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SEX AND AGE CHARACTERS AND SALIVARY GLANDS OF THE CHIMNEY SWIFT

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In the spring of 1955, an investigation was begun on the salivary glands of the Chimney Swift (*Chaetura pelagica*). Emphasis was to be placed on the growth and development of these glands seasonally, and comparisons and correlations were to be made between their macroscopic and microscopic appearance and other anatomical, biological, and reproductive features of this species. In the interim, Marshall and Folley published a significant paper (1956) concerning several of these same aspects in swiftlets (*Collocalia* spp.), whose gelatinous nests have been consumed by humans for centuries because of their nutritional values. The basis for their paper was the histologic structure of the glands of only two birds, and, using their findings as a guide for continuing the present study, I amassed additional data to give a more complete understanding of the salivary gland development in another species.

This investigation was started as a "simple" study of salivary glands, but as the work progressed it became apparent that many aspects of the life history of the Chimney Swift, such as sex and age characters and molt, were largely unavailable in the literature. It was necessary, then, to work out these "peripheral problems" in some detail before the salivary gland study could be completed. Thus, some of the following data seem unrelated to salivary glands at first glance, but they are presented here because (1) a complete understanding of these additional morphological, anatomical, and biological details permits an accurate interpretation of the biology and physiology of the salivary gland, and (2) these data, although incomplete in certain refinements, represent significant contributions to the published, extant data on the life history of the Chimney Swift.

MATERIALS AND METHODS

Seventy-five Chimney Swifts were collected from 1955 through 1957 in central Georgia and South Carolina where this species is a common summer resident and an abundant fall migrant. Most of the birds were shot between 6 p.m. and dark, and they were either dissected immediately, frozen in aluminum foil, or preserved whole in Bouin's fixative. The majority of the swifts were taken near Macon, Bibb County, Georgia, but approximately five per cent of the total came from each of the following localities: Athens, Clarke County; Oglethorpe, Macon County; and Sandersville, Washington County, Georgia, and the Savannah River Plant, Aiken County, South Carolina. In 1955, 18 swifts were collected, in 1956, 38, and in 1957, 19. As the accompanying tables and figures will show, the birds were taken from mid-April until mid-October, with the individual dates of collection being rather uniformly spread throughout this period (see table 1).

After weighing the birds not fixed in Bouin's solution, examining them for molt, and dissecting them for sex and age determination, I decapitated each bird, plucked the head, and slit the skin under the mouth so that the fixative might penetrate the salivary glands rapidly and completely. These heads, bearing appropriate collection numbers, were then fixed in Bouin's solution so that, at a later time, the glands could be measured, weighed, and/or sectioned. Not all of the heads were fixed quickly enough to be suitable for histologic work.

SEX AND AGE DIFFERENCES

A few attempts have been made by banders of Chimney Swifts to determine correctly the sex and age of live swifts, but the suspected external differences have usually proven to be relative and, with the possible exception of molting birds in the late summer and early fall, largely ineffective in completely accurate separation of sex and age groups of live birds. Since the present study involved freshly-killed birds, it was possible to look for internal characters as well as external ones, and by applying these characters singly or in various combinations, the ages of swifts could be determined accurately at least insofar as birds-of-the-year versus adults was concerned. In the spring and early summer, however, one-year-olds were indistinguishable from older birds both internally and externally. For sex and age differences the following characters were studied: weight, molt, skull ossification, the bursa of Fabricius, and gonadal development.

Weight.—Although thousands of Chimney Swifts have been handled by banders, very few weights are available for this species primarily because only by dissection can one correlate accurately age and sex with weight. The Lacks (1951:505 ff) give weights for many adult *Apus apus,* but these data do not distinguish between weights of the sexes. The data presented in table 1 represent more seasonal weights of definitely-aged and -sexed Chimney Swifts than had been recorded previously (Fischer, MS), but Dexter (1957) has recently weighed 119 Chimney Swifts killed accidentally on May 20, 1956, in Ohio. Most of the birds in my sample were taken late in the afternoon or early evening at a time when one would expect a maximum diurnal weight, and in several birds of this sample the mouth cavity was packed with small insects as was also the gizzard. After each bird was shot it was carefully wrapped in foil to prevent weight loss. Usually within an hour each bird was weighed to the nearest tenth of a gram.

Table 1

Weights of Adult Chimney Swifts, Taken in Central Georgia and South Carolina, 1955–1957

Date	Males Number	Males Mean	Males Range	Females Number	Females Mean	Females Range
Apr. 16–30	4	25.2	24.1–27.1	2	24.2	23.4–25.0
May 1–15						
May 16–31	3	22.8	20.0–25.6	3	24.7	23.3–27.5
June 1–15	4	23.3	21.7–24.5	2	22.1	21.6–22.5
June 16–30	3	22.8	21.8–24.3			
July 1–15	4	22.2	20.7–23.1	4	21.2	19.8–22.3
July 16–31	1	23.1		2	21.9	21.5–22.3
Aug. 1–15				1	20.3	
Aug. 16–31	3	22.7	22.1–23.6	3	22.6	21.4–23.5
Sept. 1–15						
Sept. 16–30				1	23.3	
Oct. 1–15	3	29.9	28.3–31.7	2	30.4	30.4

In the Chimney Swift, the data in table 1 indicate that for both sexes the heaviest birds are found in the spring and fall whereas during the actual period of breeding and in late summer, the birds are lightest in weight. A similar situation was found in *Apus* by the Lacks. For the Chimney Swift this statement can be explained, at least in part, by the degree of relative fatness of each bird. My own subjective impressions of birds taken in April was that the birds were "moderately fat," those taken in June had "no fat," and those taken in July and August had "some fat." The few birds collected in October were termed "very fat." Quite noticeable, then, were the extremely heavy birds in October, birds which, upon dissection, proved to be the fattest of any examined.

Weights of immatures (principally non-molting birds, taken from large flocks of adults and immatures) do not differ significantly from those of adults collected at the same time. Weight data for three immature males are 22.8 grams (Aug. 28), 22.1 (Aug. 29), and 23.0 (Sept. 3). Four immature females weighed 23.0 (July 14), 21.7 (July 26), 23.7 (Aug. 23), and 24.9 (Oct. 5). Even in this small sample there was some tendency for the heaviest birds to be found later in the season.

Fischer (MS) found that in a given pair, weighed several times during and after the breeding season, the female weighed more than the male by approximately one gram. In one year (1951) this pair lost weight in the course of the summer, but in the following year a weight loss in summer was less evident. The sex of Fischer's birds was determined by the observer primarily on the basis of behavior. Other data presented by Fischer (twelve specimens taken in May at Ithaca, New York) showed that males tend to outweigh females. Similarly, Dexter (1957) found that 60 males ranged in weight from 21.5 to 27.5 grams with an average of 24.6, and 59 females ranged in weight from 21.5 to 28.0 grams with an average of 24.3. The average weight of 26 adult males from table 1 is 24.0 grams whereas the average weight of 20 adult females is 23.4. Since these data represent a much larger sample than had been available previously for the Chimney Swift, it seems reasonable to assert that on the average (1) males tend to outweigh females, although the difference is not significant statistically and could not be used reliably to distinguish sexes, and (2) in midsummer, birds of both sexes weigh less than they do in either the spring or fall at the latitude of central Georgia. This latter condition is believed to be correlated closely with fat deposits.

Molt.—With the exception of the meager data given by Bent (1940:277–278) I have been unable to locate specific details on molt in the Chimney Swift. Therefore, the following description of molt is presented in some detail so that certain aspects of the molt might be used in age determination. Ben B. Coffey, Jr., advises me (personal correspondence) that banders for many years have distinguished adult Chimney Swifts in the fall from immatures by the fact that the adults were molting and the immatures were not. Toward the end of the molting period (September), however, the accuracy of this method decreases because some adults might complete their postnuptial molt by mid-September. As will be discussed below, the degree of skull ossification indicates that the use of molt to denote an adult is reliable in ascertaining the age of a given swift up to a given time.

The first indication of the postnuptial molt in the adult is the loss of primary number one and its covert. Thereafter, the essential salient features of molt are summarized in figure 1. Aside from these sequences of molt, it is also necessary to indicate that the greater secondary coverts are replaced before the secondaries begin their molt, and that the upper and lower tail coverts molt before the rectrices. It is not uncommon to encounter spurious, unilateral tail molt, for on June 11, July 11, and July 12, birds were taken each of which was molting only one tail feather (not the lateral ones) whereas all of the other rectrices were old. The inception of tail molt was not determined precisely, but presumably it occurs in late July. Eleven adults obtained on July 12 and 13 showed no signs of tail molt. Even though most adults showed some indications of molt of the rectrices or primaries until early October, occasionally birds believed to be adults on the basis of skull ossification had completed their molt as early as September 19. After September 1, three out of eight adults had completed their molt, and on the basis of plumage alone they would have been indistinguishable from immatures.

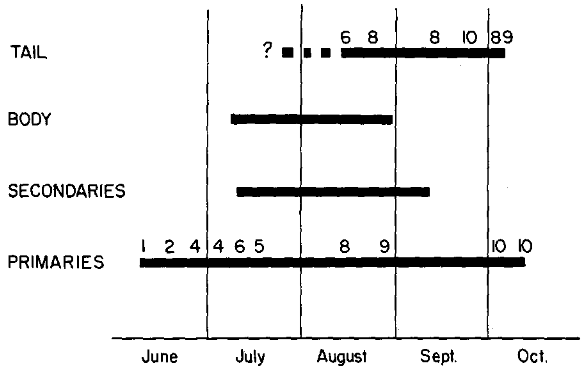

Fig. 1. Timing of the postnuptial molt of the adult Chimney Swift near Macon, Georgia. Numerals indicate the numbers of new feathers for a given area of the body on a specific day.

Molt data for immature birds are meager here because of the relatively small sample obtained, but there is evidence from ten birds that no significant amount of molt occurs in the immatures once they have left the nest. One immature, taken on July 14, had nearly all of its feathers (remiges, rectrices, body feathers) still partly ensheathed, and evidently it had not been out of the nest very long. Other immatures, taken from late July until early October, showed only slight traces of body molt with the exception of one bird which was molting a few upper and lower tail coverts.

From these data, then, it would seem that until about mid-September a molting bird is almost certainly an adult, but after this time the character of molt must be used with some caution.

Skull ossification.—Conventionally the degree of skull ossification has been used in some passerine species to distinguish immature from adult birds in the fall, and using this fact as a working hypothesis, I began to observe and draw the skull of each swift with the hope that this character might assist in distinguishing age groups. All of the birds examined, however, from April through October had incompletely ossified skulls. In fact, after having examined 75 swifts of all ages and sexes taken at all seasons, I have not yet found a swift with a completely ossified skull! This seems to indicate that skull ossification would be unreliable for determining age, but such was not entirely the case, for some birds taken in the fall (immatures on the basis of no molt) had larger unossified "windows" in the skull than did adults. By spring and early summer, however, the unossified "windows" of all birds were essentially of the same size so that it was impossible to distinguish one-year-olds from older birds on the basis of this character.

Figure 2 illustrates the degree of skull ossification of several individuals, showing how this character might be used relatively to distinguish birds-of-the-year from adults in the late summer and fall.

Bursa of Fabricius.—The bursa of each swift was not examined routinely, but in the few birds which were studied, this saccular structure was large in birds-of-the-year and absent in adults, both taken in mid-July. The bursa in one immature male, for example, was 9×4 mm. (outside measurement). It is perhaps true that this structure could be used to distinguish age groups in the fall, but further research is needed before it can be used accurately.

Gonadal studies.—As part of the routine examination of each swift, the seasonal

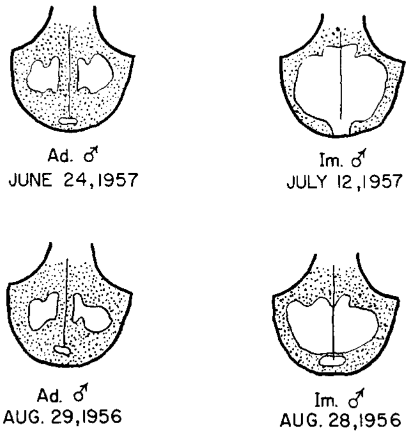

Fig. 2. Typical patterns of skull ossification in the Chimney Swift. Note the relatively smaller unossified "windows" in the adults.

activity of the gonad was checked as follows: In males the length and color of the left testis were recorded, and in females the largest follicle was measured. Of the birds which could be sexed and aged properly, measurements of gonads were obtained from 37 adult males, 5 immature males, 21 adult females, and 2 immature females. Ten other birds were examined for salivary glands, molt, and other characters, but their sex and/or age could not be determined accurately. Therefore, only 65 of the 75 Chimney Swifts are included in these gonadal studies.

Figure 3 shows testis and follicle size of adults plotted against the date. It is apparent from these data that the maximum testis size was reached in the latter part of May and early June, and that there was a regression of testis size beginning at about mid-June. By the first week in July testes had generally reached a minimum size of two or three millimeters, a size which was maintained at least until fall migration. Although the data are less complete for females, there was apparently a similar increase in gonadal activity at the end of May. The only female obtained which had significantly enlarged follicles was a bird taken on May 30, 1955. Its cloaca was open and expanded, and internally there was (1) a white egg with shell in the oviduct, (2) a 9-mm. yellow ovum in the body cavity next to the ovary, and (3) a follicle 4 mm. in diameter in the ovary. The nonbreeding follicle size was reached by early July at the latest, after which follicles were less than one millimeter.

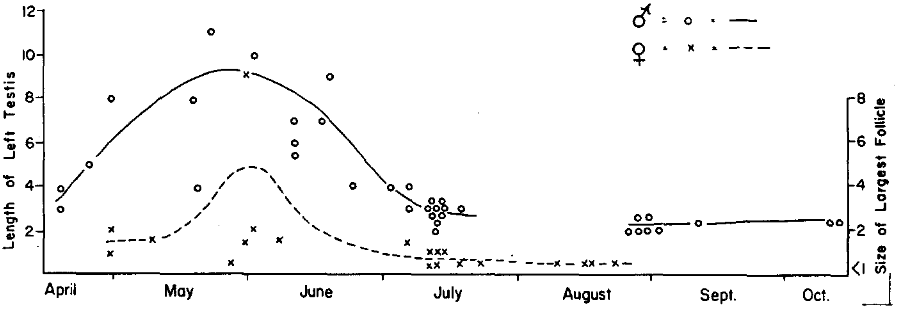

Fig. 3. Seasonal gonadal cycles in the Chimney Swift. Measurements are in millimeters.

Generally, however, the collecting of females at the height of breeding was unsuccessful. This might have been due to the fact that in feral birds there is a general tendency for a sudden recrudescence and regression of macroscopic ovarian activity. It is also possible that breeding female Chimney Swifts remain closer to the nests than do males, and therefore are less frequently encountered in random collecting. In the present study, for example, in the months of May and June, 11 males were taken whereas only six females were collected. These data at first might suggest a preponderance of males in the population, but an alternative hypothesis suggests that females are simply harder to obtain because of their duties at the nest. Fischer (MS) presents evidence in support of this suggestion since he found that the female does a little more than one-half of the incubating and later tends to cover the young more than the male does.

The five male birds-of-the-year were taken on July 12 and 13, August 28 and 29, and September 3. All of these had testes 1.5 to 2 mm. in length, sizes generally smaller than those of adults taken at the same time. The two female birds-of-the-year were taken on July 26 and August 23. Their follicles were less than one millimeter in diameter.

By careful scrutiny of figure 3, certain deviations become apparent. For example, a male taken on May 19 had a testis 4 mm. long, and a female taken on May 27 had almost indistinguishable follicles. Both of these measurements were obviously below the average sizes for adults at that season. Since the sample size was somewhat smaller than statistical treatment would normally require, one might explain these as deviations from the expected norm. However, even with our limited knowledge of the breeding biology of the Chimney Swift, an alternative explanation might be that these were nonbreeding, first-year birds, and that actually their measurements belong to a sample quite different from that of the adults. This proposition is further substantiated by the fact that the salivary glands of this male were small (3 mg.) and those of the female were equally undeveloped (6 mg.). It is of course possible that these were adults which would eventually breed, but because of the late date on which they were shot, this was probably not true. As far as the breeding of first-year swifts is concerned, Fischer (MS) states that the Alpine Swift (*Apus melba*) may breed in the first summer after hatching but that they do not usually breed until the second summer. In a marked population of the Chimney Swift, he found that five out of ten birds nested in the first summer after hatching.

One of the difficulties in working with these swifts at the latitude of central Georgia is the fact that birds taken in April and early May could be either migrants or resident birds. Furthermore, without a marked population it is impossible to know how long the birds collected in early spring had been at the given locality. The birds taken in April, for example, could have been in central Georgia for hours or for weeks. Even with these difficulties in mind, the suggestion is made here that early migrants have somewhat enlarged gonads (males with testes of 3 to 5 mm.). Further intensive collecting in late March might substantiate this point.

From the foregoing data on characters of age and sex, it becomes apparent that usually a thorough dissection is necessary before the sex and age of the Chimney Swift can be ascertained with accuracy. Molt in the fall is the best single external clue to age, but even it is not always reliable.

SALIVARY GLANDS

For many years it has been believed that swifts and swiftlets of several species use saliva in the construction of their nests, although an alternative hypothesis suggested (Home in 1817, *fide* Marshall and Folley, 1956) that gastric glandular secretions were used to bind nests together in at least one swiftlet. It has now been demonstrated conclusively by Marshall and Folley that only the secretions from the salivary glands are used to any extent in nest construction by swiftlets. Histological studies showed an increase in the development of the salivary glands but no such increase in either the esophagus or proventriculus. In marshaling evidence for his revision of the genera of swifts, Lack (1956:2) stated that "all swifts use saliva for sticking together the materials of their nests, and all, so far as known, have enlarged salivary glands in both sexes in the breeding season." It seems to me that he generalizes too much by using the term "all," for the breeding habits of many swifts are incompletely known. Even a cursory survey of the literature will reveal the fact that some swifts use mud in the construction of their nest (for example, *Streptoprocne*) and, hence, *may* not use saliva. In fact, Ridgway (1911:703), writing about the Black Swift of western North America (*Nephoecetes = Cypseloides*), states that the nest is "loosely put together and not held together by salivary secretion." A similar observation was made by Legg (1956) on a sea-cave nest of the Black Swift. These observations do not preclude the possibility that these species in fact do have active or specialized salivary glands, but, until each species is examined anatomically, it is incorrect to say that *all* swifts have enlarged salivary glands in the breeding season and use saliva in construction of nests.

Elsewhere in the literature, one encounters other misleading and unsubstantiated statements regarding salivary glands. Certainly some other species of birds do have salivary glands, but they may not be well developed and may not be used in nest construction. Wing (1956:61) states that "other swifts [than *Collocalia*] use secretions of the salivary glands in cementing their nests together, as do Swallows also." Again, a cursory survey of the literature reveals no reference which proves that North American swallows use saliva as nest cement. Bent (1942:472) quotes Coues to the effect that Cliff Swallows (*Petrochelidon pyrrhonota*) probably do not use saliva but rather mud in nest construction, and in writing about the Barn Swallow (*Hirundo rustica*) he says (*op. cit.*: 445) that "Professor Herrick . . . feels confident that the bird's saliva is not a factor in making the mud more adhesive." Marshall and Folley (1956) could not find salivary glands in the Australian Welcome Swallow (*Hirundo neoxena*). It remains for further research to demonstrate whether or not these unrelated birds have salivary glands and if the saliva is used in nest construction.

Gross appearance.—The salivary glands of the Chimney Swift are paired structures located beneath the ventral oral epithelium. Since they occupy this position even in the most advanced seasonal state, it would seem best to refer to them as sublingual glands and not buccal (see later discussion). In the two species of *Collocalia* studied and illustrated by Marshall and Folley (*op. cit.*:385) the salivary glands are similar in appearance and position to those described for the Chimney Swift.

When observed in the undeveloped state (nonbreeding adults and birds-of-the-year), these glands are separated by a wide space in the midline; thus they lie to either side of the mid-ventral line just under the skin (see fig. 4*a*). In this condition each gland narrows to a point anteriorly in a series of "cords" or "strings," which disappear into the floor of the mouth. Each gland is approximately 7 mm. in length and 2 mm. in width at its widest point, which is most posterior. In this undeveloped state it was not possible to distinguish between the glands of adults and those of birds-of-the-year on the basis of gross appearance alone, but, as will be shown later, weight of the gland offers some clue to the age of the bird.

In the fully developed condition, that is, at or about the height of the breeding season, each gland swells considerably in three dimensions until it occupies completely the area between the floor of the mouth and the skin surface (see fig. 4*b*). Each becomes highly vascular and measures approximately 14 mm. long and 5 mm. wide.

It is of interest to note that, of the two species of *Collocalia* studied by Marshall

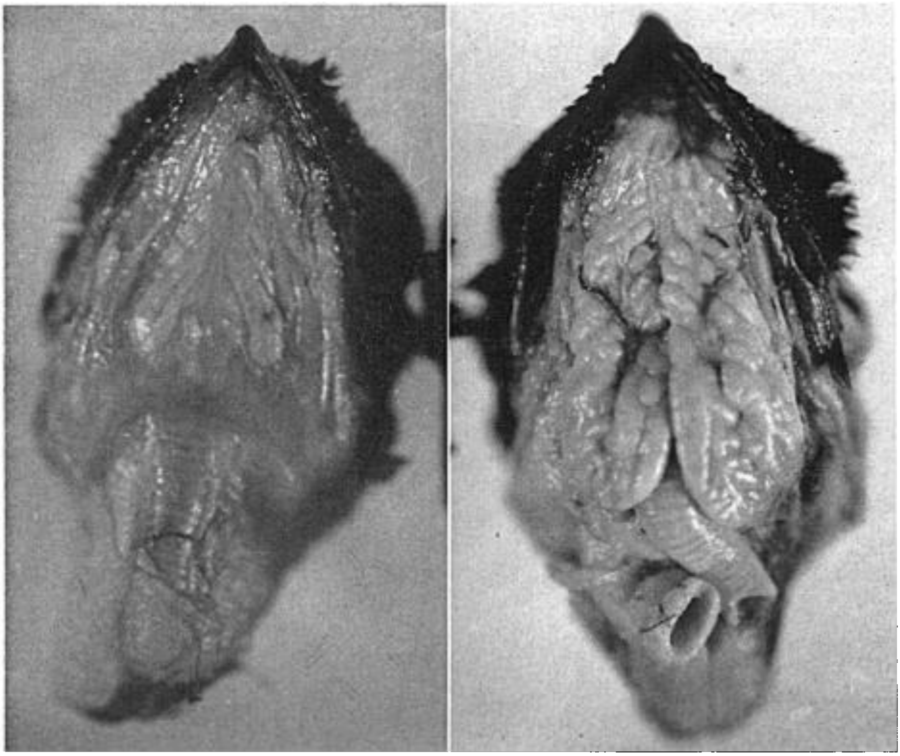

Fig. 4. *a.* Undeveloped salivary glands from adult female Chimney Swift taken on April 30, 1955, near Sandersville, Georgia; *b.* fully developed salivary glands from adult female Chimney Swift taken on May 30, 1956, at Macon, Georgia.

and Folley, taken from the same cave on the same day, one (*brevirostris*) was evidently breeding, as indicated by its enlarged salivary glands, whereas the other (*francica*) was not breeding because it had small glands. The illustrations given for these two species closely resemble the seasonal developmental picture given for the Chimney Swifts in figure 4.

Seasonal development.—The enlargement of the glands in three dimensions precludes the possibility of using any single linear measurement as a reliable index for size increase. Also, since the glands do not have a definite geometric shape, one cannot use a standard formula to compute volume as is frequently done in the routine presentation of testis recrudescence, where the volume of an ellipsoid can be used. It was decided, therefore, to dissect out one gland carefully; even in an advanced state of development a distinct separation could be made in the mid-line. The other gland was left *in situ* for later histologic study. These glands, having been stored in 70 per cent alcohol, were then dried carefully and thoroughly on a piece of filter paper, after which they were weighed on a Beckman Chainomatic balance to the nearest tenth of a milligram. Since there was some question of reliability at this level due to possible differential fluid infusion or a minute error in dissection, the figures were rounded off to milligrams. Routinely, then, the salivary glands were weighed in this fashion, with the exception of two or three which had been damaged by shot.

In figure 5, the weights of one of the salivary glands dissected from adults are plotted against time of the year. As in the case of the gonads, some of these measurements might have been from nonbreeding and/or first-year birds. However, since these age groups could not be distinguished, all measurements are included in this graph with the exception of those of known birds-of-the-year.

Although there is a correlation between the retrogression of gonads and salivary glands, comparison of figure 3 on gonad development and figure 5 on salivary gland development indicates that the testes develop earlier than the salivary glands. For example, the testes of residents which have just arrived and/or migrants in late April are about one-half the maximum size to which they will develop later, but the salivary glands of these same birds are less than one-tenth the maximum size. Although the curve of developing gonads is a gradual one, the salivary glands seem to develop more abruptly. These anatomical facts being true, it is probable that the physiological mechanisms which trigger male gonadal development occur before those which result in the enlarged salivary glands. It is of further interest to note that the regression of salivary glands and of gonads is a gradual one and it is generally consummated by mid-July or slightly before.

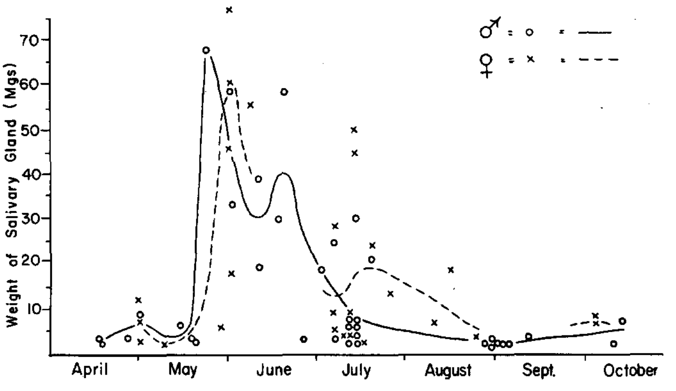

Fig. 5. Weight of one salivary gland from each bird, according to season and sex.

Figure 5 shows that the trends for salivary gland development in the two sexes are nearly identical. The bimodal trendline is probably spurious and results from inadequate sampling in June and July. The seasonal glandular development in both sexes is to be expected, for Fischer (MS) and other workers have shown that both sexes take apparently equal roles in nest construction. Also, Fischer points out that the saliva may be used throughout incubation. In fact, a semicircle of saliva is added to the wall above the nest after incubation begins; this reinforces the nest.

Histological appearance.—Serial sections were prepared of six salivary glands and the associated mouth epithelium, and representative sections of several other glands were examined for comparative purposes. These were cut at 10 microns and were stained with Harris' hematoxylin and eosin. Drawings of three glands are presented in figure 6, and these are intended to represent typical glands in the inactive, regressing, and active conditions.

The active gland was taken from an adult male, shot on May 22, with a near maximum weight of the salivary gland (68 mg.). In this condition it is evident that the stratified squamous epithelium and the buccal glands are larger than in the inactive gland. The cells of each salivary gland lobe were evidently principally mucous-secreting, but some serous cells might have been present although not in demilunes. These mucous cells

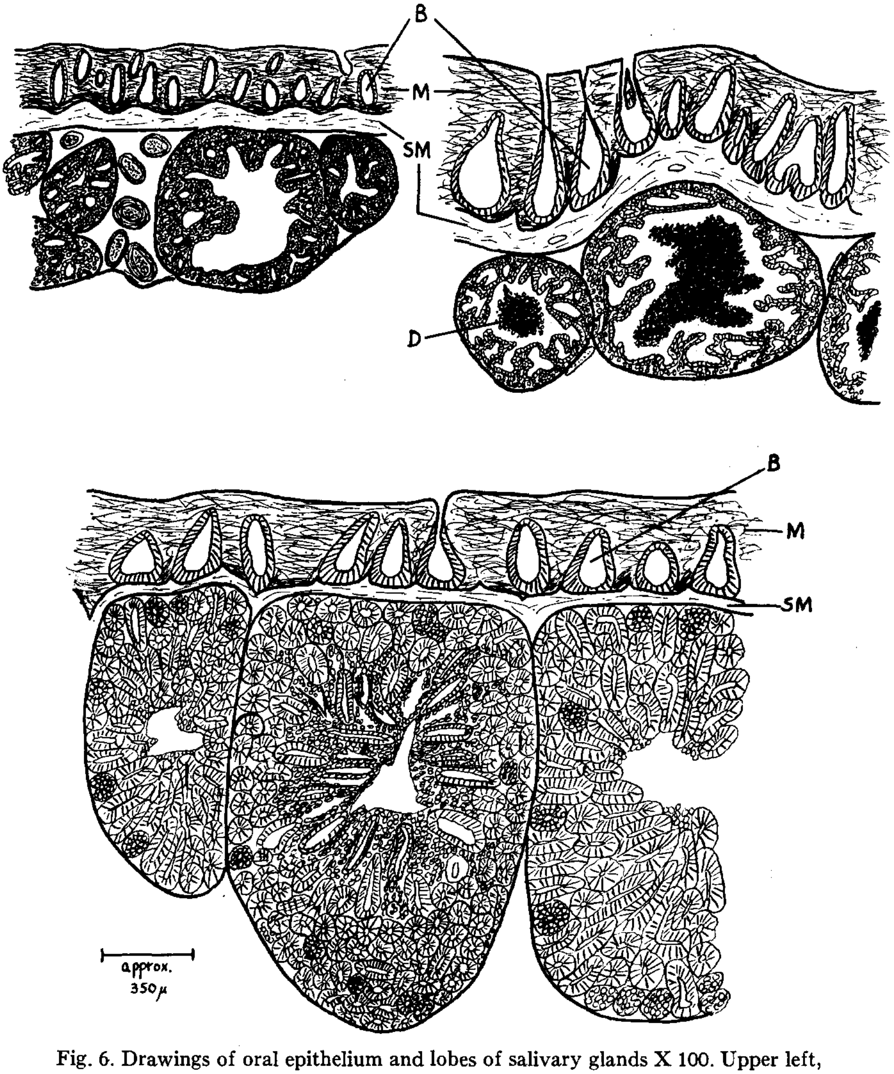

Fig. 6. Drawings of oral epithelium and lobes of salivary glands X 100. Upper left, inactive gland; upper right, regressing gland; lower, active gland. B—buccal gland; M—mucosa; SM—submucosa; D—detritus.

of the buccal and salivary glands were columnar in shape. The lumina of the salivary gland lobes did not appear to be lined with a cuboidal epithelium in the active condition, but in the inactive gland such an epithelium was noted. Serial sections showed that each of these lumina opened one by one toward the anterior part of the gland until each lobe had emptied its products into the oral cavity beneath and anterior to the tongue.

The salivary gland (39 mg.) from an adult male taken on June 11 was used to exemplify a regressing condition in figure 6. Whereas the mouth epithelium and buccal glands resemble those in the active condition, the lobes of the salivary glands are noticeably smaller. Histologically these lobes are irregular internally with only a few well developed tubules and alveoli, and in each large lumen there is a mass of cellular debris. Apparently this represents cells cast off from the tubules as the gland shrinks to an inactive condition and size. This phenomenon resembles a similar one observed in the regressing testes of many birds and mammals.

For the inactive state a gland weighing 3.2 mg. was chosen from an adult male, taken on August 29. As contrasted with the other two drawings in figure 6, the mouth epithelium, buccal glands, and lobes of the salivary glands are all smaller and presumably not secreting. Mucous cells of the glands are principally cuboidal in shape.

Hormonal and/or nervous control.—To date there are no experimental data which show conclusively the controlling mechanisms responsible for the growth and secretion of salivary glands in swifts, but recent experimental evidence from mammals bears upon this situation in birds. As Marshall and Folley (*op. cit.*:387) correctly averred, Lacassagne and other French workers (*fide* Shafer, Clark, and Muhler, 1956) have demonstrated in the rat and mouse relationships between various sex hormones and the submaxillary salivary glands. For some time it was believed that androgens alone were responsible for the maintenance of size and activity of these glands, but in the past 15 years additional research on other hormones has shown that it is not just a simple one-to-one relationship. Currently research in this field is being conducted because of the important relationship between saliva and dental caries in mammals.

In a recent publication, Shafer, Clark, and Muhler (*op. cit.*) have summarized the current knowledge relating to hypophysectomized rats and their salivary glands. Their findings indicate an intricate relationship among testosterone, thyroxine, and the anterior pituitary gland hormone(s). As the result of hypophysectomy the submaxillary glands of rats atrophy. Upon the simultaneous administration of both thyroxine and testosterone, it was found that atrophy of the glands could be inhibited, whereas other hormones (cortisone, pituitary growth hormone, insulin, estradiol, and progesterone) were largely ineffective in inhibiting the atrophy of the salivary glands.

Lacassagne (1940) demonstrated a sexual difference in the submaxillary gland of mice, and suggested that male saliva differs in quality from female saliva. In the present study on the salivary glands of the Chimney Swift, I was unable to find any sexual differences in these glands either macro- or microscopically, and since the existing life history data indicate that both sexes use saliva in the same fashion, one would expect *a priori* no sexual difference in the avian salivary glands.

Few if any concrete data are available concerning the nervous control of salivary gland development, but Grad and Leblond (*fide* Shafer and Muhler, 1955:148) "have pointed out the synergistic effect of testosterone and thyroxine on the rat submaxillary gland and state that because of this apparent major role of these hormones, nervous influences on this gland are of little significance."

Although it is usually unwise to make general statements about hormonal relationships in different animals, it seems reasonable here to suggest a tentative working hypothesis for a possible hormonal-anatomical mechanism in the swifts. These suggestions are, of course, based upon the foregoing experimental evidence from mammals. At the onset of breeding in the Chimney Swift, it can be stated that the titers for androgens and some anterior pituitary gland hormones are high. This is possibly also true for the thyroid hormone, but there is less supporting evidence. If these facts are true, then the combined action of these hormones could cause the growth and perhaps the secretory activity of the salivary glands. Nervous factors may play some role in this picture, especially at the point of secretion. This hypothesis could be tested experimentally by the removal of certain glands and the subsequent administration of the appropriate hormones if someone could devise a method of keeping swifts in a fairly natural state in captivity.

SUMMARY

Seventy-five Chimney Swifts were collected over a period of three years in Georgia and South Carolina in order to effect a study of their paired salivary glands. In the course of the study, data were assembled on molt, weight, skull ossification, and gonad size in an attempt to discover criteria for sex and age. With the possible exception of molt, dissection is necessary to determine sex and age.

Salivary glands were studied (1) by weighing one gland from each bird to the nearest milligram and (2) by preparing some histologic sections. Weights revealed seasonal enlargements similar to cyclical gonadal enlargement, as did the microscopic material. Sections also revealed enlargement of the oral epithelium and buccal glands.

It is tentatively suggested that the *modus operandi* for the enlargement and possible secretion of the glands is mediated via hormones, namely, the combined actions of testosterone, thyroxine, and hormone(s) from the pituitary gland.

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