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TITLE Relation Between Size And Age of The Fowl Cloaca, Bursa, And Gonads with Special Reference To Growth And Structural Variations In Their Constituent Parts From Hatching Date To Sexual Maturity

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Abstract of Dissertation

RELATION BETWEEN SIZE AND AGE OF THE FOWL CLOACA, BURSA, AND GONADS WITH SPECIAL REFERENCE TO GROWTH AND STRUCTURAL VARIATIONS IN THEIR CONSTITUENT PARTS FROM HATCHING DATE TO SEXUAL MATURITY

by

Clare Helmer Bennett

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1944

RELATION BETWEEN SIZE AND AGE OF THE FOWL CLOACA, BURSA, AND GONADS WITH SPECIAL REFERENCE TO GROWTH AND STRUCTURAL VARIATIONS IN THEIR CONSTITUENT PARTS FROM HATCHING DATE TO SEXUAL MATURITY

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CLARE HELMER BENNETT

Investigation of the avian cloaca has been a subject of intensive interest to relatively few workers during the past two hundred and fifty years.

Review of the literature shows that the anatomy of the cloaca and its size in relation to the size of the bursa and gonads in various age groups of Aves is fragmentary. Additional observations on the cloaca of birds from hatching time to sexual maturity are desirable.

The study is based on the cloacas of one hundred eighty-one pedigreed Single Comb White Leghorn chickens, three Hungarian partridges and two Ring-necked pheasants.

Results of the study showed:

1. The cloaca of the fowl, partridge and pheasant consists of three compartments; the coprodaeum which was the largest, the urodaeum which was the smallest and the proctodaeum which was smaller than the coprodaeum yet larger than the urodaeum.

2. The cloacal compartments and their limits were similar in the three species studied. The position of the cloacal papillae was likewise similar. All species showed the bursa connected to the proctodaeum by a funnel-shaped canal. A broad fold was observed in the proctodaeum of the fowl, partridge and pheasant.

3. A deep coprodael pocket and a uretal vestibule were observed in the partridge while an oblique coprodael fold was seen in the fowl and pheasant. Uretal papillae in the pheasant were found on the anterior edge of longitudinal folds and were not disc-shaped as in both the fowl and partridge. The bursal aperture was exposed in the partridge while in the fowl and pheasant it was covered by the uro-proctodael fold.

4. Growth in size of the cloaca when measured in percentage increase in length and width was greater in the female than in the male.

5. Maximum size of the cloaca in the male and female fowl was reached from the 131 st to 156 th day of age.

6. Growth in the individual compartment of the cloaca showed that the coprodaeum in the male and female fowl increased rapidly up to the 7 th day

and remained fairly constant until the maximum on the 131 st day. Growth in length of the urodaeum was essentially alike in the male and female fowl until the 59 th day and then was greater in female than in male.

7. The increased length of the female cloaca between the ages of 156 and 195 days was due to increased length of the urodaeum.

8. Growth in width of the female urodaeum closely paralleled that of the male through the 131 st day but in the female increase in width was greater from the 131 st day until the 195 th day than it was in the male for the same period.

9. Growth of the proctodaeum was similar in the male and female from hatching date until the 156 th day. Following, which, the female showed a greater increase than the male through the 195 th day.

10. There was no significant growth in the uretal papillae from hatching date through sexual maturity while growth in the genital papillae of the male closely paralleled that of the female through the 32 nd day, after which the male showed a greater increase than the female. The genital papillae in the female showed rapid atrophization after the 131 st day.

11. The bursa reached maximum growth on the 59 th day in the male and 131 st day in the female.

12. Results showed a correlation between bursal atrophization and sexual maturity which on the basis of Riddle's observations may be due to prolactin.

13. There was no significant increase in the number of bursal folds from hatching date to sexual maturity.

14. Results of this study and those of Rowan, Bissonnette, Marshall and Riddle suggest cloacal size is influenced by (1) endocrine factors associated with the gonads and the anterior pituitary and (2) an exteroceptive factor (light) which through the intermediation of the nervous system acts upon and modifies the endocrine factors.

RELATION BETWEEN SIZE AND AGE OF THE FOWL CLOACA, BURSA, AND GONADS WITH SPECIAL REFERENCE TO GROWTH AND STRUCTURAL VARIATIONS IN THEIR CONSTITUENT PARTS FROM HATCHING DATE TO SEXUAL MATURITY

by

CLARE HELMER BENNETT

A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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I. INTRODUCTION

Investigation of the avian cloaca has been a subject of intensive interest to relatively few workers during the past two hundred and fifty years. There have been no previous attempts to present detailed drawings of actual dissections in a series of age groups. Early efforts were concerned mostly with sketches and diagrams. Later work has been related chiefly to the microscopic study of the organ and its development.

One of the earliest workers, Fabricius (1688), investigated this structure from an embryological and developmental point of view. Almost two centuries later Grant (1833) found that structural differences existed in the different parts of the cloaca. Forbes (1877) contributed to this field by studying the relations between the cloaca and bursa in several orders of birds.

Gadow (1887) made a comprehensive study of the cloaca and reported for the first time the anatomical differences in its various parts. This author stated that three regions could be recognized, i.e., an anterior (1) coprodaeum, a middle (2) urodaeum, and a posterior (3) proctodaeum.

Ward and Gallagher (1920), Groebbels (1932), MacDonald and Taylor (1933), Sisson (1937) and McLeod (1939) have described the cloaca in connection with other avian studies. The observations reported by these authors are in general agreement with those described in the preceding paragraphs.

Retterer (1885) obtained measurements of the bursa during the height of its development. Jolly (1915) found that the bursa reached

maximum size at the onset of sexual development and then decreased to a vestige following sexual maturity. Riddle (1928) investigating doves and pigeons found that maximum bursal development was attained prior to gonadial development. Gower (1939), Linduska (1943) and Kirkpatrick (1944) used the bursa as an age indicator in pheasants.

Latimer (1924), and Mitchell, Card, and Hamilton (1926) studied the relation between body growth and gonadial growth in the fowl. Kaufmen (1927) investigated body growth and gonad growth in the common pigeon. Parker, McKenzie, and Kempster (1942) studied the relation between comb size and gonad size in the fowl.

The preceding review of the literature shows that the anatomy of the cloaca and its size in relation to the size of the bursa and gonads in various age groups of Aves is fragmentary. Additional observations on the cloaca in birds from hatching time to sexual maturity are desirable. Observations made in this study will be presented under five headings: (A) anatomy of the avian cloaca; (B) relation between size and age of the cloaca in the fowl from hatching date to sexual maturity; (C) relation between size and age of the coprodaeum, urodaeum and proctodaeum in the fowl from hatching date to sexual maturity; (D) relation between size and age of the bursa in the fowl from hatching date to sexual maturity; (E) relation between size and age of the gonads in the fowl from hatching date to sexual maturity.

II. MATERIALS AND METHODS

Material was secured by the cooperation of Dr. C. A. Brandly of the Regional Poultry Laboratory and Professor J. A. Davison of the College Poultry Plant. Additional material was secured from the Pinecroft Poultry Farm and Hatchery, Owosso, Michigan, and the State Game Farm, Mason, Michigan.

Birds obtained from the Regional Poultry Research Laboratory were brooded and maintained in complete confinement. The chickens were kept within two large brooder houses equipped with wire panel floors. In other houses where litter was used, the pens were cleaned as often as necessary to keep them in good condition. Windows and doors of the brooder houses were carefully screened against flies, mosquitoes, and other insects. In addition, sparrows were not permitted to nest nor raise their young in or about any of the buildings. Care was exercised to reduce to a minimum the presence of flies and other introduced parasites by the practice of delivering feed to the different houses through vestibules and removing droppings and litter from these houses in large garbage cans with covers. Two sets of cans were used in these two operations. All litter and droppings collected were burned in an incinerator.

All feed was supplied in open hoppers. Running water and drinking fountains in each pen aided in keeping fresh, clean water before the birds at all times. Diet furnished the chickens consisted of a starting, growing, and laying mash mixed according to the following formula: ground yellow corn, 27%; ground medium oats, 15%; wheat middlings, 15%; wheat bran, 15%; dried skim milk, 5%; meat scrap, 5%; sardine meal, 5%;

soybean oil meal, 5%; alfalfa leaf meal, 5%; oyster shell flour, 2%; salt mixture (iodized salt and anhydrous manganous sulphate), 0.65%; fortified cod liver oil (400 AOAC chick units D, 3000 I. U. units A per gram), 0.35%; insoluble grit, 1%. In addition to the above, all birds over eight weeks of age were fed (in hoppers in mid-afternoon) the following grain mixture: cracked yellow corn, 50%; oats, 25%; wheat, 25%.

All chickens were pedigreed Single Comb White Leghorns. A series of ten age groups was obtained. In every series an attempt was made to have at least ten birds of each sex for each age group; however in some series it was not physically or economically possible to do so at the time this study was made. In obtaining the data which will be given in the following pages eighty five males and eighty six females were dissected. Birds were killed by cervical fracture or electrocution.

The cloacas studied were obtained by the following methods: A longitudinal incision, three inches long, was made in the skin midway between the legs and body. The legs were pulled down and away from the body disarticulating the hip. A transverse slit two to four inches long was made just behind the xiphoid process of the sternum. The skin was pulled forward and to the side, exposing the sternum and the muscles of the abdomen. By means of a pair of heavy scissors a transverse incision was made in the muscles posterior to the xiphoid process. The incision was continued anteriorly and dorsally at its right and left extremities until the sternum was freed at its anterior border; then it was deflected anteriorly or entirely removed. Visceral structures anterior to the heart were sectioned transversely, after which they were deflected caudally. Visceral and heart attachments were then severed. The gonads were removed and placed in 10%

solution of formalin.

The cloaca was removed from the coelomic cavity by freeing its attachment to the anal sphincter. The structure was then pulled outward until the recto-cloacal junction was exposed. Severance of the cloaca from the rectum was made anterior to the junction. Cloacas removed in this way were labeled and stored in 10% solution of formalin.

The cloaca of each specimen, in preparation for its study, was slit along either the mid-ventral or mid-dorsal surface from a point a little beyond the recto-cloacal junction to the free border of the anal sphincter. The free edges of the slit were pinned back, allowing a complete view of all compartments and their adjoining structures.

The pinning was done upon a special cork surfaced dissecting box, which was improvised to fit over the stage and base of a BKW Wide Vision Bausch and Lomb Microscope. Ordinary common pins and sizes 00, 0, 3, and 5 insect pins were used. For very fine work concerning the smaller folds and papillae, sizes 00 and 0 were used.

All dissections were made at 7X using a BKW Wide Vision Bausch and Lomb Microscope. Measurements were obtained by use of metal dividers and recorded in millimeters. A standard, white celluloid, six-inch millimeter rule was used. In determining the diameters of the compartments of the cloaca, a longitudinal incision was made along either the mid-ventral or mid-dorsal region. The free borders of the cloaca were then pinned back, care taken not to alter the size of the chambers by undue stretching. This procedure allowed full view of all compartments and structures within the cloaca.

Due to the fact that the cloacas had previously been placed in a 10% formalin solution, which hardened the tissues, the original position of all folds and structures was preserved. In determining the

diameters of the compartments it was necessary to measure only the distance between their lateral walls, the original position of these walls being made conspicuous when the interior of the cloaca was exposed. Measurements made on cross sections of the various compartments of cloacas, indicated that the above procedure was fairly accurate.

Structures were weighed on an analytical balance and results were recorded in milligrams. Measurements and weights taken for each age group and for each sex were averaged. A study was then made of the difference found between the different age groups of each sex and between the sexes themselves.

Sketches were made from the actual dissections, which were pinned down and held in place on standard $7\frac{1}{4}$ x 11 wax bottom dissecting pans. As considerable time elapsed during the period these dissections were being sketched, it was necessary to keep the specimens preserved and in proper position at all times. Because of this, the specimens to be sketched were kept pinned in position and covered with a 6% solution of formalin. This strength was chosen as being suitable for preserving the tissue and eliminating molds, yet not being of sufficient strength to affect one moderately sensitive to the odor of formalin. Glass plates were cut to size to fit over these pans so that the specimens to be sketched could be kept on hand at all times and available for study and comparison.

III. OBSERVATIONS

A. Anatomy of the Avian Cloaca

All observations given in this section were made as described in the preceding pages. Observations made are shown in Plates I, II, and III.

1. FOWL. The cloaca of the fowl is the posterior termination of the digestive system. It lies within a U-shaped cavity bounded dorsally by the caudal vertebrae and posteriorly by the posterior third of the sacrum and laterally by the caudal processes of the ilia. The ventral surface lies free within the abdominal cavity. The cloaca is a funnel shaped structure which is attached anteriorly to the rectum and posteriorly to the body wall.

Ventral aspect. Plate I, Figure 2 shows that the coprodaeum (b) is the largest and most anterior of the cloacal compartments. It is triangular in shape and limited anteriorly by the recto-coprodael junction (d). Longitudinal folds (o) at this junction suggest the presence of a sphincter. This is in agreement with the observation of Gadow (1887). Calhoun (1933) however did not find a definite sphincter at this junction. Posteriorly the uro-coprodael fold (e) separates this chamber from the urodaeum (l). Plate III, Figure 3 shows that the coprodael surface of the uro-coprodael fold (e) is lobulated at its free margin and membranous. It forms an orifice which in some specimens is circular and in others it is elliptical. Plate I, Figure 2 shows that the urodaeum is posterior to the

PLATE I

Avian Cloaca.

Figure 1. External surface; fowl; age 1 day; A. Dorsal aspect; male. B. Ventral aspect; female. C. Dorsal aspect; female. X 1.

Figure 2. Ventral aspect; male fowl; age 153 days. X 1.

Figure 3. Ventral aspect; female; Hungarian Partridge; age 96 days. X 1.

Figure 4. Ventral aspect; female ringneck Pheasant; age 106 days. X 2.

(a) rectum; (b) coprodaeum; (c) bursa; (d) recto-coprodael junction; (e) uro-coprodael fold; (f) and (f') uretal papillae with apertures; (g) and (g') genital papillae; (h) proctodaeum; (i) broad dorsal fold of proctodaeum; (j) uro-proctodael fold; (l) urodaeum; (m) and (m') genital pockets; (o) longitudinal fold of coprodaeum; (t) uretal vestibule; (u) aperture of bursal canal.

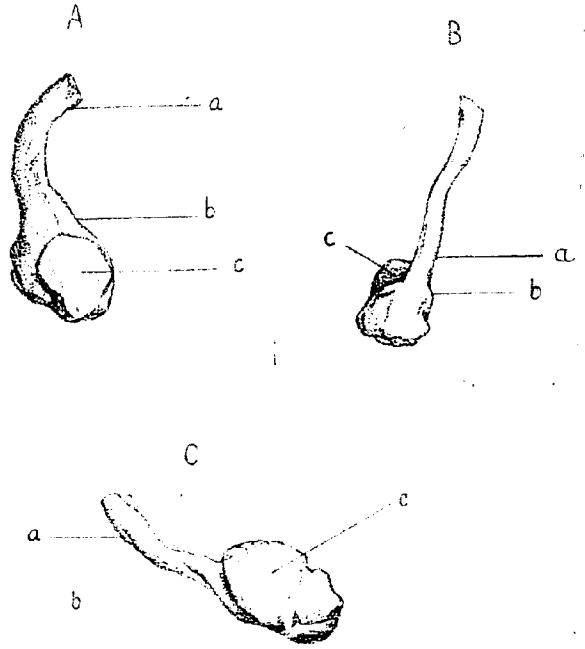
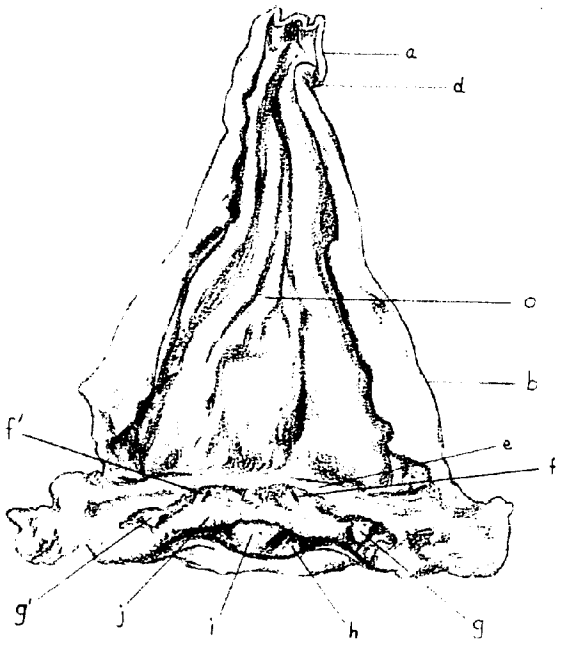


Figure 1



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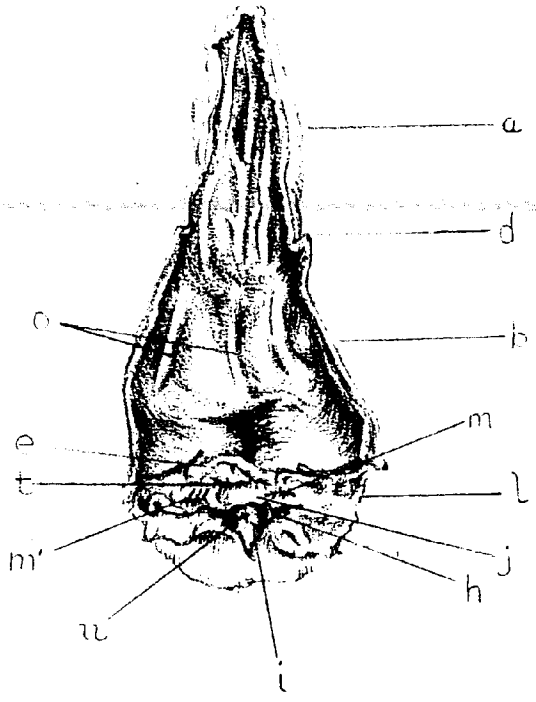


Figure 3

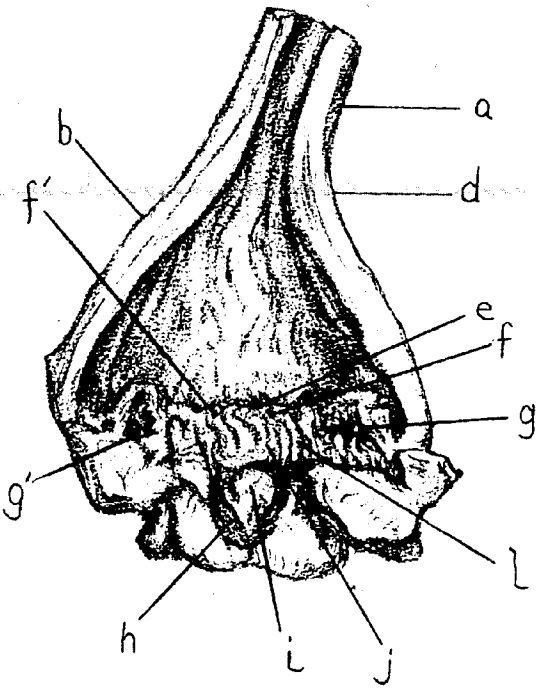


Figure 4

coprodaeum. It is rectangular in shape and smaller than either the coprodaeum or the proctodaeum. Anteriorly this chamber is limited by the uro-coprodael fold (e) and posteriorly by the uro-proctodael fold (j). This is in agreement with the observations of Forbes (1877) and Gadow. Located on the median dorsal wall of the urodaeum are the uretal apertures (f and f') which are found either on the surface of disc-shaped papillae or longitudinal folds. Lateral to the uretal apertures are located cone-like genital papillae within pocket-like depressions. These observations are in agreement with those of Forbes.

It is likewise perceivable from Plate I, Figure 2 that the most posterior chamber of the fowl cloaca is the proctodaeum. It is rectangular in shape and larger than the urodaeum, yet smaller than the coprodaeum. Anteriorly it is separated from the urodaeum by the uro-proctodael fold (j). Posteriorly it is limited by the anal sphincter. Extending along the mid-dorsal wall of the compartment from the uro-proctodael fold to the anal sphincter is the broad fold (i), the anterior border of which is covered by the uro-proctodael fold.

Dorsal aspect. Plate II, Figures 3 and 4 show that the dorsal aspect of the cloacal compartments is essentially the same as that described for the ventral aspect. Observations made in this section suggest that the urodaeum can be divided into right and left moieties by the v-shaped uro-coprodael fold (e). Each moiety contains medially; a cone-shaped genital papilla (g) within a genital pocket (m) and laterally a uretal papilla and aperture (f). Further observations reveal that the uro-proctodael fold is less developed on the ventral wall of the urodaeum than on the dorsal wall. This observation is in agreement with that of Gadow who found that the "sphincter vesicle of Martin St. Ange" (uro-proctodael fold) was best developed

PLATE II

Avian cloaca and bursa.

Figure 1. Inner aspect of bursa; female Ringneck Pheasant. Age 106 days. X 2.

Figure 2. Inner dorsal aspect of cloaca; male Ringneck Pheasant. Age 66 days. Bursa has been severed from the proctodaeum and deflected to the left. X 1.

Figures 3 and 4. Inner dorsal aspect of cloaca; female fowl. Figure 3, age 180 days; Figure 4, age 166 days. Bursa has been severed from the proctodaeum and deflected to the left. X 1.

(a) rectum; (b) coprodaeum; (c) bursa; (d) recto-coprourel junction; (e) uro-coprodael fold; (f) and (f') uretal papillae with apertures; (g) and (g') penial papillae; (h) proctodaeum; (i) anus; (j) urodaeum; (k) and (k') penial pockets; (l) oviducal aperture; (o) longitudinal fold of coprodaeum; (p) bursal folds, (q) bursal canal.

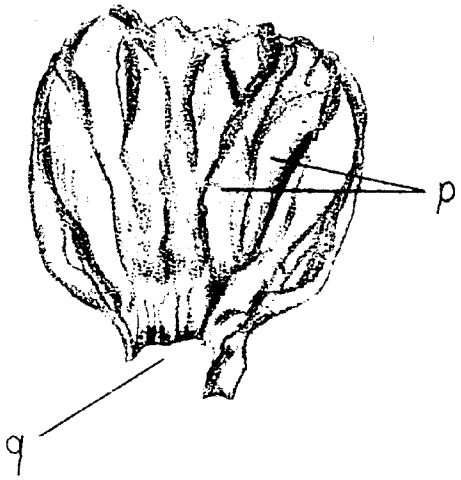
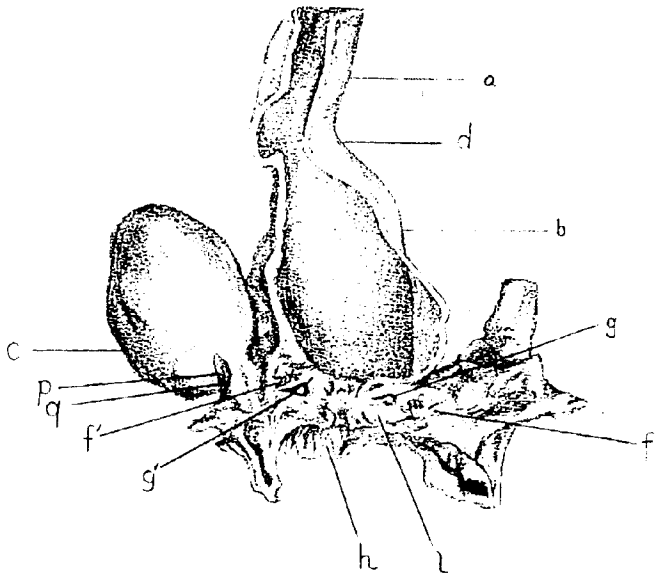


Figure 1



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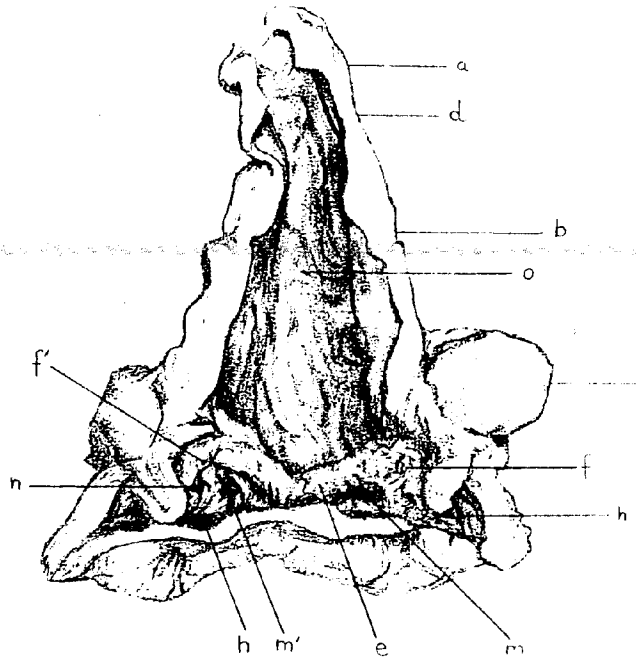


Figure 3

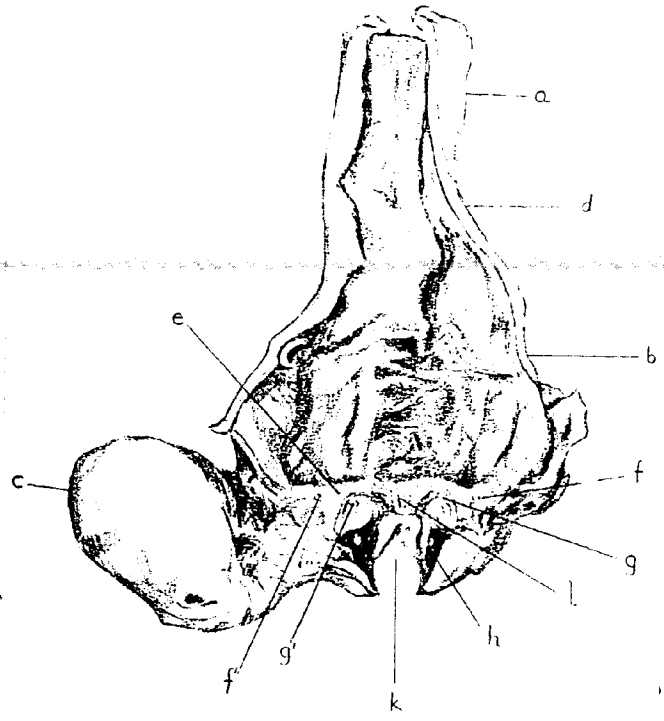


Figure 4

on the dorsal and lateral walls of the urodaeum. The proctodaeum (h) is almost completely covered by the uro-proctodael fold. This fold whose apex contacts the apex of the uro-coprodael fold completes the division of the compartment into right and left halves. Mid-ventrally the uro-proctodael fold is fused to the proctodaeum. Observations shown in Figure 4 reveal that the bursa (c) is attached to the dorsal surface of the proctodaeum (h). In Figure 3 the bursa is attached and almost completely covered by the deflected portion of the proctodaeum.

Sagittal aspect. Plate III, Figure 4 shows that anteriorly the coprodaeum (b) largest of the compartments is separated from the rectum (a) by a narrowed area, the recto-coprodael junction (d). The oblique fold (s) which arises from the inner ventral surface of the coprodaeum and extends dorso-caudally along the lateral wall of the chamber further suggests the presence of this junction. This agrees with the description given by Kaupp (1918) who used this fold as a means of identifying the recto-coprodael junction. Posteriorly the uro-coprodael membrane (e) separates this chamber from the urodaeum (l) which in this aspect appears as large as the proctodael chamber (h). On the ventral lateral wall of the urodaeum is a cone-like genital papilla (g) within a pocket-like depression. Just dorsal to the genital papilla is the uretal aperture (f) located on the tip of a papilla-like fold. Posteriorly the urodaeum is limited by the uro-proctodael membrane (j) which separates this chamber from the proctodaeum (h). The proctodaeum is limited anteriorly by the uro-proctodael membrane (j) and posteriorly by the anal wall. The bursa (c) is connected to the dorsal surface of the proctodaeum (h) by means of a funnel-shaped canal (q). Within the bursa are longitudinal mucosal folds (p) which extend along the walls from the dorsal surface to the canal. These observations

PLATE III

Avian cloaca and uro-coprodael aperture.

Figures 1 and 2. Sagittal aspect; Hungarian Partridge. Figure 1, male; age 59 days: Figure 2, female; age 86 days. Upper portion of bursa has been removed to show relationship of canal. X 1.

Figure 3. Uro-coprodael aperture; male fowl; age 184 days. Coprodaeum has been slit along its mid-ventral surface and the free edges of the slit deflected to expose orifice. X 1.

Figure 4. Sagittal aspect; female fowl; age 184 days. X 1.

(a) rectum; (b) coprodaeum; (c) bursa; (d) recto-coprodael junction; (e) uro-coprodael fold: (f) uretal papilla with aperture; (g) genital papilla (h) proctodaeum; (j) uro-proctodael fold; (k) anus; (l) urodaeum; (p) bursal folds; (q) bursal canal; (r) posterior wall of proctodaeum; (s) oblique fold of coprodaeum.

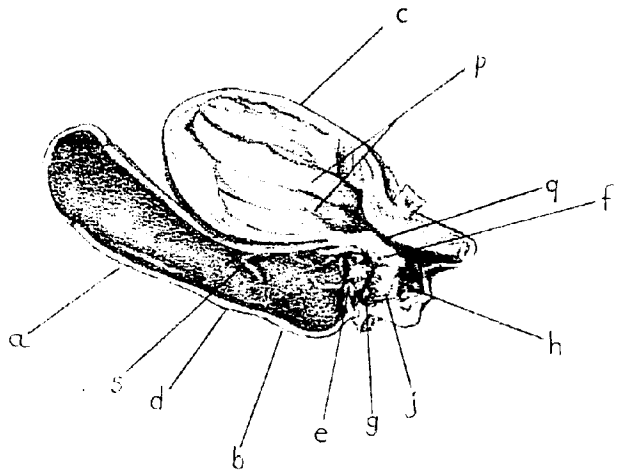


Figure 1

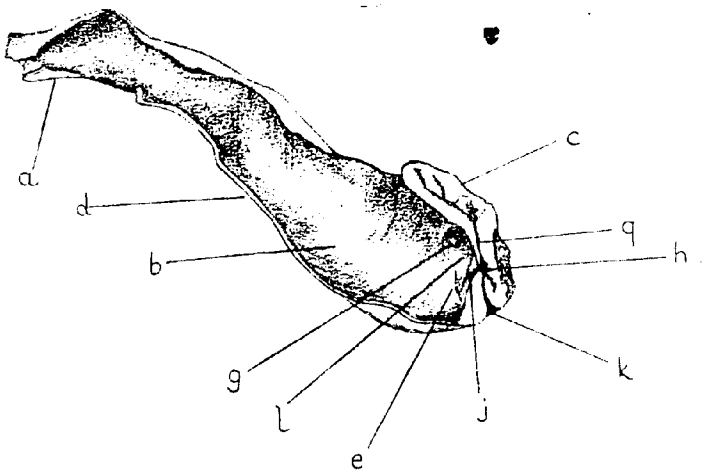


Figure 2

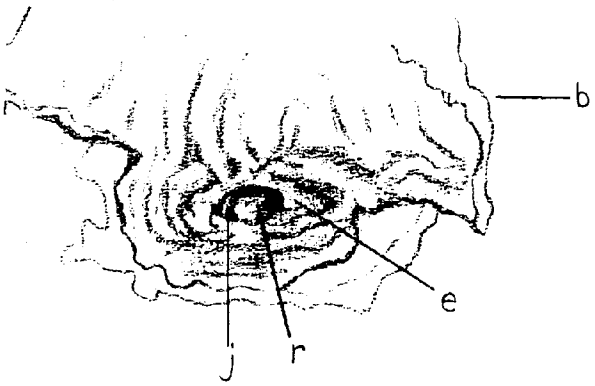


Figure 3

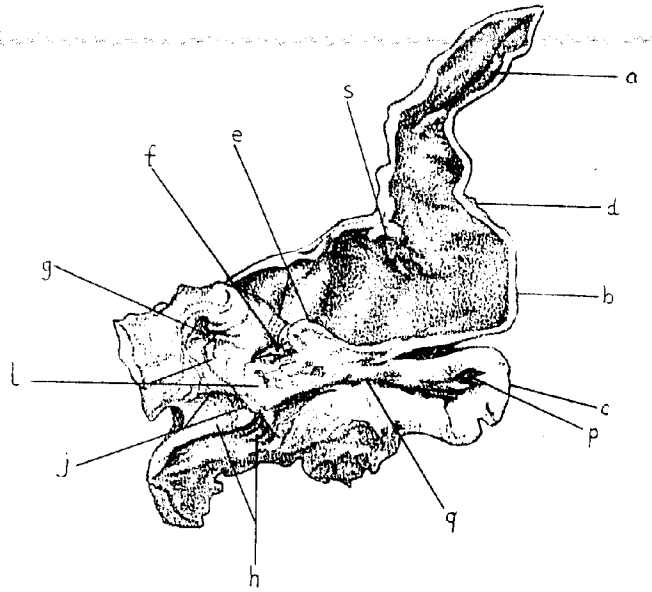


Figure 4

are in agreement with those of Forbes, Gadow, Groebbels (1932) and Macleod (1939).

Observations made on the cloaca of the fowl show that the coprodaeum is the most anterior and largest of the compartments. It is separated anteriorly from the rectum by a recto-coprodael junction and oblique fold. Posteriorly it is separated from the urodaeum by a uro-coprodael membrane. Just posterior to the coprodaeum is the urodaeum which is the smallest of the compartments. It is separated anteriorly from the coprodaeum by a uro-coprodael membrane and posteriorly from the proctodaeum by uro-proctodael membrane. On the ventro-lateral and dorso-lateral walls of this compartment are found the genital and uretal papillae. Posterior to the urodaeum is the proctodaeum which is median in size. It is separated anteriorly from the urodaeum by the uro-proctodael membrane. Posteriorly it is limited by the walls of the anal sphincter. Extending along the inner mid-dorsal wall of this compartment from its anterior to its posterior limits is found a broad fold, the anterior border of which is covered by the uro-proctodael fold.

2. PARTRIDGE. Observations made on the partridge were made as described in the preceding section. Observations are given in this section in Plate I, Figure 3 and Plate III, Figures 1 and 2.

Ventral aspect. It is evident from Plate I, Figure 3 that the coprodaeum (b) is separated anteriorly from the rectum (a) by a series of longitudinal folds (c) which suggest the presence of a sphincter at the recto-coprodael junction (d). The disappearance of the folds (c) in this area and the appearance of an external fold further supports the view that a sphincter is present at this point. A deep pocket is found at the posterior limit of the coprodaeum. Posterior to the

coprodaeum and separated from it by an irregular lobulated membrane, the uro-coprodael fold (e), is the urodaeum (l). On the mid-dorsal wall of this compartment is found the uretal vestibule (t) in which are located the uretal apertures. Just lateral to the vestibule are the genital papillae within pocket-like depressions (m and m'). Posteriorly the urodaeum is separated from the proctodaeum (h) by an irregular lobulated membrane, the uro-proctodael fold (j). The broad fold (i) extends along the mid-dorsal wall of the proctodaeum from the uro-proctodael fold to the anal sphincter. In the middle of this fold, the anterior margin of which is covered by the uro-proctodael fold, is located the aperture of the bursal canal (u). Posteriorly the proctodaeum is limited by the walls of the anal sphincter.

Sagittal aspect. Plate III, Figures 1 and 2 show that the coprodaeum (b) is separated from the rectum (a) by a slight constriction, the recto-coprodael junction (d). An oblique fold (s) arises from the inner dorsal surface of the coprodaeum and extends ventrocaudally, terminating along the lateral wall of the compartment. The presence of this fold and the recto-coprodael junction suggest the presence of a sphincter. Posteriorly the coprodaeum is separated from the urodaeum (l) by the uro-coprodael fold (e). On the dorsal lateral wall of the urodaeum is the right uretal aperture located at the tip of a fold-like papilla (f). Ventral to this papilla and located on the wall of the urodael chamber is the cone-shaped genital papilla (g). Separating the urodaeum (l) from the proctodaeum (h) is the uro-proctodael fold (j) which is the anterior limit of the proctodael chamber. Posteriorly this chamber is limited by the walls of the anal sphincter. Entering the anterior dorsal border of the proctodaeum is the funnel-shaped bursal canal (q) leading from the bursa

(c). The cavity of the bursa, at these ages, is completely filled with well developed folds (p).

Observations made on the cloaca of the partridge show that the coprodaeum is limited anteriorly by a recto-coprodael junction and an oblique fold and posteriorly by a uro-coprodael membrane. Posterior to this chamber is the urodaeum which is limited anteriorly by the uro-coprodael membrane. Within this chamber on the dorso-lateral and ventro-lateral walls are found the uretal and genital papillae. Posterior to the urodaeum and separated from it anteriorly by the uro-proctodael membrane is the proctodaeum. Entering the anterior dorsal margin of this chamber is a canal leading from the cavity of the bursa which at certain ages is completely filled with folds.

3. PHEASANT. Observations made on the pheasant were made as described in the preceding section. Observations are presented in Plate I, Figure 4 and Plate II, Figure 2.

Ventral aspect. Plate I, Figure 4 shows that the rectum (a) is separated from the coprodaeum (b) by a constricted area, the recto-coprodael junction (d). The nature of the longitudinal folds in this area suggest the presence of a sphincter. Likewise, the coprodaeum is separated from the urodaeum (l) by the uro-coprodael fold (e). On the dorsal wall of the urodael chamber are the uretal apertures (f and f'). These apertures are found at the anterior border of longitudinal folds rather than on disc-shaped papillae observed in the fowl and partridge. The genital papillae (g and g') are just lateral to the uretal apertures and are similar to those described for the fowl and partridge in that they open into the chamber through pocket-like depressions. Posterior to the urodaeum and separated from it by

an irregular lobulated membrane, the uro-proctodael fold (j), is the proctodaeum (h). An obovate mucosal fold, the broad fold (i), is found upon the dorsal wall of this chamber. On the anterior margin of this fold is located the aperture of the bursal canal. Unlike the fowl and the partridge this aperture is covered by the uro-proctodael membrane. Posteriorly the proctodaeum is limited by the walls of the anal sphincter.

Dorsal aspect. Plate II, Figure 2 shows that the rectum (a) is separated from the coprodaeum (b) by a constriction, the recto-coprodael junction (d). Posteriorly this compartment is separated from the urodaeum (l) by an irregular lobulated membrane, the uro-coprodael fold (e). On the ventro-lateral wall of this chamber are found the cone-shaped genital papillae (g and g') within pocket-like depressions. Lateral to these papillae are the uretal apertures (f and f') often located on small elevated mucosal folds. Posterior to the urodaeum and separated from it by the uro-proctodael fold, is the proctodaeum (h). The pouch-shaped bursa (c) is connected to the dorsal surface of the proctodaeum (h) by means of a canal (q). Within the bursa are well developed folds (p). Posteriorly the proctodaeum is limited by the walls of the anal sphincter.

It is evident from the preceding observations that the cloaca of the fowl, partridge and the pheasant consists of three compartments. Observations made on the individual compartments show that the coprodaeum in the three species studied is the largest, while the urodaeum is the smallest. The proctodaeum is smaller than the coprodaeum, yet larger than the urodaeum.

Observations made show that these compartments and their limits are essentially the same in the three species studied. The position of

the urinal and genital papillae is similar in the fowl, partridge and pheasant. Likewise all species studied were similar in that they showed a bursa connected to the dorsal surface of the proctodaeum by a funnel-shaped canal and a broad fold extending along the mid-dorsal wall of this chamber.

It is likewise evident from the preceding observations that the deep pocket at the posterior limit of the coprodaeum and the urinal vestibule in the urodaeum of the partridge were unlike that seen in the fowl and pheasant. An oblique coprodael fold was observed in the fowl and pheasant while none was seen in the partridge. The pheasant differed in urinal papillae in that they were always found on the anterior edges of longitudinal folds and not disc-shaped as in both the fowl and partridge. The bursal aperture was exposed in the partridge while in the fowl and pheasant it was covered by the uro-proctodael fold.

B. Relation between Size and Age of the Cloaca in the Fowl from Hatching Date to Sexual Maturity

Observations given in this section of the study will be presented in Figures 1 and 2 and Table 1.

CLOACA. Comparative sizes of the fowl cloaca from hatching time to sexual maturity were observed. These observations are shown in Figures 1 and 2 and Table 1. Length measurements were obtained by use of metal dividers. The recto-coprodael junction was used as the anterior limit of the cloaca and the walls of the anal sphincter as the posterior limit. The cloaca was opened by making a longitudinal incision along its ventral or dorsal surface. The free edges of the incision were then turned back and pinned to the dissection pan. Extreme care was used in obtaining the measurements. In those specimens in which the recto-coprodael junction was indefinite, the anterior limit of the coprodaeum was approximated at a point midway between the rectum and coprodaeum.

Figure 1, Table 1, Column 5 show that the length of the male cloaca increased from 5.8 mm in the 17 day foetus to a maximum of 41.2 mm in the 131 day fowl, decreased to 34.0 mm in the 156 day fowl, and then remained fairly uniform in size (33.3 mm) until the 195 th day. Increase in length of the female cloaca, closely paralleled that of the male, but differed in that maximum length (36.2 mm) in the female on the 131 st day was less than maximum length (41.2 mm) in the male. It is also evident in Figure 1, Table 1 that constancy of increase in length remained more uniform in the

Figure 1. Length of the cloaca in the fowl. Ordinates, length of cloaca in millimeters. Abscissae, age in days. _____, males; - - - -, females.

Figure 2. Width of the cloaca in the fowl. Ordinates, width of cloaca in millimeters. Abscissae, age in days. _____, males; - - - -, females.

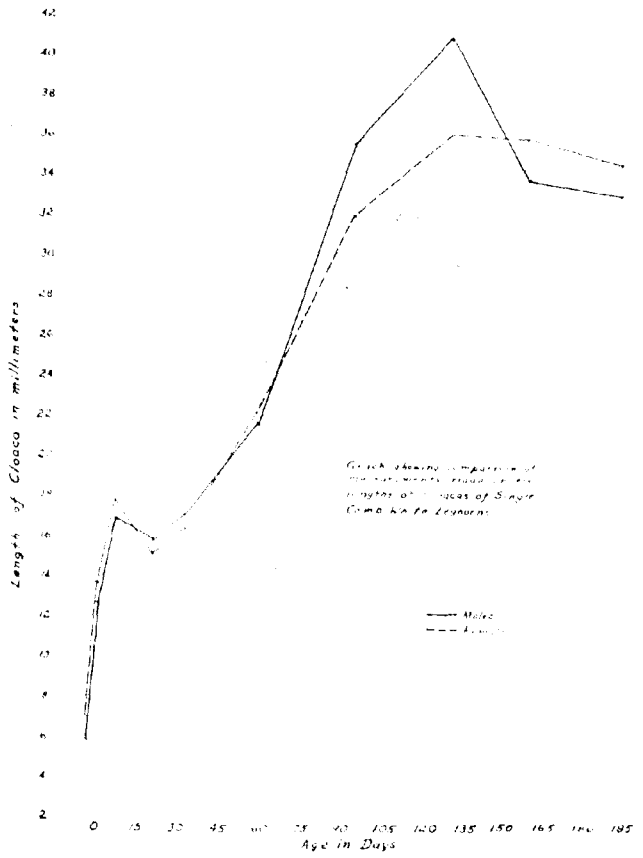


Figure 1

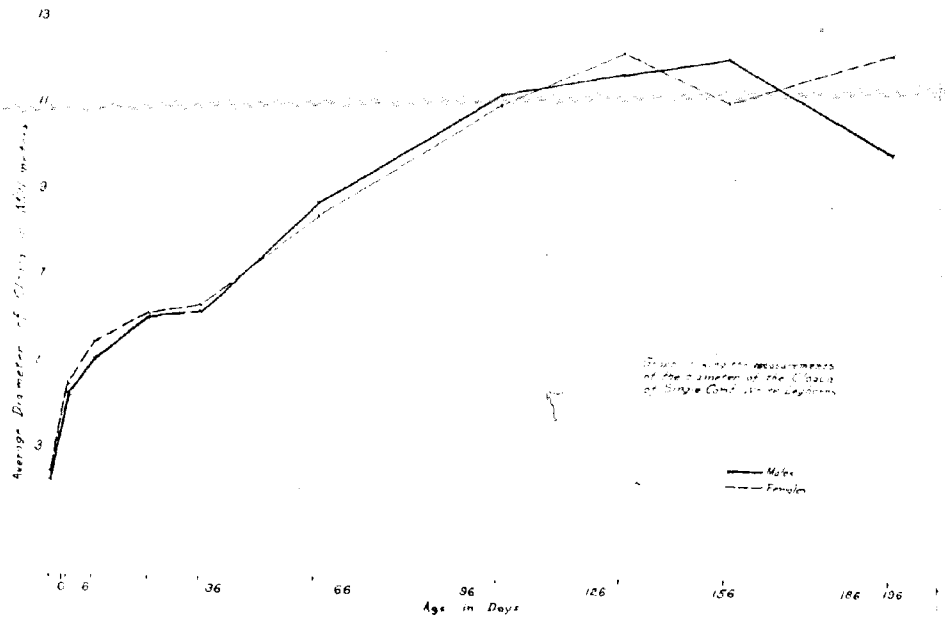


Figure 2

TABLE 1

SIZE OF THE FOOT CIOACA FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4	5	6
Sex	Age in Days	Month Specimen Killed 1941	Number of Specimens	Length (mm)	Width (mm)
	17 day foetus	January	8	5.8	2.2
	1	January	11	13.6	4.3
	7	January	13	16.9	5.0
	20	February	10	15.8	6.0
	32	February	12	17.0	6.2
	59	February	10	21.6	8.7
Male	101	Aug.-Sept.	6	35.7	11.3
	131	Sept.-Nov.	5	41.2	11.8
	156	November	6	34.0	12.2
	195	September	4	33.3	10.0
	17 day foetus	January	4	7.0	2.4
	1	January	11	13.6	4.4
	7	January	13	17.8	5.4
	20	February	10	15.0	6.0
	32	February	13	16.4	6.3
	59	February	10	22.1	8.4
Female	101	Aug.-Sept.	16	32.1	11.1
	131	Sept.-Nov.	5	36.2	12.3
	156	November	7	36.2	11.2
	195	September	9	34.8	12.3

female from the 131 st day (36.2 mm) to the 195 th day (34.8 mm) than it was in the male over the same period of time. The variations in length of the cloaca between the 7 and 20 day chick are probably not significant.

Further analysis of these results show that the percentage increase of cloacal length in the male was 272.4 from the 17 day foetus to the 59 day fowl while from the 59 day fowl to the 131 day fowl, the age at which maximum length was attained, percentage increase decreased to 90.7. Following the 131 st day the percentage decrease in length was 23.7. Likewise in the female the percentage increase of cloacal length from the 17 day foetus to the 59 day fowl was 215.7 while from the 59 day fowl to the 131 day fowl, the age at which maximum length was attained, the percentage increase decreased to 63.8. In the period between 131 days and 195 days the percentage decrease in length of the cloaca was 4.0.

It is evident from these results that percentage increase in length of the cloaca in the male was greater than it was in the female from hatching date until a maximum was reached (41.2 mm). However, the percentage decrease in length of the cloaca was less in the female after the maximum was reached than in the male.

Figure 2, Table 1, Column 6 show that the width of the cloaca in the male increased from 2.2 mm in the 17 day foetus to a maximum of 12.2 mm in the 156 day fowl and then decreased to 10.0 mm at the 195 th day, which is probably not significant. Increase in width of the female cloaca closely paralleled that of the male but differed in that the maximum width of the cloaca was reached on the 131 st day and remained fairly constant until sexual maturity. The small variations shown between the 131 st and the 156 th day are probably

not significant and depend on (1) paucity of observations, and (2) unavoidable inaccuracies in the method used.

Further analysis of these results show that the percentage increase in width of the male cloaca was 295.4 from the 17 day foetus to the 59 th day while from the 59 th to the 156 th day, when the maximum was reached, the percentage increase in width decreased to 40.2. Further study of Figure 2 and Table 1 will show that the percentage increase in cloacal width in the female closely paralleled that of the male.

It is evident from these results that the male shows a greater increase in percentage growth in size of the cloaca than the female and that maximum size in both sexes is attained from the 131 st day to the 156 th day. Size of the cloaca from the 156 th day to sexual maturity remains fairly constant in both sexes.

C. Relation between Size and Age of the Coprodaeum, Urodaeum and Proctodaeum in the Fowl from Hatching Date to Sexual Maturity

Observations made on the coprodaeum, urodaeum and proctodaeum are presented in Figures 3-8 inclusive and Table 2.

Coprodaeum. In making the length observations, the recto-coprodael junction was used as the anterior limit while the uro-coprodael fold was used as the posterior limit. In observations on width the walls of the coprodaeum were used as the lateral limits. Mean widths at the recto-coprodael junction (narrowest limit) and at the uro-coprodael fold (widest limit) were averaged giving a value that represented the mean width of the compartment.

Results given in Figure 3 and Table 2 Column 4 will show that the length of the male coprodaeum increased from 3.3 mm in the 17 day foetus to 11.9 mm in the 7 day chick, decreased to 10.4 mm in the 20 day chick, and then increased to a maximum of 26.3 mm on the 131 st day. Following the 131 st day the length decreased to 19.8 mm in the 195 day fowl.

Further analysis of these data will show that the percentage increase in length of the coprodaeum of the male reached 260.6 from the 17 day foetus to the 7 day chick, decreased to 14.4 between the 7 and 20 days, then increased again to 152.9 between the 20 th and 131 st day. Maximum length of 26.3 mm was reached on the 131 st day. It is evident from further study of Figure 3 and Table 2 Column 4 that the percentage increase in length of the coprodaeum in the female parallels fairly closely that of the male.

Figure 4, Table 2 Column 5 show that the width of the male

Figure 3. Length of coprodaeum in the fowl. Ordinates, length in millimeters. Abscissae, age in days. _____, males; - - - -, females.

Figure 4. Width of coprodaeum in the fowl. Ordinates, width in millimeters. Abscissae, age in days. _____, males; - - - -, females.

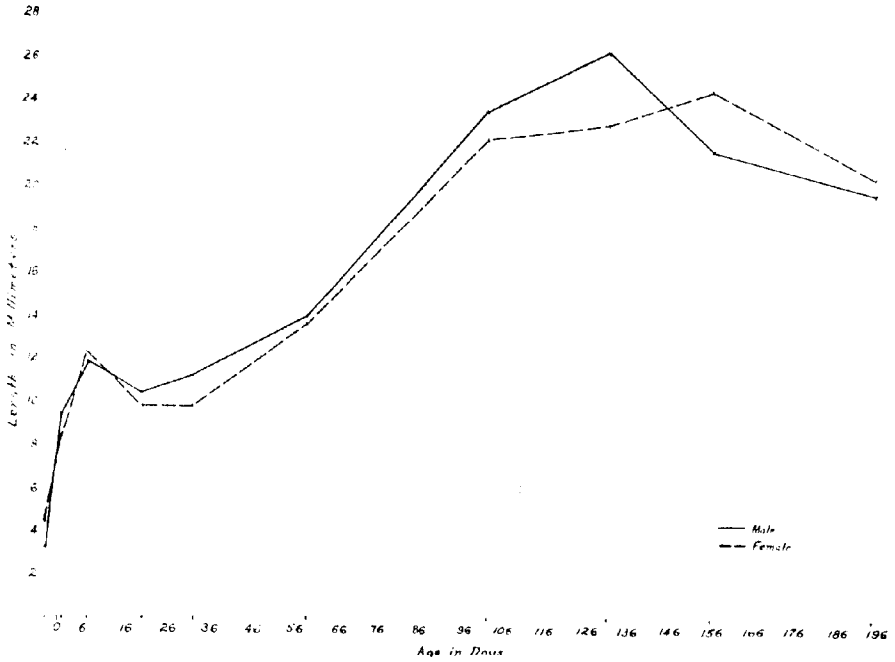


Figure 3

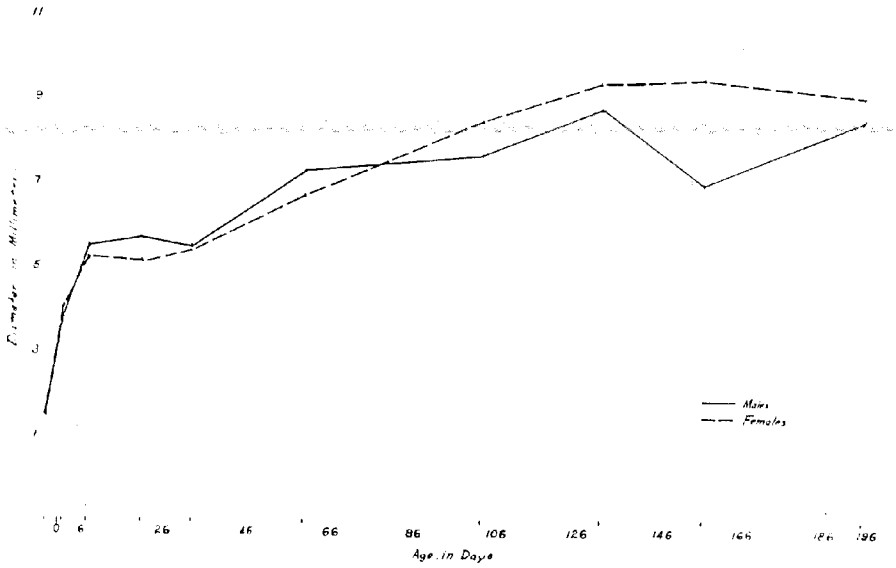


Figure 4

TABLE 2

SIZE OF COMPARTMENTS OF THE FOWL CLOACA
FROM HATCHING DATE TO SEXUAL MATURITY

			Columns					
1	2	3	4	5	6	7	8	9
			Coprodaeum		Urodaeum		Proctodaeum	
Sex	Age in Days	Number of Specimens	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)
	17 day foetus	8	3.3	1.5	1.2	2.9	1.0	2.8
	1	11	9.3	3.8	1.6	3.8	2.3	4.7
	7	13	11.9	5.5	2.0	4.0	3.5	5.4
	20	10	10.4	5.7	2.9	6.0	4.0	6.9
Male	32	12	11.2	5.5	3.0	6.5	4.2	7.3
	59	10	14.0	7.3	4.0	9.1	5.1	11.1
	101	6	23.8	7.7	4.6	12.8	7.5	13.5
	131	5	26.3	8.8	4.9	13.6	7.2	15.8
	156	6	21.8	7.0	4.7	12.0	7.7	12.5
	195	4	19.8	8.6	4.5	12.4	6.8	10.8
	17 day foetus	4	4.4	1.5	1.3	3.0	1.4	3.2
	1	11	9.2	4.1	1.7	4.1	2.5	5.1
	7	11	12.3	5.2	2.0	4.9	3.1	6.9
	20	10	9.8	5.1	2.9	6.3	3.7	7.4
	32	13	9.8	5.4	2.9	7.0	4.5	8.1
Female	59	10	13.7	6.7	4.2	9.3	5.1	11.2
	101	16	22.3	3.5	4.7	12.6	7.1	13.7
	131	5	23.0	9.4	4.9	13.3	7.4	16.4
	156	7	24.6	9.5	4.9	11.6	7.4	13.4
	195	9	20.6	9.1	7.6	15.8	9.6	14.9

coprodaeum increases rapidly from 1.5 mm in the 17 day foetus to 5.5 mm in the 7 day chick then increases slowly to reach a maximum width of 8.8 mm on the 131 st day after which the width remains fairly constant through the 195 th day. The slight decrease in width on the 156 th day is probably not significant.

Comparison of the data given in the above figure and table shows that width of the female coprodaeum is approximately equal to that of the male on the 72 nd day and that the width in the female is greater than in the male from this date until the 195 th day.

Further analysis of these data will show that the percentage increase in width of the male coprodaeum from the 17 day foetus to the 7 day chick was 266.6 and that from the 7 th day to the 195 th day, when maximum width was reached, it decreased from 266.6 to 60.0. It is evident from further study of Figure 4 and Table 2 Column 5 that percentage increase in width of the coprodaeum in the female closely parallels that of the male from hatching date through sexual maturity.

Transposition of the data obtained for length and width of the coprodaeum at various ages to growth makes it apparent that growth increases rapidly from hatching date to the 7 th day, and then it remained fairly constant until a maximum was reached on the 131 st day. The decreased length and width of the coprodaeum on the 156 th day is probably not significant as observations were recorded for only six birds.

Urodaeum. In measuring the length of the urodaeum, the uro-coprodael fold was considered as the anterior limit while the uro-proctodael fold was taken as the posterior limit. In measuring the width of the urodaeum, the inner walls of the compartment were con-

sidered as the lateral limits. Results are presented in Figures 5 and 6 and Table 2 Columns 6 and 7.

Figure 5, Table 2 Column 6 show that the length of the urodaeum in both male and female closely parallel each other until the 131 st day. The female urodaeum then increases rapidly to a maximum of 7.6 mm on the 195 th day while the length of the urodaeum in the male reaches the maximum of 4.9 mm on the 131 st day and remains rather constant in size (4.5 mm) through the 195 th day. It is evident that the increase in length from 1.2 mm in the 17 day foetus to a maximum of 4.9 mm in the 131 day male is gradual and that the length remains fairly constant from this age through the 195 th day.

In comparing the percentage increase it can be seen that in the male from the 17 day foetus to the 59 th day, the percentage increase was 233.3 while in the female for the same period the increase was 223.1. From the 59 th to the 195 th day percentage increase in the male reached only 12.5 as compared to 81.0 in the female.

These results make it evident that percentage increase in length of the urodaeum was essentially alike in both sexes until the 59 th day and then percentage increase in length from the 59 th day to the 195 th day was greater in the female (81.0) than it was in the male (12.5).

A comparison of the data given in Figure 1 and Table 1 with the data given in Figures 5 and 6 and Table 2 shows that the increased length of the female cloaca in fowl between the ages of 156 days and 195 days is due primarily to the increase in length of the urodaeum. It was brought out in the preceding pages that the length of the coprodaeum remained fairly constant between the 156 th and 195 th days.

Figure 5. Length of the urodaeum in the fowl. Ordinates, length in millimeters. Abscissae, age in days. _____, males; - - - -, females.

Figure 6. Width of the urodaeum in the fowl. Ordinates, width in millimeters. Abscissae, age in days. _____, males; - - - -, females.

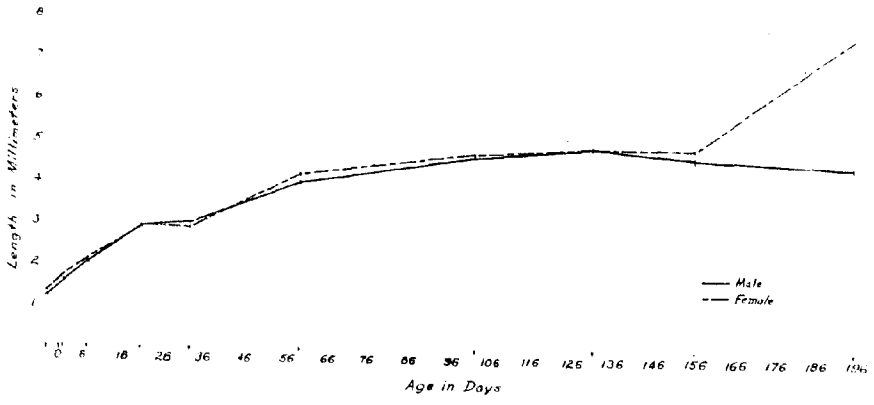


Figure 5

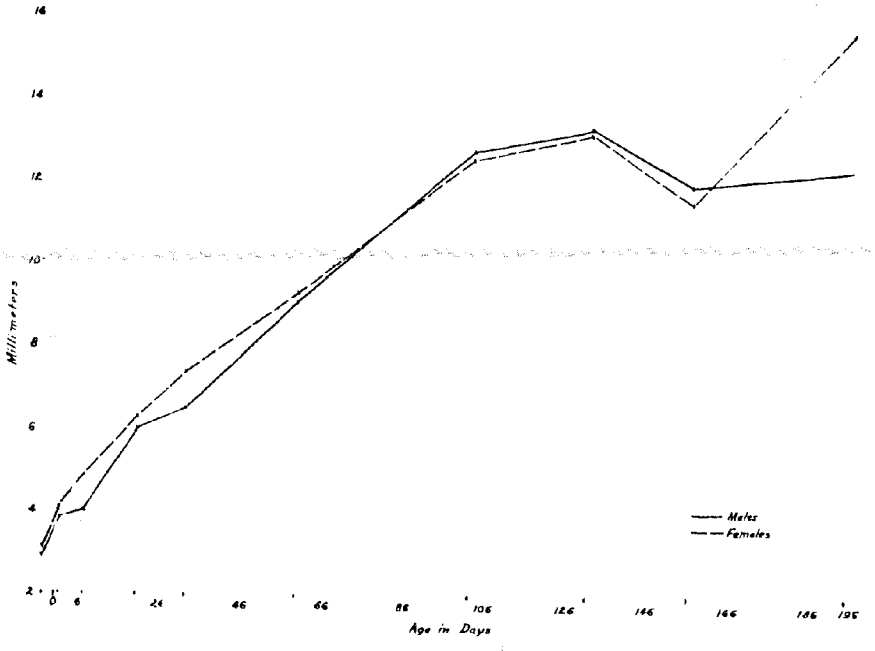


Figure 6

Figure 6, Table 2 Column 7 show that the width of the urodaeum in the male increased from 2.9 mm in the 17 day foetus to a maximum of 13.6 mm on the 131 st day and remained fairly constant in width through the 195 th day. Further analysis of these data will show that the percentage increase in width in the male was 369.7 from the 17 day foetus until the maximum was reached on the 131 st day after which a percentage decrease of 9.8 was recorded from the 131 st day to the 195 th day. It is evident from the data given in the above figure and table that the percentage increase in width of the female urodaeum closely parallels that of the male through the 131 st day, but in the female, percentage increase in width was greater (18.8) from the 131 st day until the 195 th day than it was in the male (9.8) in the same period.

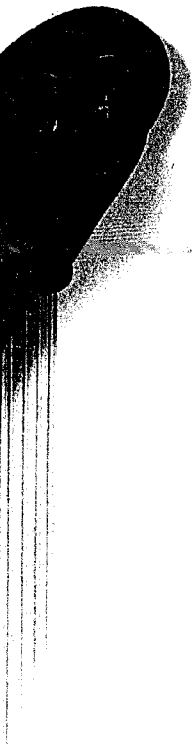
Proctodaeum. In measuring the length of the proctodaeum the uro-proctodael fold was considered as the anterior limit while the inner walls of the anal sphincter were considered as the posterior limit. Results are presented in Figures 7 and 8 and Table 2.

Figure 7, Table 2 Column 8 show that the length of the proctodaeum in the male rapidly increased from 1.0 mm in the 17 day foetus to 3.5 mm in the 7 day chick, slowly increased to a maximum of 7.5 mm on the 101 st day and then remained fairly constant through the 195 th day. The decrease in length recorded for the 195 th day is probably not significant and would undoubtedly approximate the length recorded for the 101 st day fowl if observations were made on a greater number of birds.

Further analysis of this data will show that the percentage increase in length of the male proctodaeum increased 250.0 from the 17 day foetus to the 7 day chick then decreased to 114.3 at the

Figure 7. Length of the proctodaeum in the fowl. Ordinates, length in millimeters. Abscissae, age in days. ____, males; - - - -, females.

Figure 8. Width of the proctodaeum in the fowl. Ordinates, width in millimeters. Abscissae, age in days. _____, males; - - - -, females.



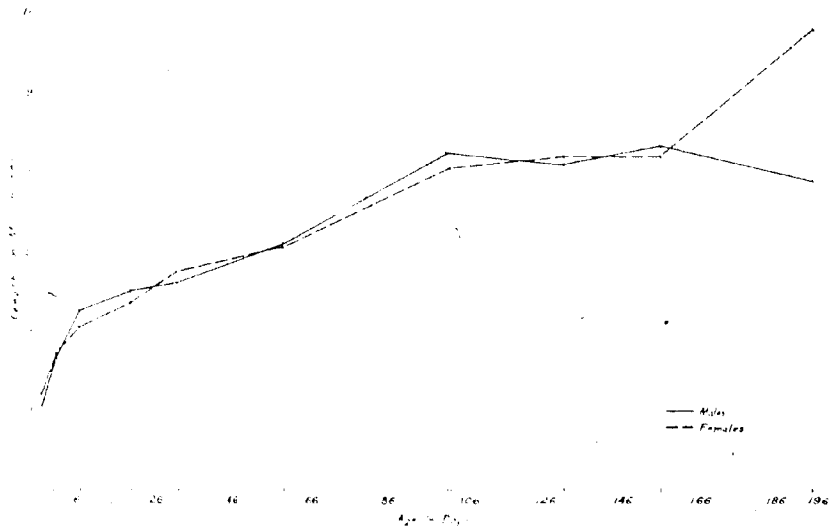


Figure 7

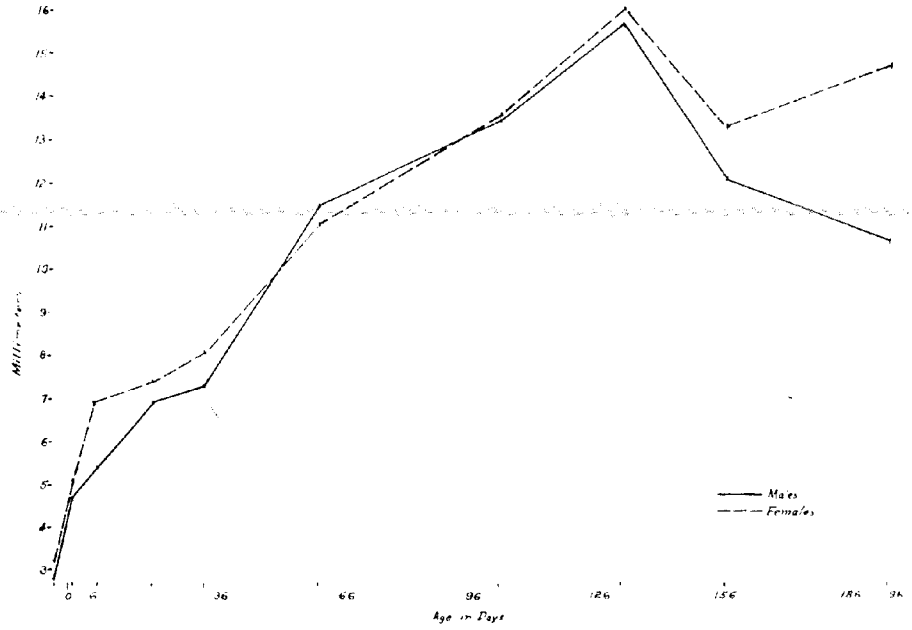


Figure 8

101 st day, the age at which maximum length was reached. Further study of the above figure and table will show that the percentage increase in length of the proctodaeum of the female closely parallels that in the male to the 156 th day and then percentage increase in length is greater in the female than it is in the male from the 156 th day to the 195 th day.

Figure 8, Table 2 Column 9 show that the width of the male proctodaeum increased from 2.8 mm in the 17 day foetus to a maximum of 15.8 mm in the 131 day fowl then decreased to 10.8 mm on the 195 th day.

Further analysis of these results will show that the percentage increase in width of the proctodaeum in the male was 464.3 from hatching date until maximum width was reached (131 days) and then decreased to 46.3 at the 195 th day. It is evident from the above figure and table that percentage increase in the female is fairly closely correlated with that of the male from hatching date to sexual maturity. Transposition of the data obtained for length and width of the proctodaeum at various ages to growth shows that growth in length is similar in the male and female from hatching date through the 156 th day, and that growth is accelerated to a greater degree in the female between days 156 and 195 than it is in the male in the same period.

CLOACAL PAPILLAE. Specific attention was paid to size of the uretal and genital papillae which were located on the dorso-lateral and ventro-lateral walls of the urodaeum (1), (Plate III, Figure 4).

Observations given in this section were made by the use of metal dividers and a standard white celluloid millimeter rule. Observations made are presented in Tables 3 and 4.

a. Uretal papillae. Table 3, Columns 3 and 4 demonstrate that the mean height and width of the uretal papillae in the male and female remained fairly constant from hatching date through sexual maturity, and that there was no significant increase in growth during this time in either the male or female.

b. Genital papillae. Table 4 Column 4 shows that the height of the genital papillae in the male increased from 0.5 mm in the 17 day foetus to a maximum of 3.7 mm in the 131 day fowl and then remained fairly constant through the 195 th day. The variation following the maximum at 131 days are probably not significant.

Further analysis of the preceding data shows that the percentage increase in height of the genital papillae in the male was 640.0 from hatching date until the maximum was reached (131 days), after which the percentage decrease was 15.6 which is probably not significant. It is evident from Table 4 Column 4 that the percentage increase in height of genital papillae in the female closely parallels that of the male through the 32 nd day after which the male shows a greater increase than the female until the maximum on the 131 st day. Following the 131 st day the female showed a rapid atrophization of the papillae. Further study of Table 4 Columns 5 and 6 made it apparent that the widths and thicknesses of the genital papillae in the male and female closely parallel the increase in height.

Comparison of the results given in the preceding paragraph make it evident that increase in growth of the genital papillae when measured by percentage increase is fairly similar in the male and female from the date of hatching through the 32 nd day after which the male showed a greater increase until the maximum is reached on

TABLE 3

MEAN HEIGHTS AND WIDTHS OF URETAL PAPILLAE IN THE FOWL FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4
Age in Days	Number of Specimens	Height (mm)	Width (mm)
17 day foetus	12	0.4	0.3
1	22	0.5	0.4
20	20	0.5	1.0 *
32	25	0.5	1.3 *
59	20	1.0 #	0.5
101	22	0.5	0.5
131	10	0.5	0.5
156	13	---	0.5
195	13	---	0.6

* Several specimens in which the apertures were unusually wide.

\# The males gave unusually high measurements.

--- No definite papillae could be observed.

TABLE 4

SIZE OF GENITAL PAPILLAE IN THE FOWL
FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4	5	6
Sex	Age in Days	Number of Specimens	Height (mm)	Width (mm)	Thickness (mm)
Male	17 day foetus	8	0.5	0.4	0.2
	1	11	0.6	0.4	0.3
	7	13	0.8	0.6	---
	20	10	1.1	0.9	0.4
	32	12	1.2	0.9	0.5
	59	10	2.0	1.3	1.0
	101	6	2.8	1.6	1.0
	131	5	3.7	1.9	1.4
	156	6	2.8	1.6	1.5
	195	4	3.2	1.8	1.1
Female	17 day foetus	4	0.4	0.3	0.2
	1	11	0.5	0.5	0.3
	7	11	0.9	0.6	0.3
	20	10	1.0	0.8	0.4
	32	13	0.9	0.9	0.5
	59	10	1.2	1.2	0.8
	101	16	1.6	1.3	0.8
	131	5	2.0	1.6	1.0
	156	7	1.7	1.5	0.9
	195	9	*	*	*

--- Data not taken.

* Only three specimens showed presence of papillae; they averaged 2.1 mm in length, 0.9 mm in width, and 0.8 mm in thickness.

the 131 st day.

The variation in height, width and thickness of the genital papillae in the male following the 131 st day is probably not significant for the following reasons: (1) too few observations made, and (2) method used allows for greater variations. In the female a rapid decrease in growth occurred following the maximum at 131 days through the 195 th day. It is also evident from the preceding results that the genital papillae in the male reached a greater size than the female from hatching date to sexual maturity.

D. Relation between Size and Age of the Bursa in the Fowl from Hatching Date to Sexual Maturity

Observations made on the bursa are presented in Figures 9-13 inclusive and Tables 5-7 inclusive.

Bursa. Results shown in Figure 9, Table 5 Column 5 will show that the length of the bursa in the male increased from 4.7 mm in the 17 day foetus to a maximum of 21.4 mm in the 59 day fowl, remained fairly constant in length through the 131 st day, then decreased to 11.0 mm at the 195 th day. A further study of Figures 9 and Table 5 Column 5 make it evident that the length of the bursa in the female fairly closely parallels that of the male through the 59 th day after which it continues to increase in length, but the maximum of 26.8 is not reached until the 131 st day and then it decreases to 11.5 mm on the 195 th day.

Further analysis of the preceding results shows that the percentage increase in length of the bursa in the male was 355.5 from the 17 day foetus until the maximum was reached on the 59 th day. This fairly rapid increase to a maximum was followed by a decrease which on a percentage basis is 9.5 on the 195 th day. In the female the percentage increase in length of the bursa was 473.3 from the 17 day foetus until the maximum was reached on the 131 st day, then as was the case in the male, the length decreased. The percentage decrease was 133.0 from the 131 st day until the 195 th day.

It is perceivable from the preceding results that maximum length of the bursa (21.4 mm) is reached in the male in 59 days while in the female the length gradually increased to reach a maximum of

Figure 9. Length of the bursa in the fowl. Ordinates, length of bursa in millimeters. Abscissae, age in days. - - - -, males; ____, females.

Figure 10. Width of the bursa in the fowl. Ordinates, width of bursa in millimeters. Abscissae, age in days. _____, males; - - - -, females.

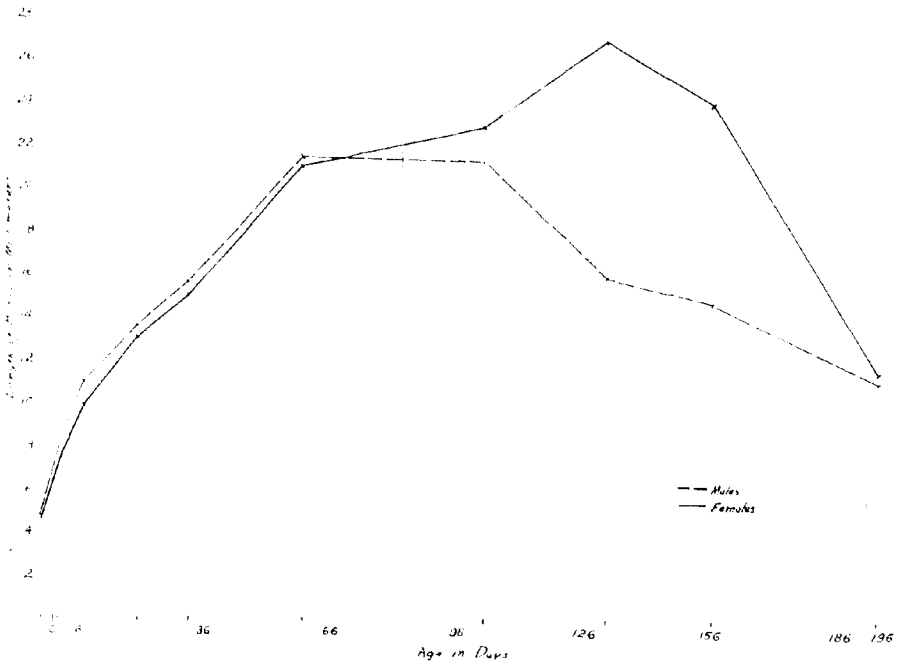


Figure 9

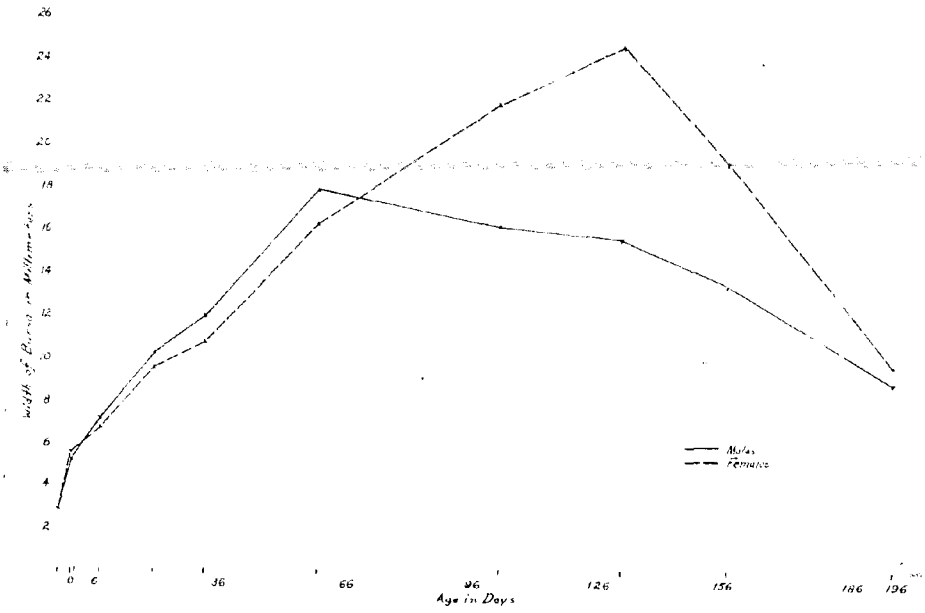


Figure 10

TABLE 5

SIZE AND WEIGHT OF THE BURSA IN THE FOWL FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4	5	6	7	8
Sex	Age in Days	Month Specimen Killed 1941	Number of Specimens	Length (mm)	Width (mm)	Thickness (mm)	Weight (mg)
	17 day foetus	January	8	4.7	2.8	2.0	12.6
	1	January	11	7.9	5.2	3.9	48.1
	7	January	13	11.0	7.1	4.4	114.9
	20	February	10	13.6	10.2	8.0	497.8
	32	February	12	15.6	11.9	10.0	761.1
Male	59	February	10	21.4	17.8	14.0	2189.1
	101	Aug.-Sept.	6	21.4	16.0	10.3	1530.8
	131	Sept.-Nov.	5	15.8	15.4	9.8	1821.0
	156	November	6	14.7	13.3	8.8	844.5
	195	September	4	11.0	8.7	5.2	232.0
	17 day foetus	January	4	4.5	2.9	1.7	14.0
	1	January	11	7.6	5.5	2.5	35.0
	7	January	11	9.9	6.7	4.1	65.5
	20	February	10	13.0	9.5	7.0	387.4
	32	February	13	15.0	10.7	9.2	759.1
Female	59	February	10	21.0	16.2	11.8	1823.4
	101	Aug.-Sept.	16	22.8	20.7	16.6	3406.6
	131	Sept.-Nov.	5	26.8	24.4	17.0	4827.4
	156	November	7	23.9	19.0	15.6	3306.0
	195	September	9	11.5	9.5	7.8	568.6

26.8 mm on the 131 st day.

Data given in Figures 10-12 inclusive and Table 5 Columns 6-8 inclusive likewise show that the width, thickness and weight of the bursa reaches a maximum on the 59 th day in the male and the decreases slowly to a vestige on the 195 th day. In the female the width, thickness and weight of the bursa increases slowly to reach a maximum on the 131 st day then decreases rapidly to a vestigial structure on the 195 th day, i.e., it is apparent in the above figures and table that the decrease in length, width, thickness and weight was gradual in the male and fairly rapid in the female, i.e., the weight of the bursa in the male reached 2189.1 mg on the 59 th day then slowly decreased to 232.0 mg on the 195 th day. However, in the female the weight of the bursa rapidly increased to a maximum of 4827.4 mg on the 131 st day and then decreased to 568.6 mg on the 195 th day.

It is evident with the data given in the preceding paragraphs that the bursa reaches a maximum on the 59 th day in the male and on the 131 st day in the female then decreases in both sexes to a vestige at sexual maturity. Jolly (1915) found that in the fowl the bursa reached its complete development at the beginning of 150 days while Riddle (1928) found that in doves and pigeons maximum bursal size was attained from 69 to 75 days of age.

Comparison of the Figures 9-12 inclusive and Table 5 with Figures 14-17 inclusive and Table 8 make it perceivable that the gonads are undeveloped at 59 days while the bursa has reached or is attaining maximum development and that sexual maturity is attained following atrophization of the bursa. These observations are in agreement with those of Riddle.

Figure 11. Thickness of the bursa in the fowl. Ordinates, thickness of bursa in millimeters. Abscissae, age in days. - - - -, males; _____, females.

Figure 12. Weight of the bursa in the fowl. Ordinates, weight of bursa in milligrams. Abscissae, age in days. - - - -, males; _____, females.

Figure 11

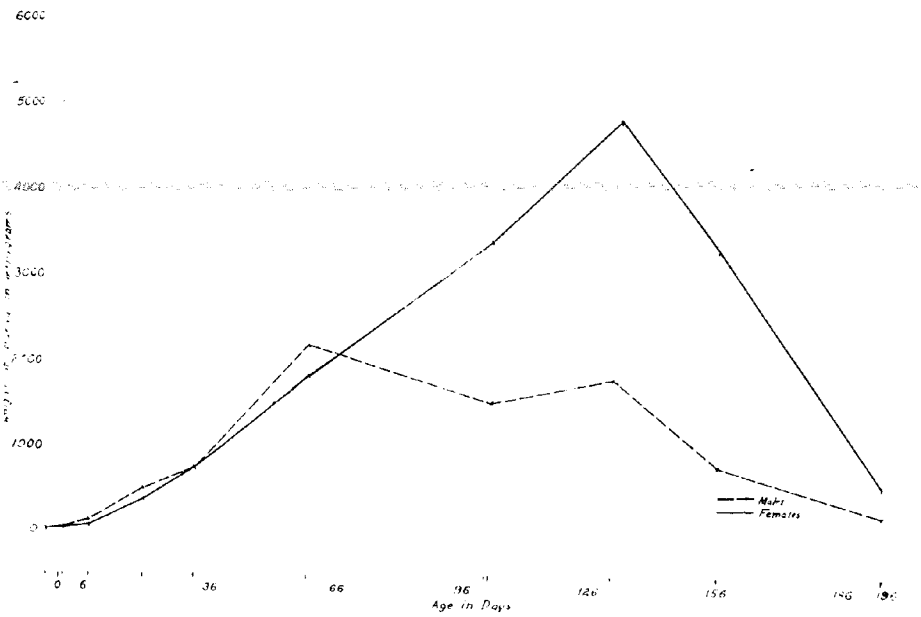


Figure 12

The preceding results show that there is a correlation between bursal atrophization and sexual maturity in the fowl. Jolly (1913) suggested that the bursa prepared a hormone-like substance which suppressed post-natal development of the gonads. Riddle thought his observations supplied some evidence for such a relationship. He also thought that the follicular hormone (FSH) from the anterior pituitary exercised a retarding action on the testes in post-natal stages. In 1938 Riddge supplemented this theory by presenting evidence that excess amounts of prolactin from the anterior pituitary suppressed gonadial growth.

On the basis of Riddle's observations and the results presented in this study it appears probable that gonadial development is retarded in post-natal ages by an excess of prolactin until maximum bursal growth is attained, after which the amount of prolactin secreted by the anterior pituitary decreases allowing rapid gonadial development to occur.

Bursal folds. Figure 13, Table 6 Column 4 show that the number of bursal folds in the male increased from 15 in the 17 day foetus to 16 in the 20 day chick, then remained fairly constant through the 131 st day and decreased to 11 at the 156 th day. The variation in number of folds in the 1 st and 7 th days is probably not significant. Following the 156 th day through sexual maturity (195 days) the bursal folds atrophy rapidly. It is evident from further study of the above figure and table that the number of bursal folds in the female fairly closely parallel those of the male.

The preceding results make it apparent that there is no significant increase in number of bursal folds in either the male or female fowl from the hatching date to the 156 th day, after which

Figure 13. Number of folds in the bursa of the fowl. Ordinates, number of folds. Abscissae, age in days. - - - -, males; _____, females.

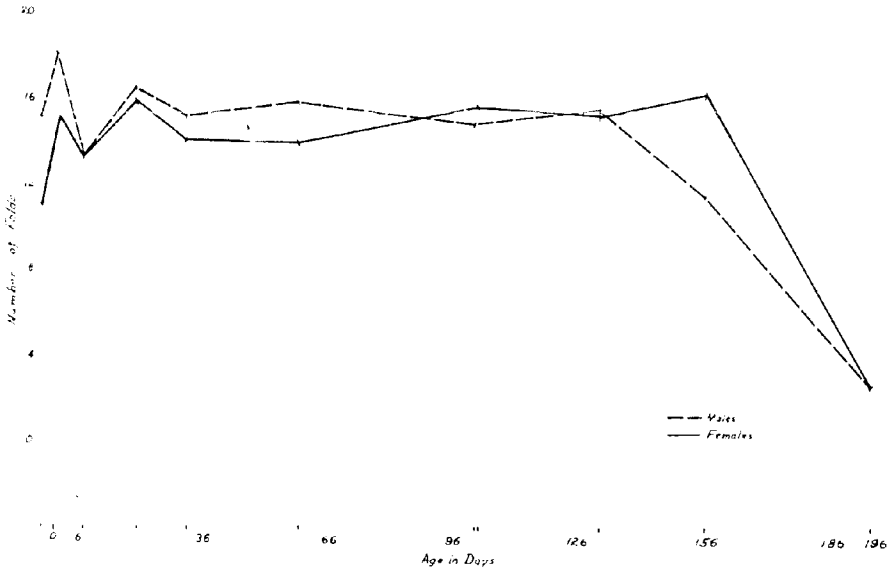

20
16
12
8
4
0
Number of Fish
Males
Females
0
6
36
66
96
126
156
186
196
Age in Days

Figure 13

TABLE 6

NUMBER OF FOLDS IN THE BURSA OF THE FOWL FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4
Sex	Age in Days	Number of Specimens	Number of Bursal Folds
Male	17 day foetus	8	15
	1	11	18
	7	13	13
	20	10	16
	32	12	15
	59	10	16
	101	6	15
	131	5	15
	156	6	11
	195	4	**
Female	17 day foetus	4	11
	1	11	15
	7	11	13
	20	10	16
	32	13	14
	59	10	14
	101	16	16
	131	5	15
	156	7	16
	195	9	***

** Only two specimens showed folds (averaged 3 folds).

*** Only one specimen showed folds (three folds).

there is rapid atrophization of the folds through sexual maturity.

Bursal canal. Text, Table 7 Column 4 shows that the width of the bursal canal in the male increased from 0.6 mm in the 17 day foetus to a maximum of 1.9 mm in the 7 day chick and then remained constant through the 101 st day, after which it decreased to a minimum of 0.5 mm at the 195 th day. The decrease in width following the 3? day chick is probably not significant for the following reasons: (1) paucity of observations and (2) unavoidable inaccuracies in the method used. Likewise in the female, the width of the bursal canal increased from 0.5 mm in the 17 day foetus to a maximum of 2.5 mm in the 101 day fowl, then decreased to 0.9 mm in the 195 day fowl.

Further analysis of these results demonstrate that the percentage increase in width of the bursal canal in the male was 216.7 from the 17 day foetus until the maximum was reached at the 7 th day, after which the width remained constant through the 101 st day. From the 101 st day to the 195 th day the percentage decrease was 280.0. In the female the percentage increase in width of the bursal canal was 400.0 from the 17 day foetus to the 101 st day, the age at which maximum width was reached. In the period between the 101 st and 195 th day the width of the bursal canal decreased and when calculated on a percentage basis it was found to be 177.8.

The preceding results make it perceivable that the male reaches maximum width of the bursal canal at an earlier age than the female, while in the female, bursal canal width does not reach a maximum until the 101 st day; in the former the greatest size reached is 1.9 mm and in the latter it is 2.5 mm.

It is evident from the results shown in the preceding paragraphs that the increase in growth of the bursa parallels fairly

TABLE 7

WIDTH OF BURSAL CANAL IN THE FOWL FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4
Sex	Age in Days	Number of Specimens	Width of Bursal Canal (mm)
Male	17 day foetus	8	0.6
	1	11	1.4
	7	13	1.9
	20	10	1.9
	32	12	1.9
	59	10	1.8
	101	6	1.9
	131	5	1.6
	156	6	0.9
	195	4	0.5
Female	17 day foetus	4	0.5
	1	11	1.2
	7	11	2.1
	20	10	1.7
	32	13	1.7
	59	10	1.4
	101	16	2.5
	131	5	2.4
	156	7	2.0
	195	9	0.9

closely that of the bursal canal while the number of bursal folds appear to be independent of bursal size and weight until the 156 th day, after which decreased growth in the bursa closely parallels decrease in number of bursal folds through sexual maturity.

E. Relation between Size and Age of the Gonads in the Fowl from Hatching Date to Sexual Maturity

Observations given in this section were made as described in the preceding pages. Observations made on the gonads, and the season of the year at which time observations were made, are given in Tables 8 and 9 and Figures 14-17 inclusive.

Gonads. Text, figure 14 and Table 8 Column 5 shows that the length of the left gonad in the male increased from 4.3 mm in the 17 day foetus to a maximum of 23.0 in the 101 day fowl, after which it decreased to a median minimum of 17.0 mm on the 156 th day then it increased to a second maximum of 22.5 mm on the 195 th day. In the female the length of the left gonad increased from 6.4 mm in the 17 day foetus to a maximum of 19.8 mm in the 131 day fowl and then it decreased to 19.1 mm in the 156 day fowl.

Further analysis of these results shows that percentage increase in length of the left male gonad is 148.8 between the 17 day foetus and the 59 day fowl, while percentage increase in length is 115.0 in the next 42 days, the age at which maximum gonadial length was reached. In the female, percentage increase in length is 145.3 between the 17 day foetus and the 59 day fowl, while the percentage increase in length is 26.1 in the next 72 days, the age at which maximum length of the gonad is attained. The percentage increase in length of the right gonad of the male closely parallels that of the left gonad. Other results given in Figures 15 and 16 and Table 8 Columns 7 and 9 show that increases in width and thickness of the left gonad in both male and female closely parallel the increases

Figure 14. Length of the gonads in the fowl. Ordinates, length in millimeters. Abscissae, age in days. _ . . . _, left, _____, right, males; - - - -, left, females.

Figure 15. Width of the gonads in the fowl. Ordinates, width in millimeters. Abscissae, age in days. ___ _ ___, left, - - - -, right, males; _____, left, females.

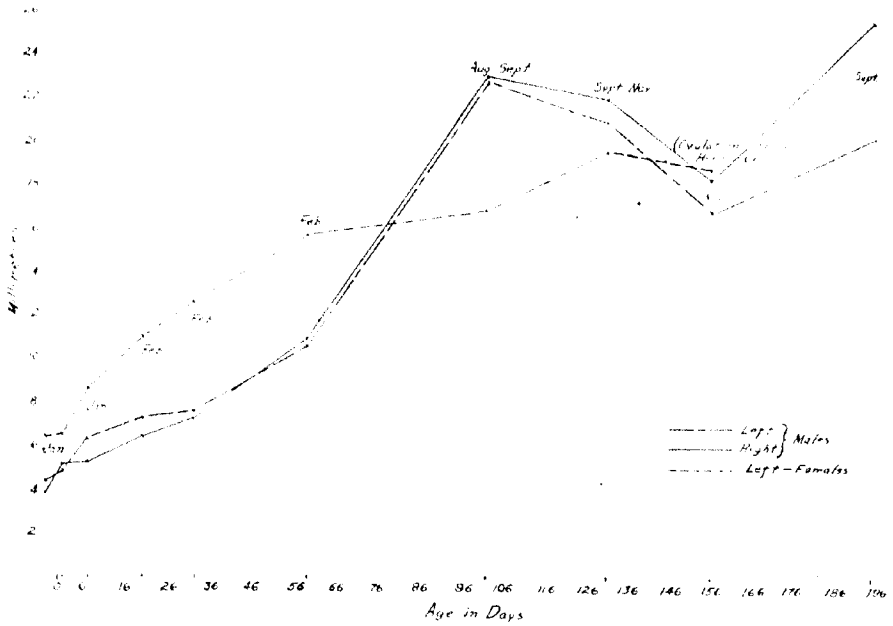


Figure 14

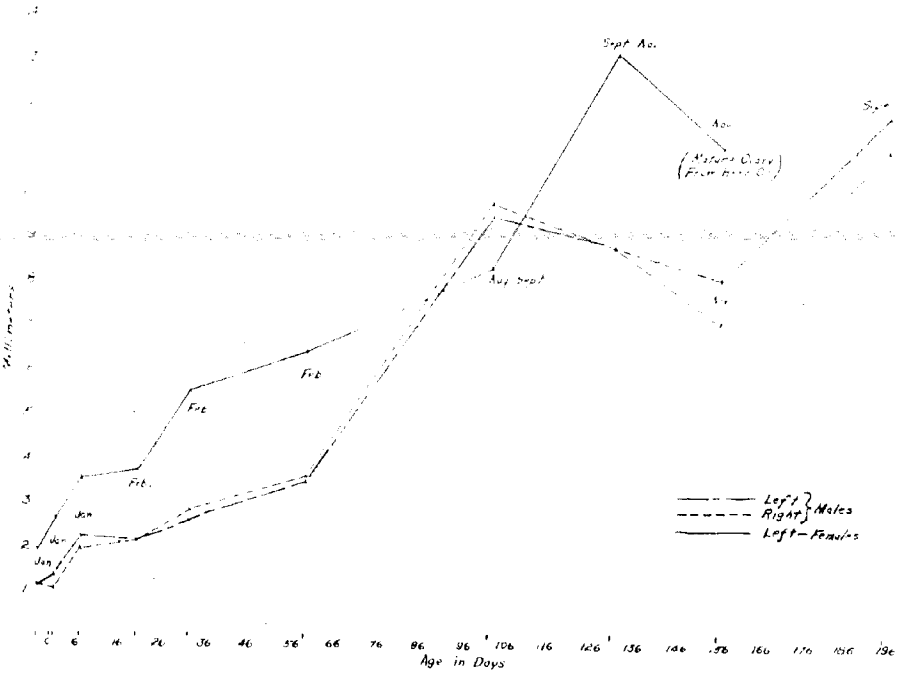


Figure 15

TABLE 8

SIZE AND WEIGHT OF THE FOWL GONADS
FROM HATCHING DATE TO SEXUAL MATURITY

Columns

1	2	3	4	5	6	7	8	9	10	11	12
	Age in	Month Specimen Killed	Number of	Length (mm)		Width (mm)		Thickness (mm)		Weight (mg)	
Sex	Days	1941	Specimens	Left	Right	Left	Right	Left	Right	Left	Right
	17 day foetus	January	8	4.3	3.8	1.1	1.1	1.1	0.9	3.8	3.6
	1	January	11	4.9	5.1	1.5	0.9	1.0	0.9	2.6	2.1
	7	January	13	6.3	5.2	2.2	1.9	1.6	1.5	7.0	5.6
	20	February	10	7.2	6.5	2.1	2.1	1.7	1.6	18.8	16.8
	32	February	12	7.6	7.3	2.6	2.8	1.9	1.9	22.9	21.6
	59	February	10	10.7	10.9	3.5	3.6	2.9	2.7	83.9	77.3
Male	101	Aug.-Sept.	6	23.0	23.3	9.5	9.8	9.7	9.7	1546.7	1607.7
	131	Sept.-Nov.	5	21.2	22.2	8.8	8.8	8.4	7.6	998.8	962.2
	156	November	6	17.9	18.5	8.1	7.1	7.2	6.2	520.9	473.8
	195	September	4	22.5	25.8	11.8	11.9	11.0	9.9	2238.8	2217.9
	17 day foetus	January	4	6.4	---	1.9	---	0.6	---	5.6	---
	1	January	11	6.5	6.6	2.6	1.3	1.9	0.7	8.5	3.3
	7	January	11	8.6	---	3.5	---	1.6	---	16.6	---
	20	February	10	10.9	7.5	3.7	1.5	1.6	0.6	40.3	9.0
	32	February	13	12.7	8.8	5.5	1.6	1.6	0.6	65.8	4.4
Female	59	February	10	15.7	14.1	6.4	1.9	3.4	0.8	144.7	14.4
	101	Aug.-Sept.	16	16.9	---	8.3	---	4.6	---	348.8	---
	131	Sept.-Nov.	5	19.8	---	13.3	---	5.2	---	576.6	---
	156	November	7	19.1	---	11.1	---	6.7	---	696.9	---
	195	September	9	mature ovary	---	mature ovary	---	mature ovary	---	mature ovary	---

--- Gonad not identified.

Figure 16. Thickness of the gonads in the fowl. Ordinates, thickness in millimeters. Abscissae, age in days. ___ _ ___, left, - - - -, right, males; _____, left, females.

Figure 17. Weight of the gonads in the fowl. Ordinates, weight in milligrams. Abscissae, age in days. _____, left, ___ ___, right, males; ___ _ ___, left, females.

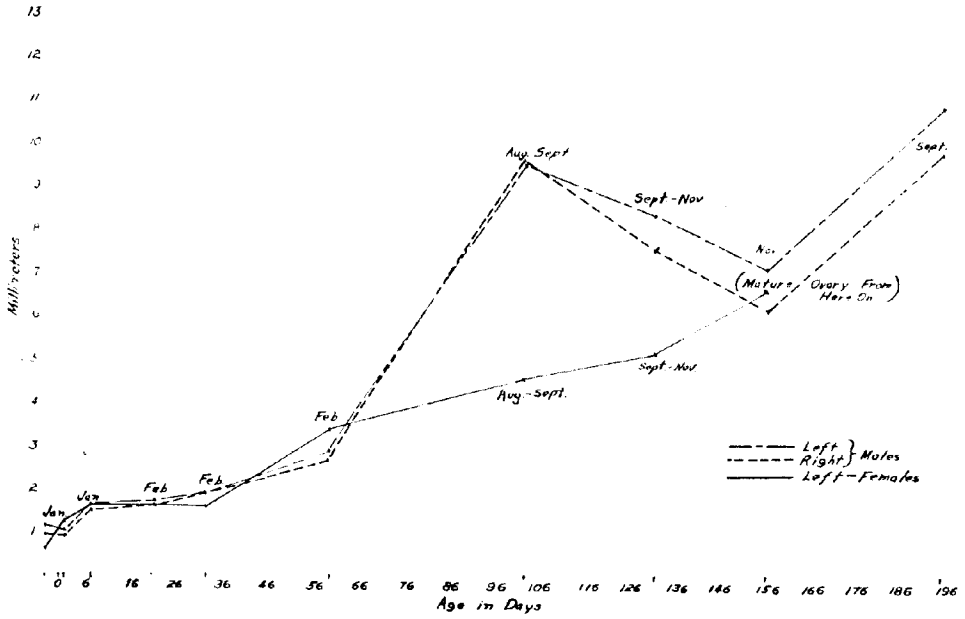


Figure 16

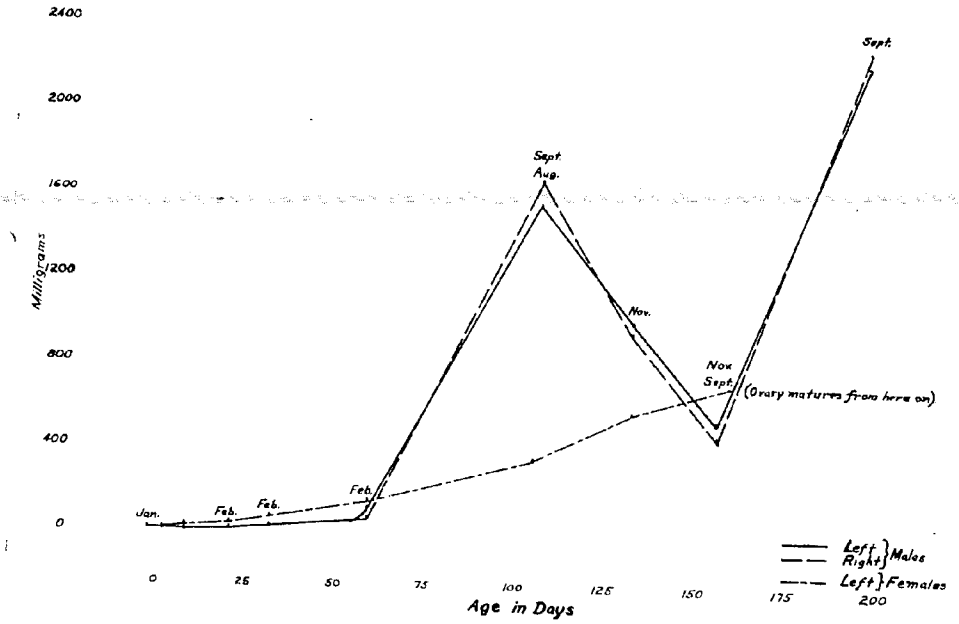


Figure 17

observed in gonadial length. It is evident from these results that percentage increase in length of the gonad is fairly similar in both the male and female from the 17 day foetus to the 59 day fowl and that the percentage increase in length is greater in the male than in the female from the 59 day fowl until a maximum length is reached.

Figure 14 and Table 8 also demonstrate that the left gonad of the male after reaching a maximum length of 23.0 mm in Aug.-Sept., decreases to 17.0 mm in November. In gonads collected from birds during the previous September mean length of the gonad again reached 22.5 mm. Length of the right male gonad paralleled that of the left, although the mean length of the right reached 25.8 mm in September. In the female the length of the right gonad fairly closely paralleled that of the left up to the 59 th day, after which time it decreased to a vestige.

Figure 17 and Table 8 Columns 11 and 12 show that the weight of the left male gonad progressively increased to a maximum (1546.7 mg) in Aug.-Sept. (101 days of age) and then decreased to 520.0 mg in November (156 days of age). In the preceding September gonads collected from birds again increased to a maximum of 2238.8 mg (195 days of age). These observations indicate that two factors are important in determining weight of the male gonad, i.e., (1) age of the bird and (2) seasonal variations. The relation of size to seasons has been studied by Bissonnette (1930). He finds that the major factor operating in producing observed changes in testes is the increased day-length, thus agreeing with Rowan (1931) in his work on juncos.

A comparison of the data given in Table 8 with that given in

Table 1 suggests that the size of the male cloaca is fairly independent of gonad size after the cloaca reaches maximum length and width. Likewise, cloacal size in the female seems to be independent of the variations in size of the gonads, after the maximum is attained, i.e., the maximum mean length of the cloaca in the 131 day female is 36.2 mm and the maximum mean weight of the left ovary is 576.6 mg. In the fowl of 156 days, the maximum mean length of the cloaca is 36.2 mm while the maximum mean weight of the ovaries in this age group is 696.9 mg. In the mature female the cloaca has a mean length of 34.8 mm. These results indicate that gonad weight and cloacal size of the fowl are not closely related after 131 days of age.

To further study gonad size in relation to the seasons of the year, additional observations were made on male gonads collected in July and August 1942. The results obtained are given in Table 9.

Table 9 Column 4 shows that the length of the left gonad increases from 23.0 mm in Aug.-Sept. to a maximum of 40.5 mm in July of the following year. Gonads removed at the time these observations were made on the cloaca weighed 1546.7 mg in Aug.-Sept. and increased to a maximum of 6797.3 mg in July of the following year. The length and weight of the right gonad closely paralleled that of the left. These observations indicate that maximum weight of the gonads is fairly closely correlated to maximum length of the cloaca.

The results shown in this study would suggest that cloacal size is influenced by endocrine factors associated with the gonads and the anterior pituitary. According to Marshall (1936) variations in the gonads are brought about by two factors: (1) endocrine

TABLE 9

SIZE AND WEIGHT OF THE GONADS OF THE MALE FOWL
FROM 101 DAYS OF AGE THROUGH 195 DAYS OF AGE

(Additional Observations on the 135 day and 151 day fowl)

Columns

1	2	3	4	5	6	7	8	9	10	11
Age in Days	Number of Specimens	Month & Year Specimen Killed	Length (mm) Left	Length (mm) Right	Width (mm) Left	Width (mm) Right	Thickness (mm) Left	Thickness (mm) Right	Weight (mg) Left	Weight (mg) Right
101	6	Aug.-Sept., 1941	23.0	23.3	9.5	9.8	9.7	9.7	1546.7	1697.7
135	7	August 1942	30.0	35.6	13.3	13.6	13.9	12.9	2792.4	2719.3
151	6	July 1942	40.5	41.3	17.5	16.1	16.2	17.0	6797.3	6660.8
195	4	September 1941	22.5	25.8	11.8	11.0	11.0	9.9	2238.8	2317.0

factors associated with the gonads and the anterior pituitary and (2) exteroceptive factors which through the intermediation of the nervous system act upon or modify the endocrine factors. Riddle (1938) found that excess amounts of prolactin from the anterior pituitary suppresses gonadal development in birds and promotes grwoth in some of the more important organs associated with the digestive system - especially the intestines. He further suggests that presence of excess prolactin may cause the seasonal cyclic difference in the gonads of birds.

Rowan, Marshall, and Bissonnette (1937) agree that light is probably the most stimulating of the exteroceptive factors. Bissonnette found that by (1) increasing day length (2) increasing intensity and (3) greater intensities of longer waved rays near the red end of the spectrum were the most activating phases of this stimulus. Evidence produced in this study and that of the above workers suggests that the correlation between maximum size of the clover and the gonads on the 131 st day and the apparent lack of this correlation after the 131 st day may be due to length of the light day.

IV. DISCUSSION

The results presented in the preceding pages show that the cloaca of the fowl, partridge and pheasant consists of three compartments. Observations made on the individual compartments showed that the coprodaeum was the largest, while the urodaeum was the smallest. The proctodaeum was smaller than the coprodaeum, yet larger than the urodaeum.

It was also shown that these compartments and their limits are essentially the same in the species studied. The position of the uretal and genital papillae is similar in the fowl, partridge and pheasant. Likewise, all species studied were similar in that they showed a bursa connected to the dorsal surface of the proctodaeum by a funnel-shaped canal and a broad fold extending along the mid-dorsal wall of this chamber.

Observations demonstrated a deep pocket at the posterior limit of the coprodaeum and a uretal vestibule in the urodaeum of the partridge which was unlike that seen in the fowl and pheasant. An oblique coprodael fold was observed in the fowl and pheasant while none was seen in the partridge. The pheasant differed in uretal papillae in that they were found on the anterior edges of longitudinal folds and not disc-shaped as in both the fowl and partridge. The bursal aperture was exposed in the partridge while in the fowl and pheasant it was covered by the uro-proctodael fold.

It was also made apparent that the growth in size of the cloaca, when measured in percentage increase in length and width was greater in the female than in the male and that maximum size of the cloaca

in the male and female was attained from the 131 st day to the 156 th day of age.

Observations made on the individual compartments have shown that growth of the coprodaeum in the fowl increased rapidly up to the 7 th day then remained fairly constant until the maximum was reached on the 131 st day. Growth in length of the urodaeum was essentially alike in male and female until the 59 th day and then was greater in the female than in the male. The increased length of the female cloaca between the ages of 156 and 195 days was shown to be due primarily to the increase in length of the urodaeum as the length of the coprodaeum remained fairly constant during that period.

It was evident from the data presented that growth in width of the female urodaeum closely paralleled that of the male through the 131 st day but in the female increase in width was greater from the 131 st day until the 195 th day than it was in the male in the same period. It was also shown that in the transposition of the data obtained for length and width of the proctodaeum at the various ages to growth, that growth of the proctodaeum was similar in the male and female from hatching date to the 156 th day following which the female showed a greater increase than the male through the 195 th day.

Observations made on the cloacal papillae showed that there was no significant increase in growth of the uretal papillae from hatching date through sexual maturity while growth of the genital papillae in the male closely paralleled that of the female through the 32 nd day after which the male showed a greater increase than the female until the maximum on the 131 st day. Following the 131 st day the papillae in the female showed rapid atrophization.

It was made evident with the data given in this study that the bursa reached maximum growth on the 59 th day in the male and on the 131 st day in the female. It then decreased in both sexes to a vestige at sexual maturity. Results showed a correlation between bursal atrophization and sexual maturity. On the basis of Riddle's observation it appears probable that gonadial development is retarded in postnatal ages by an excess of prolactin from the anterior pituitary until maximum bursal growth is attained.

Observations made on bursal folds showed that there was no significant increase in number of bursal folds in either the male or female fowl from hatching date to the 156 th day, after which there was rapid atrophization of the folds through sexual maturity.

Observations on the bursal canal demonstrated that the male reached maximum width at an earlier age (7 days) than the female, while in the female bursal canal width does not reach a maximum until the 101 st day.

It was further shown that bursal growth paralled fairly closely, growth of the bursal canal while the number of bursal folds appeared independent of bursal size and weight until the 156 th day, after which decreased growth in the bursa closely paralleled decrease in number of bursal folds.

Observations on the gonads made it perceivable that growth, when measured in percentage increases of length, width, thickness and weight, was fairly similar in the male and female fowl from hatching date until the 59 th day and that gonadial growth was greater in the male than in the female from the 59 th day until maximum size was reached. It was further shown that gonad size in the male progressively increased to a maximum in August - September 1941, then

decreased in the following November, while gonads collected in the preceding September again increased to a maximum size. These results indicated two factors important in determining weight of the male gonads, i.e., (1) age of the bird and (2) seasonal variations.

To further study gonad size in relation to the seasons additional observations were made on male gonads collected in July and August of the following year (1942). Results showed that maximum growth of the male gonads was fairly closely correlated to maximum growth of the cloaca.

Investigations of Rowan, Bissonnette, Marshall and Riddle and results presented in this study suggested that cloacal size is influenced by (1) endocrine factors associated with the gonads and the anterior pituitary and (2) an exteroceptive factor (light) which through the intermediation of the nervous system acts or modifies the endocrine factors. These factors likewise are probably responsible for the correlation between maximum size of the cloaca and gonads on the 131 st day and apparent lack of correlation after the 131 st day.

V. SUMMARY

1. The cloaca of the fowl, partridge and pheasant consists of three compartments; the coprodaeum which was the largest, the urodaeum which was the smallest and the proctodaeum which was smaller than the coprodaeum yet larger than the urodaeum.

2. The cloacal compartments and their limits were similar in the three species studied. The position of the cloacal papillae was likewise similar. All species showed the bursa connected to the proctodaeum by a funnel-shaped canal. A broad fold was observed in the proctodaeum of the fowl, partridge and pheasant.

3. A deep coprodael pocket and a uretal vestibule were observed in the partridge while an oblique coprodael fold was seen in the fowl and pheasant. Uretal papillae in the pheasant were found on the anterior edge of longitudinal folds and were not disc-shaped as in both the fowl and partridge. The bursal aperture was exposed in the partridge while in the fowl and pheasant it was covered by the uroproctodael fold.

4. Growth in size of the cloaca when measured in percentage increase in length and width was greater in the female than in the male.

5. Maximum size of the cloaca in the male and female fowl was reached from the 131 st to 156 th day of age.

6. Growth in the individual compartment of the cloaca showed that the coprodaeum in the male and female fowl increased rapidly up to the 7 th day and remained fairly constant until the maximum on the 131 st day. Growth in length of the urodaeum was essentially alike in the male and female fowl until the 59 th day and then was

greater in female than in male.

7. The increased length of the female cloaca between the ages of 156 and 195 days was due to increased length of the urodaeum.

8. Growth in width of the female urodaeum closely paralleled that of the male through the 131 st day but in the female increase in width was greater from the 131 st day until the 195 th day than it was in the male for the same period.

9. Growth of the proctodaeum was similar in the male and female from hatching date until the 156 th day. Following which, the female showed a greater increase than the male through the 195 th day.

10. There was no significant growth in the ureteal papillae from hatching date through sexual maturity while growth in the genital papillae of the male closely paralleled that of the female through the 32 nd day, after which the male showed a greater increase than the female. The genital papillae in the female showed rapid atrophization after the 131 st day.

11. The bursa reached maximum growth on the 59 th day in the male and 131 st day in the female.

12. Results showed a correlation between bursal atrophization and sexual maturity which on the basis of Riddle's observations may be due to prolactin.

13. There was no significant increase in the number of bursal folds from hatching date to sexual maturity.

14. Results of this study and those of Rowan, Bissonnette, Marshall and Riddle suggest cloacal size is influenced by (1) endocrine factors associated with the gonads and the anterior pituitary and (2) an exteroceptive factor (light) which through the

intermediation of the nervous system acts upon and modifies the endocrine factors.

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