CXII. OBSERVATIONS ON THE IODINE CONTENT OF THE THYROID AND OVARY OF THE FOWL DURING THE GROWTH, LAYING, AND MOULTING PERIODS.

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THE domestic hen produces up to 200 eggs per annum or approximately ten times the number intended by nature for the propagation of the species. This high level of productivity has been brought about by selective breeding and by appropriate dieting. The absorption of food and the physiological processes responsible for its transformation into the materials of the egg must therefore be maintained at a high level of activity for considerable periods during the active sexual life of the fowl. Very little is known of either the manner or the site of the transformation of the absorbed food into egg material. If the transformation occurs in any site other than the ovary and oviduct, the passage of the transformed materials in the blood-stream to the sexual organs must involve corresponding changes in the composition of the blood. To test the validity of this hypothesis an investigation was begun at this Institute, which dealt in particular with the composition of the blood and tissues during growth, egg production and moulting. The histological appearance of several of the ductless glands was also studied.

This paper is based on the changes observed in the iodine content and structure of the thyroid and in the iodine contents of the ovary and ova.

Material. The birds used were White Leghorns from the same source and of approximately the same age. They were housed under normal conditions, having free access to grass. The ration consisted of wheat offal, oats, maize and fishmeal. Both diet and management were kept constant.

Method. A bird was removed from the pen at intervals, and starved for 18 hours. The jugular vein was cut, the blood being collected for various analyses. The bird was then weighed and a *post-mortem* examination made. The thyroids were dissected out, freed from the parathyroids and adhering tissue and weighed. One lobe was kept for histological examination and the other digested in 10 % KOH and used for the estimation of iodine. The method employed was the Leitch-Henderson [1926] modification of Fellenberg's procedure.

RESULTS.

Table I.

Date	Age weeks	No. of birds	Body-wt. g.	Thyroid wt. g.	Thyroid wt. per kg. body-wt. g.	Iodine %	Total iodine γ	Iodine per kg. body-wt. γ	Remarks
July	8½	1	315	0.0125	0.040	0.1075	13.5	42.5	Growth period
July	9½	1	295	0.0200	0.070	0.1115	22.3	75.5	
Sept.	13	2	950	0.0581	0.060	0.0895	51.5	54.2	
Nov.	18	1	1300	0.0725	0.055	0.2387	173.0	133	
Jan.-Feb.	31-35	5	1514	0.1288	0.085	0.3129	402	269	Period of low egg-production
Jan.-Feb.	36-40	4	1474	0.1330	0.090	0.2849	359	237	
Feb.-Mar.	41-45	3	1402	0.1322	0.090	0.2609	354	237	
Mar.-Apl.	46-50	3	1218	0.0849	0.070	0.3477	295	239	Period of maximum egg-production
May	51-55	3	1253	0.0865	0.069	0.2014	174	161	
June-July	56-58	4	1582	0.0825	0.052	0.2269	189	194	
July	59-60	4	1600	0.1309	0.082	0.2347	295	191	Moulting period
July	61-65	2	1525	0.0946	0.062	0.2286	221	140	
Aug.	66-70	1	1135	0.0811	0.072	0.2124	164	146	
Sept.	71-72	2	1200	0.0843	0.071	0.2421	201	175	

Average weight of fresh gland for 31 mature birds killed at intervals over a period of 14 months, 0.10 g.

Average weight of thyroid per kg. body-weight, 0.074 g.

Thyroid weight.

Variation with age. The table shows that the thyroid weight increases in proportion to body-weight (*i.e.* with age) in the growing bird. In the mature bird, however, (after 30 weeks) no correlation is found between thyroid weight and body-weight.

Seasonal variation. The thyroid weight shows a marked seasonal variation. The average for the period from mid-March to mid-July shows a loss of 35 % as against January to March. The weight is greatest previous to the period of maximum egg-production, and decreases during this period. There are indications of a slight rise with the onset of moulting, followed by a secondary fall.

Thyroid iodine.

Variation with age. Total thyroid iodine increases with body-weight in the growing bird. Up to 13 weeks the percentage of iodine is about 0.1. In the adult pullet after 30 weeks the percentage is markedly higher—the average values ranging from 0.20 to 0.34.

Seasonal variation. The seasonal variation in iodine content follows the variation in thyroid weight very closely as regards total iodine, rather less closely as regards percentage.

DISCUSSION.

The fact that the thyroid weight increases in proportion to body-weight in the growing bird is in accordance with what occurs in mammals [Orr and Leitch, 1929].

Evidence of a similar seasonal variation in thyroid size in pigeons has been obtained by Riddle and Fisher [1925], their data showing a loss of 41 % in weight from April to July as against January to March.

Comparison of thyroid weight with other data. The average weight of the fresh gland in the adult birds examined was 0.10 g. Latimer [1924], working on White Leghorns in Minnesota, showed that the average for 12 pullets was 0.173 g.¹, a value approximately 1.75 times that obtained in our experiment. It is probable that the relatively higher weight of the American thyroids is associated with environmental and dietetic factors.

Similar differences have been observed between the thyroid weights of British and American sheep. Martin [1912] working on thyroids from sheep slaughtered at Newcastle-on-Tyne found the average weight of the fresh gland to be 1.4 g. Figures obtained at this Institute in June (Leitch and Stuart, unpublished data) for sheep thyroids show an average of 2.7 g. fresh weight. Both these values are markedly low when compared with those of Seidell and Fenger [1912], viz. 5.5 g. weight in summer, and 8.5 g. in winter for normal American sheep.

Similar data are obtainable for cattle. In thyroids from English cattle slaughtered at Liverpool, Fellenberg and Pacher [1927] found the average weight of fresh gland to be 12.5 g. while Seidell and Fenger [1912] record 25.0 g. in summer and autumn, and 60.0 g. in winter and spring (for normal glands).

Relation to body-weight. The average weight of thyroid per kg. was found to be 0.074 g. Latimer's¹ data show that the corresponding figure for the 12 pullets examined by him is 0.13 g., a value almost twice that obtained by us. As before mentioned, this is probably associated with environmental factors.

Compared with the figures available for cattle, the hen has a greater weight of thyroid per kg. of body-weight. According to Fenger [1914], the amount of fresh thyroid per kg. of body-weight in cattle is 0.047 to 0.05 g. which is significantly lower than the average for our birds, viz. 0.074 g.

Reliable data for other types of mammals are not available.

Thyroid iodine. The increase in total thyroid iodine with age in the growing bird shown in our results is in agreement with the findings of Chaudhuri [1928] who showed that in cockerels the iodine content of the gland increases up to maturity (14 weeks). He correlates this increase with the development of active spermatogenesis.

According to Fenger [1913] and Orr and Leitch [1929] this is not the case in mammals—the percentage of iodine not being affected from late foetal life until the onset of old age.

The fact that the seasonal variation in iodine percentage tends to follow

¹ The figures referring to Latimer's data are obtained from his graph showing the weight of thyroid plotted on the gross body-weight. Only the pullets whose body-weights fell between 1100 and 1600 g. were taken, since they most nearly corresponded with the weight of the birds examined by us.

the variation in thyroid weight is in contrast to the findings of previous workers on mammals. Baumann [1896] noted that in sheep and man there was an inverse relationship between size of thyroid and percentage of iodine. Martin [1912] found that in sheep, when the iodine content of the glands was at a maximum, their weight was at a minimum. This was confirmed by Seidell and Fenger [1912] who worked on the thyroids of American sheep, hogs and oxen.

It has, however, been pointed out by Orr and Leitch [1929] that this inverse relationship holds only in the case of glands having a low iodine content (below 0.03 % fresh weight). This level (0.03 %) is the critical concentration of iodine in the thyroid. Below this level, the weight of the gland increases as the iodine content diminishes. From this level to about 0.2 % the weight does not alter with increasing iodine content. Above this second critical level (0.2 %) increase in iodine content of the gland is associated with increase in weight.

The existence of such critical levels has not been established for birds, but it is suggested that in the thyroids examined in this experiment we are dealing with glands above the second critical level, so that any increase in iodine content, such as is observed during the period from January to March, is accompanied by an appreciable increase in the weight of the gland.

Percentage of thyroid iodine in fowls compared with that in mammals. The percentage in birds as compared with mammals is very high. Nosaka [1926] states that thyroid iodine is high in the chicken and low in the horse, ox, dog, guinea-pig and rabbit. Chaudhuri's [1928] data show that the percentage iodine in the thyroid of birds is approximately three times that in mammals. Results published by Orr and Leitch [1929] point in the same direction. The average values obtained in this investigation range from 0.20 to 0.35 %. These are slightly higher than the figures given by Orr and Leitch probably owing to the fact that the diet in our experiment was relatively rich in iodine, the intake amounting to 40–50 γ per bird daily.

In connection with the high percentage of thyroid iodine it is worthy of note that goitre is of very rare occurrence in fowls. Kernkamp [1925] working in Minnesota, a state where the incidence of goitre in animals is high, found only two cases of goitre out of 2409 autopsies on poultry. These two cases occurred in White Orpingtons from the same farm. From the *post-mortem* notes, however, it seemed probable that the goitre was due to structural abnormality of the birds rather than to the influence of environmental factors.

Relation to body-weight as compared with mammals. The thyroid iodine per kg. of body-weight is very high in birds. Our average figures for adult birds range from 140 to 269 γ , while Cameron [1924] quotes figures for mammals as follows: guinea-pigs, 28 γ ; heifers, 59 γ ; man, 77 γ ; all of which are markedly lower than the values obtained by us.

The ovary. It is probable that the seasonal variation in iodine content of the thyroid is associated in some measure with the output of iodine during

egg-production, since the yolk of the egg contains appreciable amounts. While our figures during both winter and summer are for laying hens, the period of maximum egg-production occurs during April and May. Hence the depletion of the reserve of iodine owing to yolk formation is likely to become apparent during the period from April to September.

Several workers have recorded high figures for iodine in the ovary of cattle, rabbits and guinea-pigs [Fellenberg, 1923; Maurer and Ducrue, 1928]. These findings are not confirmed by Leitch [1929], who states that the iodine content of the whole ovary in the cow is low, though that of the small corpora lutea is relatively high.

In our experiment the ovarian tissue of the fowl was separated as completely as possible from all but the very minute ova, and the iodine content determined on this material. In all cases merely a trace was found. When, however, the smaller ova were not removed, an appreciable amount of iodine was present. Analyses were then made of the ovarian tissue, mature yolk, and entire egg from the same hen. The following figures show the nature of the results obtained:

<i>Iodine, γ per 100 g.</i>			
No. of hen	Ovary	Large ova	Entire egg
345	Trace	11.4	4.2
318	Trace	26.0	9.8

From the figures it appears that the percentage of iodine is at its maximum in the mature ovum before it enters the infundibulum, and decreases in the entire egg, indicating that the greater part of the iodine is contained in the yolk. This probably accounts for the high figure for iodine obtained by Fellenberg [1923] in fish roe, where yolk forms a large percentage of the ovum.

Histology. Histological examination of the thyroid showed that the increase in percentage of iodine in the adult as compared with the growing bird was related to the size of the vesicles of the gland, the appearance of the epithelium lining them, and the amount of colloid they contained.

In the chick the vesicles are relatively small, and the epithelium cubical. In the immature pullet the vesicles are larger, the epithelium somewhat flattened, and the colloid is present in relatively large amount. In the mature bird, whether laying or moulting, the vesicles are large, distended with colloid, and the epithelium flattened.

No difference in the structure of the glands attributable to the difference in function between laying and moulting could be distinguished, so that the difference in appearance between the immature birds and the adults is probably due to the different periods of growth. The appearance in the young bird suggests a relatively active, and that in the mature laying and moulting birds a relatively inactive, state.

SUMMARY.

Thyroid glands were obtained from hens fed on a constant diet over a period of 14 months during the periods of growth, egg-production and moulting, and the following results were obtained.

1. The thyroid weight and total thyroid iodine increase in proportion to increase in body-weight in the growing bird.

2. There is a seasonal variation in thyroid weight—the average from mid-March to mid-July showing a loss of 35 % as against January to March.

3. The seasonal variation in both percentage and total iodine tends to follow the seasonal variation in thyroid weight.

4. The average weight of fresh gland and the thyroid weight per kg. of body-weight is low compared with the values obtained for the same breed in the goitre belt of the United States of America.

5. The weight of thyroid per kg. body-weight, the percentage iodine and the total thyroid iodine per kg. body-weight are higher than in mammals.

6. The ovary contains only a trace of iodine, yolk of egg contains an appreciable amount.

7. The histological appearance of the thyroid suggests a state of relatively great activity in the immature bird, and of relative inactivity in the laying and moulting birds.

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