

THE HATCHING MUSCLE IN THE AMERICAN COOT

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It is believed that a young bird hatches by using a muscle which extends from the neck to the middle of the back of the head. This muscle increases in size during development but most rapidly just before hatching. After hatching, it decreases in size. In grown birds the muscle, although relatively small, is used for other purposes. Inside the egg the embryo is so positioned with its bill against the shell, and with the neck curled, that it can use this muscle to extend the head and bill upward to pip the egg and eventually hatch out.

There has been some work done on this muscle in the chicken (Keibel, 1912; Pohlman, 1919; Fisher, 1958), in North American grebes (Fisher, 1961a) and in Franklin's Gull (Fisher, 1961b). The work of Fisher supports this idea of hatching, as outlined above.

My purpose in this paper is to point out and explain the phases of the gross development of this muscle in the American Coot, *Fulica americana*, from the time the embryo weighs just a few grams to the age of two weeks.

MATERIALS AND METHODS

One hundred fifty-eight eggs were taken from nests in the Delta Marshes at Delta, Manitoba, Canada. Immediately upon return to the Delta Waterfowl Research Station, the eggs were incubated, usually within

two or three hours of collection. The eggs in each clutch were numbered and the clutches kept separate in the incubator. Incubation was at 99.5 degrees F and from 60 to 70% relative humidity. The young coots were removed from the incubator at one day of age and kept in indoor pens. Their food was a high-protein, turkey pre-starter mix. An abundance of water was supplied for drinking and swimming. Never were more than seven or eight young coots kept in any one pen.

Since the female coot lays one egg each day and starts incubating upon the laying of the first egg, the eggs in any one clutch were in different stages of development at the time of collection. It was thus not possible to age the embryos by back-dating from the time the first egg hatched. Sometimes two eggs in the same clutch hatched on the same day. For these embryos which were not permitted to complete their development I used body weight as an index to the stage of development. After hatching, both age and weight were used to indicate development. I attempted to get a series of embryos representing all weight stages.

Removal of unhatched embryos was done within 30 minutes of removal of the egg from the incubator. The egg was cracked on a line around the end containing the air pocket so as not to damage the specimen in any way and to permit examination

of the position of the head. The membranes were removed from the embryos, including the yolk sac in embryos in which it had not yet been completely drawn into the body. The embryos were dried by gently rotating them on paper towels for not more than one minute. After drying, the embryos were weighed on a balance to the nearest tenth of a gram. The muscles were removed with iridectomy scissors and weighed immediately on a Roller-Smith Precision Balance to the nearest ten-thousandth of a gram. The birds were then preserved in formalin for later study of the egg-tooth.

The thickness of the egg shell was measured at two different places on the edge of the breakage line of eggs which had produced normally-hatched young. A dial micrometer, calibrated to thousandths of an inch, was used.

RESULTS

Segmentation begins to appear faintly at approximately the 7-gram stage of embryonic development. Segments are definitely visible by the 9-gram stage and are in all cases visible throughout incubation. But just before hatching the segments may be difficult to see because of the large lymph content of the muscle. Segmentation gradually disappears after hatching. At six or seven days of age it is very faint, and in many specimens is not visible thereafter. In some embryos only parts of the posterior and anterior boundaries of the individual segments remain.

The development of segmentation starts anteriorly (Fig. 1). The anterior segment appears first and is the largest throughout the history of

the muscle. The posterior segment is always the smallest. Usually three pairs of segments are present before hatching. In only one instance was there any variation in the number of segments; one chick had a slight enlargement of a fourth pair of segments.

The first medial contact between segments of opposite sides is between the anterior pair; this is the condition in one-fourth of the 6-gram specimens. By the time the embryos reach 7 grams in body weight most show medial contact at least between the first pair of segments. At the 8- or 9-gram stage the medial contact has proceeded posteriorly to include the first two pairs of segments in approximately 50% of the specimens. There is medial contact between the first two pairs by the prepip stage in most specimens. And some individuals also have limited contact between the anterior parts of the third pair of segments. After hatching there is a progressive decrease, from posterior to anterior, in the amount of medial contact, until at 17 days of age only part of the inner margins of the first pair are touching (Fig. 1).

The muscle increases in absolute weight from 0.020 grams at 8 grams of body weight to 0.24 grams at 15 grams of body weight, at which time the embryo is ready to pip. Muscle weight decreases from the pipping stage, when it weighs 0.16 grams, to approximately 0.05 or 0.07 grams at two or three days of age. After this it slowly increases in weight.

There are two times in development when the muscles are very large, if the muscle weight is com-

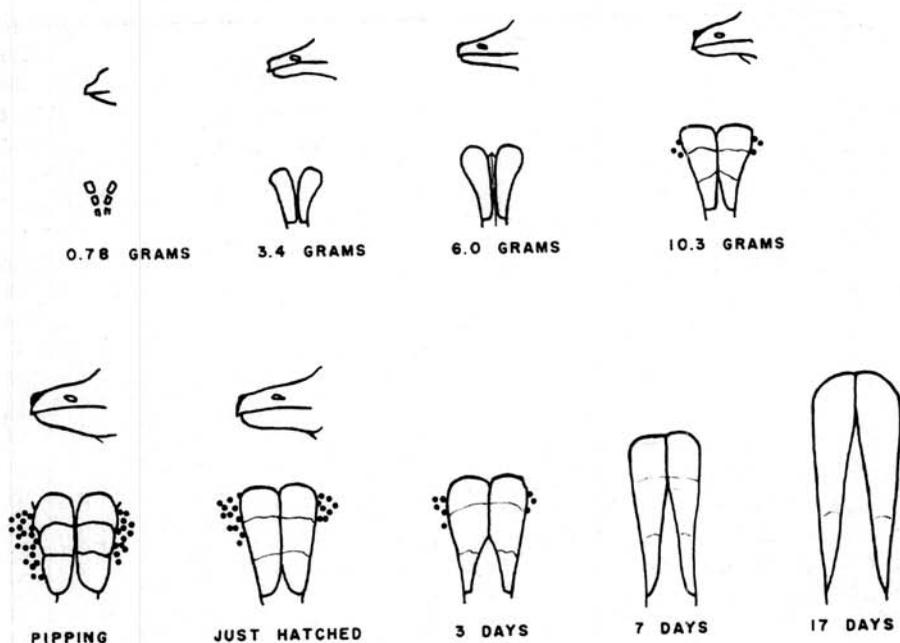
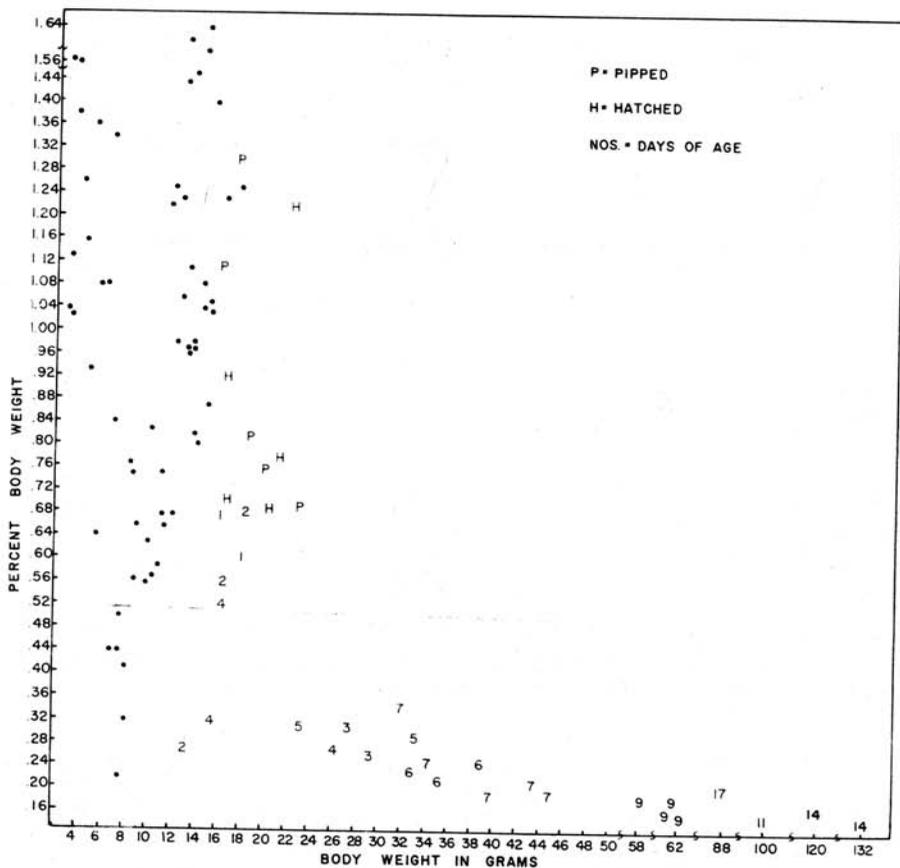


Fig. 1.—Diagrams of development of the egg tooth and hatching muscle in the American coot. Weights refer to body weights.

puted in relation to body weight (Fig. 2). The first time is at the 4-gram stage or earlier when the muscle constitutes about 1.56% of body weight. The second time is between the body weights of 13 and 16 grams. The first instance is due to the more rapid development of the anterior part of the embryo. The latter time is during the prepip stage. As the development progresses from the 4-gram stage, the muscle weight becomes relatively less until about the 7- or 8-gram stage when the muscle may make up as little as 0.2% of body weight (Fig. 2). During the rest of the incubation period weight increases rapidly, in relation to body weight, and reaches a maximum of 1.64% of body weight. During the pipping

period the muscle begins to decrease very rapidly in weight, and this continues through the second day of age. Beginning at about the third day of age the decrease in relative weight becomes more gradual and continues to decline at least until 14 days of age. At five or six days of age the muscle is about the same relative size as it was when the embryo weighed only 7 or 8 grams.

The lymph glands situated on either side of the pair of muscles on the neck are believed to have some influence on the action of the muscle. It is known that they produce lymph which moves into the muscle, and Pohlman (1919) states that this hinders the action of the muscle. H. I. Fisher (1961a) believed that this infiltration of lymph may ac-



about 8% of the birds prior to hatching, but are not seen after hatching.

In only 4 of 97 birds were the glands absent or less than 1 mm. in diameter on one side or the other. There was no difference in the frequency of occurrence or in size between the glands of the two sides.

I noted earlier that the muscle has a large lymph content. This results in a clear to yellowish "lymph color", as I shall call it; lymph color first appears in the muscles at the 9-gram stage, but only to a slight degree and only in 50% of the specimens. When the 13-gram stage is reached nearly all the specimens show a strong lymph color which continues through the hatching period. In this period the muscle appears lymph-filled, a condition which appears in only about one-fourth of the specimens at the 12-gram stage. Lymph-filled muscles were never found in specimens more than 12 hours of age, but the muscles retain a pinkish-yellow color until about the 3-day stage when the "normal" reddish color begins to appear. By 5 to 7 days after hatching, the muscles are reddish.

Since the development of the egg-tooth, as a part of the body aiding in hatching, is related to the development of the hatching muscle, I shall indicate here a few of the more obvious stages. The smallest embryo in which I could find any indication of an egg-tooth weighed 0.78 grams. There is a definite bump on the end of the bill by the 3-gram stage, and by 10-grams in body weight this protuberance is pointed upward and forward (Fig. 1). The egg-tooth is largest at the time of pipping. It diminishes in size very

rapidly in the later stages of pipping and immediately after hatching. There is no evidence of an egg-tooth after three days of age.

Since there may be a relationship between the size of the muscle and the thickness of the shell, I shall give here the measurements of the thickness of the zone of breakage during hatching. In 34 eggs this averaged 0.0105 ± 0.0001 inches, with a range from 0.0095 to 0.0122 inches.

DISCUSSION AND SUMMARY

Development of segmentation in the hatching muscle is the same in coots as in the chick (Keibel, 1912, Pohlman, 1919, Fisher, 1958) and in the Franklin's Gull (Fisher, 1961b). Segments or blocks of tissue which will form the muscle first appear distinctly to the unaided eye at the 0.5-gram stage. The first segments in the formed muscle appear at 7 grams, are definite by the 9-gram stage, and consist of 3 pairs in most instances. A 4th segment was observed more often in the North American grebes (Fisher, 1961) than in the coots. The development starts anteriorly and progresses toward the posterior. Thus the anterior segments are the largest and the posterior segments are the smallest.

Segmentation is not visible in some birds after 6 or 7 days of age and only traces of the segmental boundaries remain visible in others. The first medial contact becomes visible between the anterior pair of segments. The area of contact increases between other segments, reaching the 3rd pair just before hatching. After hatching, the line of medial contact

decreases progressively. This same developmental pattern was noted in the above literature.

Absolute weight of the muscle in the coot increases from the 8-gram stage of body weight to the pipping stage. Once the chick is hatched, the weight of the muscle decreases for a few days and then starts to increase again. There is no apparent decline of the weight during or after hatching in the grebes, but the data were few.

Relative weight is great at first observation; it then decreases until the 8-gram stage. During the rest of the incubation period the weight increases relatively, up to the prepip and pipping periods when it starts to decline rapidly. This decrease is more gradual from about 3 days to at least 14 days of age.

There is not much change in the size of the lymph glands from the time they first become apparent, when the bird weighs 7 grams, until it weighs 16 to 18 grams. The width decreases and the glands become string-like at 16 to 18 grams when the chick is pipping. These glands are absent after approximately 3 days of age. Although there are no visible lymph glands in the area of the muscle of the North American grebes, Fisher (1961a) said there is an obvious infiltration of lymph. In the Franklin's Gull (Fisher, 1961b) the glands start to elongate at 10 grams. This elongation increases more rapidly than the width, reaching its maximum just after hatching.

The color of the muscle is changed by the infiltration of the lymph. This "lymph color" first appears at

9 grams in 50% of the specimens. It then increases in amount and number of specimens in which it is visible, showing strong lymph discoloration up through hatching. After 12 hours of age the muscle slowly returns to its normal reddish color.

The egg-tooth first appears at 0.8 grams of body weight and grows larger and more pointed up to pipping. During pipping and hatching the egg-tooth decreases in size. There is no sign of it after three days of age.

Thickness of the egg shell at the time of hatching was 0.0105 ± 0.0001 inches.

Success in maintaining and raising young coots, which has been very difficult in the past, was thought to be mostly the result of three factors: (1) putting newly hatched young in with a few older birds (ducks or coots) that were feeding successfully; (2) allowing at least five square feet for each young bird in the pen; and (3) using a very high protein diet.

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