvenience as a result of being deprived of these organs.

Reviewing the whole question, it seems reasonable to conclude that the cæca do not play any very important or special part in the digestive or assimilative processes and that they merely compensate for the relative shortness of the intestine, chiefly by assisting in the process of absorption. It cannot be denied that the chief part of the digestive process has been completed before the food material has reached the level of the cæcal openings, since the intestinal contents, even before reaching this position, have acquired all the characters of normal fæces. Furthermore, examples of the absence of these tubes are met with in all types of birds whatever be their habits of life or the character of their food, so that in these cases the intestine is called upon to carry out the entire digestive process without the aid of such appendages and without the presence of other organs which might compensate for their absence.

Experiments in Connection with Cæcal Tubes.

The colouring agents which proved most serviceable in these experiments were methylene blue and magenta, the former being preferable in most cases because it is a good contrast to the bowel contents, and, although it becomes bleached in the intestine, usually immediately recovers its blue colour on exposure to the air when the bowel is opened. Occasionally, however, particularly if the birds have been feeding on grass, its normal colour for some reason does not become restored, so that in these cases it is preferable to use magenta.

Experiment 1.—Healthy hen which had been feeding on oats for two weeks prior to the experiment and had been passing fæces of a comparatively dry character during this period.

At 9.30 A.M. crop empty; forcibly fed on moderately firm dough made from bread and stained with methylene blue until crop became moderately full. Droppings normal until 2 P.M., when first blue-stained dropping was passed. Hen now destroyed. *Post-mortem* examination made at 3.30 P.M.

Result.—A large proportion of dough still in crop; intestinal contents, including fluids, stained blue throughout; contents semi-fluid in first part of intestine, but gradually became more solid on passing backwards, until in large intestine they were transformed into ordinary dry fæces. The cæca contained a quantity of almost chocolate-coloured pultaceous material, and the blue stain had extended the full length of these tubes, but had only stained the mucous membrane and the exterior of this material, not yet having mixed with the latter.

Experiment 2.—Healthy hen which had been feeding on oats for five days prior to experiment and had been passing fæces of a comparatively dry character during this period.

At 10 A.M. fed on moderately firm dough, coloured with methylene blue as in No. 1. Droppings normal until 2.5 P.M., when first slightly blue-

coloured dropping was found on the floor of the cage, apparently only passed a very short time before. Hen now destroyed.

Result.—Exactly similar to that in No. 1, but in the right cæcal tube the blue stain had not quite reached the blind extremity, about half an inch of the mucous membrane and contents being here unstained.

Experiment 3.—Healthy hen which had been feeding on oats for two days prior to experiment and had been passing fæces of a comparatively dry character during this period.

At 10 A.M. fed on moderately firm dough, coloured with methylene blue as in Nos. 1 and 2. Droppings normal (unstained) until the hen was destroyed at 1.20 P.M.

Result—First part of intestine full of semi-fluid contents, but these became drier and less in quantity until in the large intestine they consisted of only a small quantity of comparatively dry almost normal fæces. Cæcal contents consisted of the usual chocolate-coloured pultaceous material. The blue had stained the intestinal mucous membrane and contents as far back as the middle of the large intestine, and had extended into the cæca for a little more than half their length, staining their mucous membrane and the exterior of their contents.

Experiment 4.—Healthy hen which had been feeding on oats for two days prior to experiment and had been passing fæces of a comparatively dry character during this period.

Fed at same time and on same material and destroyed at same time as No. 3. No blue-coloured fæces had been passed before destruction.

Result.—Similar to that in No. 3, but the blue stain had only extended into the cæcal tubes for about 1 inch, staining their mucous membrane here.

Experiment 5.—Healthy hen which had been feeding on oats for one day prior to experiment and had been passing fæces of a comparatively dry character during this period.

Fed on blue-stained dough as in No. 4, and destroyed the same time after feeding as in Nos. 3 and 4.

Result.—The intestinal contents of a similar consistence to that in Nos. 3 and 4, but for some reason the methylene blue did not regain its normal colour when exposed to the air, and was therefore unrecognisable. The cæcal contents were of the ordinary pultaceous type but darker in colour than usual, and no blue staining could be recognised in these tubes. The crop of this bird contained some blades of grass, and it is not improbable that the digested grass had some detrimental effect on the staining properties of the methylene blue.

Experiment 6.—Healthy hen which had been feeding on oats for three days prior to experiment, but was passing semi-fluid fæces during this period.

At 9.15 A.M. crop empty, forcibly fed on moderately firm dough stained with magenta. Droppings as usual (unstained) until 1.10 P.M., when first magenta-coloured dropping was found on bottom of cage, apparently only passed a few seconds previously. Hen now destroyed.

Result.—Intestinal contents semi-fluid throughout, including those in large intestine, and all stained uniformly with magenta. Cæcal tubes comparatively full of semi-fluid material, indistinguishable from that in large intestine and also uniformly stained throughout with magenta.

Experiment 7.—Healthy hen which had been feeding on oats for two days prior to experiment and had been passing semi-fluid fæces during this period.

At 9.45 A.M. crop empty, forcibly fed on moderately firm dough stained with magenta. Droppings as usual until 1.5 P.M., when first magenta-coloured dropping was passed. Hen now destroyed.

Result.—Intestinal contents semi-fluid throughout, including those in the large intestine, and all uniformly stained with magenta. Contents of large intestine very small in quantity. Cæcal tubes contained a small quantity of semi-fluid material similar to that in large intestine but not stained with magenta, which had apparently not yet entered these tubes.

Experiment 8.—Healthy hen which had been fed on oats for one day prior to experiment, the fæces during this period being of a semi-fluid character.

At 9.50 A.M. crop empty, now forcibly fed on moderately firm dough stained with magenta. Droppings as usual (unstained) until hen was destroyed at 1.30 P.M.

Result.—Intestinal contents semi-fluid throughout, only small quantity in large intestine, these contents and intestinal mucous membrane stained with magenta as far back as a little beyond the middle of large intestine. Contents of cæca consisted of a comparatively small quantity of material similar to that in the large intestine, and uniformly mixed with magenta throughout.

Experiment 9.—Healthy hen which had been passing fæces of normal moderately dry consistence.

Drenched, when crop empty, with 2 ounces of solution of methylene blue. Destroyed one and a half hours afterwards, no blue-coloured fæces having been passed.

Result.—Intestinal contents and mucous membrane stained blue as far back as and slightly beyond the cæcal openings, but no blue stain had yet entered the cæca. Cæcal contents consisted of the usual brownish-coloured pultaceous material.

Experiment 10.—Healthy fowl which had been passing fæces of normal moderately dry consistence.

Drenched, when crop empty, with 2 ounces of solution of methylene blue. First blue-coloured dropping passed one and three-quarter hours afterwards; fowl now destroyed.

Result.—Intestinal contents and mucous membrane stained blue throughout, but no blue stain had yet entered the cæca. Cæcal contents same as in No. 9.

Experiment 11.—Hen which had been passing fæces of normal moderately dry character.

Drenched, when crop empty, with 2 ounces of solution of methylene blue. First blue-coloured dropping passed two hours afterwards; hen now destroyed.

Result.—Intestinal contents and mucous membrane stained blue throughout. The blue stain had extended full length of cæca, staining mucous membrane and exterior of contents. These contents similar to those in No. 10.

Experiment 12.—Hen which had been passing fæces of normal moderately dry consistence.

Drenched, when crop empty, with 1 ounce of solution of methylene blue. Destroyed two hours afterwards, before any coloured fæces had been passed.

Result.—Intestinal contents and mucous membrane stained blue as far backwards as a little beyond the cæcal openings, but no stain had yet entered cæca. Cæcal contents of the usual pultaceous type. This animal was tuberculous, having several nodules in intestine and one in each cæcal tube.

Experiment 13.—Hen which had been passing fæces of normal moderately dry consistence.

Drenched, when crop empty, with 1 ounce of solution of methylene blue.

Destroyed two hours and forty-five minutes afterwards, immediately after the first blue-coloured dropping had been passed.

Result.—Intestinal contents and mucous membrane stained blue throughout. The blue stain had extended to the blind extremities of the cæcal tubes, staining their mucous membrane and the exterior of their contents. These contents of the usual pultaceous type.

Experiment 14.—Three hens. One ounce of magenta solution injected through cloaca of each animal. Destroyed immediately afterwards.

Result.—In all three cases the magenta-staining had extended the entire length of the cæca, staining their mucous membrane and the exterior of their contents. In two cases the stain did not extend forward in the intestine beyond the cæcal valves, but in the third it had extended about a foot in front of this level.

Experiment 15.—Hen which had been passing fæces of normal moderately dry consistence.

Injected through cloaca with 1 ounce of methylene blue solution. Droppings blue-coloured for seven hours afterwards; fowl destroyed twenty-four hours after injection.

Result.—Blue had disappeared from the intestine; cæcal contents of the usual homogeneous pultaceous type, and towards their centre the blue could be easily recognised, but was not apparent on the exterior.

Experiment 16.—Hen which had been passing fæces of normal moderately dry consistence.

Injected through cloaca with 1 ounce of methylene blue solution. Droppings blue-coloured for about eight hours afterwards. Hen destroyed forty eight hours after injection.

Result.—Blue had disappeared from the intestine. Cæcal contents of the usual pultaceous type, and towards their centre the blue stain could be recognised on careful examination, but on microscopic examination the blue particles could be easily demonstrated.

Experiment 17.—Hen which had been passing fæces of a semi-fluid character.

Injected through cloaca with 1 ounce of methylene blue solution. Droppings blue-stained for about seven hours afterwards. Destroyed twelve hours after injection.

Result.—Blue had entirely disappeared from both intestine and cæca. Cæcal contents semi-fluid and similar to those in last part of the intestine, and no blue recognisable.

Experiment 18.—Hen which had been passing fæces of a semi-fluid character.

Injected as in No. 17. Droppings blue-stained for about six hours afterwards. Destroyed eight hours after injection.

Result.—Blue had entirely disappeared from both intestine and cæca. Cæcal contents semi-fluid and similar to those in last portion of intestine, and no blue-staining recognisable.

Experiment 19.—Two hens forcibly fed on dough mixed with sand and particles of shot (lead). The sand particles varied from a fine powder to grains almost as large as oat grains, and the shot particles were of various sizes. This feeding continued for two days, at the end of which the hens were destroyed. After the first feed the sand and the shot appeared in the fæces within record time (five hours).

Result.—Gizzard full of sand and some shot particles. Intestinal contents rich in sand particles throughout, with apparently the original proportion of shot particles. Cæcal contents in both cases entirely free from sand or shot. In one bird these contents were of the usual homogeneous pultaceous type, but in the other the cæca were almost empty.

Conclusions from Above Experiments.

(1) When the contents of the large intestine and the fæces have been of a moderately dry character for some time the cæcal contents, when present, are found to consist of a characteristic, homogeneous, almost chocolate - coloured, pultaceous material, always free from sand and grit.

(2) If the contents of the large intestine and the fæces have been semi-fluid in character for some time the cæcal contents also become semi-fluid and almost indistinguishable from those in the large intestine.

(3) A portion at least of the characteristic pultaceous material present in the cæca remains in these tubes for as long as forty-eight hours.

(4) The cæca are occasionally found empty.

(5) Fluid or semi-fluid material in the cæca remains here for only a short time, being soon evacuated and immediately replaced by fresh material.

(6) The proportion of ingesta passing through the cæca varies directly with the fluid condition of the contents of the large intestine.

(7) Usually a considerable proportion of the intestinal contents does not enter the cæca.

(8) Only fluids are allowed to enter the cæca, and if these fluids are coloured the stain only very slowly mixes with the pultaceous cæcal contents when present, at first staining only the surface of this material.

(9) The rate at which fluids pass along the cæca varies directly with the quantity passing through the intestine.

(10) The time required for fluids given orally to reach the blind extremities of the cæca varies from one and a half to four hours, according to the quantity administered. If mixed with food they require longer than if drenched as fluid.

(11) In the majority of cases coloured material given by the mouth will reach the blind extremities of the cæca at about the same time as it first appears in the fæces.

(12) Coloured material given orally may occasionally appear in the fæces before it has entered the cæca, particularly if for any reason it has been hurried along the intestine with unusual rapidity.

(13) Fluids injected through the cloaca into the large intestine under slight pressure will reach the blind extremities of the cæca almost immediately, and in many cases none of this fluid is allowed to pass forward in the intestine beyond the cæcal valves.

(14) In the treatment of parasitic affections of the cæca parasitocides given by the mouth must necessarily undergo a very high degree of dilution before reaching the cæcal openings, and, when this is considered in conjunction with the probability that a large proportion of these agents may escape the cæca altogether, there appears to be no doubt that a much more effective method of treatment would be to inject these agents through the cloaca by means of a syringe or other suitable instrument.