gardens in Port-of-Spain. It is very active and restless. The song of this bird is unlike that of any of ours, being a quick ascending succession of notes, pitched very high. There is a suggestion of panting and of effort in the song, and its high key, which makes it somewhat squeaky, is rather disagreeable.

NOTES ON THE ANATOMY OF *GEOSPIZA*, *COCORNIS*, AND *CERTHIDIA*.

BY ROBERT E. SNODGRASS.

Plates XVII–XX.

Geospiza and *Certhidia* are the two distinctively peculiar avian genera of the Galapagos Islands. The former consists of a large number of species and varieties, and has always been regarded as belonging to the family Fringillidæ. *Certhidia*, consisting of eight varieties comprised in two species, was formerly placed in the Cœrebidæ, but both Lucas and Ridgway now regard it as belonging to the Mniotiltidæ. *Cocornis* is known only from the small island of Cocos, lying off the Gulf of Panama and northeast of the Galapagos Islands about four degrees north of the equator. It consists of one known species, and has always been assigned to the Fringillidæ. But it has probably been so classified more on account of its general resemblance to *Geospiza* than from a consideration of its own characters.

In all structural points *Cocornis* really resembles *Certhidia* more than it resembles *Geospiza*. To be sure, the adult males of *Cocornis* and of most of the *Geospiza* species are almost plain black, while the adults of *Certhidia* are gray with admixtures of olive and brownish. Yet, in the shape of the bill and in the structure of the skull *Certhidia* and *Cocornis* are almost identical. On the other hand, the structural differences between *Cocornis* and *Geospiza* are slight — the slender-billed *Geospizæ* differ from *Cocornis* in the characters of the skull and skeleton of the bill,

scarcely more than *Cocornis* does from *Certhidia*. The difference is not nearly so great as that between the slender-billed and the thick-billed forms of *Geospiza* itself. Hence, a study of the characters of these three genera, is suggestive of a possible derivation of *Geospiza* from *Cocornis* and of *Cocornis* from *Certhidia*. This, however, would place *Geospiza* in the Mniotiltidæ!

In the descriptions of the skulls following it will be shown that the *Geospiza* skull departs widely from that of any ordinary Fringillid species. The writer, however, does not possess enough knowledge of comparative avian anatomy to venture any theory on the correct classification of the three genera discussed, or on their possible interrelationships. A few facts are set forth in the hope that they may be of value to others.

It is probably not impossible that *Geospiza*, *Cocornis*, and *Certhidia* may be genetically related. Cocos Island is not very distant from the Galapagos, and an ancestral *Geospiza* could easily have gotten there from the latter place. Moreover the climate and flora are utterly different on Cocos and the Galapagos, and the conditions look very unfavorable for convergent evolution. Some authors have claimed a common geological origin for the islands. In such a case we would look for a relationship at least between *Cocornis* and *Geospiza*.

A study of the plumage phases of the *Geospizæ* shows that they are most probably descended from a plain yellowish-olivaceous bird. They advance through six stages from this to the entirely black phase. The lowest forms never go beyond the third stage, being in this plumage when adult.[1] Therefore, *Cocornis* must have branched off from one of the higher groups, for it is black in the adult stage. This conclusion is not endangered by the fact that it is antagonistic to the assumption that the bill and skull of *Cocornis* are intermediate between those of *Certhidia* and the lowest *Geospiza*. There are four groups of *Geospiza* separable on a color basis, and in each the evolution of the bill has been independent. The lowest members of the higher groups have bills more similar to the Certhidian bill than have those of the lowest

[1] Discussed in Papers from Hopkins-Stanford Galapagos Expedition, No. —, Birds, Snodgrass and Heller (MS.), Proc. Wash. Acad. Sci., Vol.

group, and it is between the former and *Certhidia* that *Cocornis* is really intermediate. The theory above suggested involves the assumption that the four groups of *Geospiza* became differentiated in color before the great variation in the bill took place, and consequently, that *Cocornis* branched off from one of the melanistic groups comparatively late in Geospizan history. Such an assumption is entirely in harmony with the facts discussed by Mr. Edmund Heller and the writer in the paper referred to above in the footnote. The fact that large groups of *Geospizæ* are definitely characterized by color, while there is an infinite amount of specific and subspecific variation in the bill, would indicate that the color differences were evolved and stereotyped long before the bill variation began.

What immature stages of *Cocornis* are known indicate that the adult males reach the black phase through paler phases similar to those of *Geospiza*. *Certhidia*, both in the adult and immature stages, is of a plain, pale and comparatively uniform coloration.

I. THE SKULL.

In order to show more strikingly the wide departure that the Geospiza skull makes from the ordinary Passerine type, a description of one of the most specialized forms will be given first. The descriptions of other species follow in the order of decreasing modification.

Geospiza strenua Gould (Plate XVII, Figs. 1 and 2).— Ridges of sides and posterior part of skull strikingly prominent; temporal crests parallel; interorbital area on top of skull parallel-sided and almost as wide as the inter-temporal area. In general the cranium, viewed from above, has a curious resemblance to a rodent's skull.

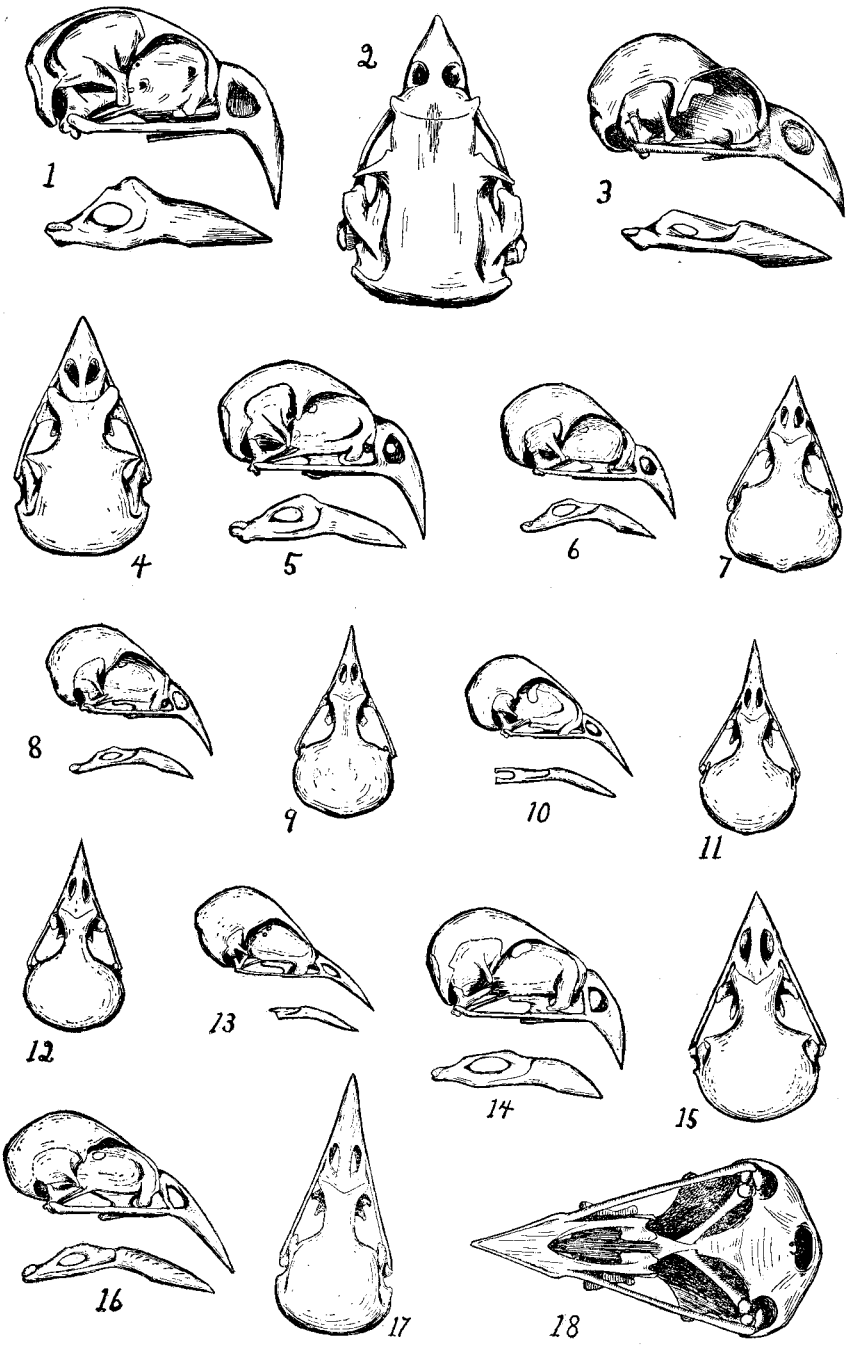
Top of head very smooth. Highest point between tips of squamosal processes; profile descending from here to lambdoidal crest in a regular curve, to base of culmen less steeply and in more nearly a straight line. Space between temporal crests transversely flat, *i. e.*, the crests are coincident with the dorsal profile. Interorbital area much wider than long, depressed mesially and declivent toward each lateral margin, the anterior margin nearly straight. Postfrontal process large, trihedral and unciform. Tem-

poral crest extremely large and high up on side of cranium, curves upward and posteriorly from posterior angle of base of postfrontal process, posteriorly it curves downward and ends in rather prominent process above ear. This crest is greatly larger than in such thick-billed genera as *Cardinalis* and *Zamelodia* (Pl. XVII, Fig. 3). In these latter forms also the crest is far below the dorsal profile of the cranium.

Temporal area very long, its length, from one extremity of temporal crest to the other, equal to distance from anterior end of crest to nostril. This gives an extremely great postorbital length to the skull, the whole configuration of the cranium being very different from that of any ordinary Passerine skull. Surface of temporal area slightly depressed and roughened, lacking the glazed appearance of top of skull. Squamosal process very large, its lower end reflexed posteriorly and lying well behind tip of post-frontal process. In *Cardinalis* the tip of the squamosal process is slightly in advance of the tip of the post-frontal process. Crotaphyte depression between post-frontal and squamosal processes wide and deep.

Tympanic region flat and almost vertical. Lambdoidal crest prominent, but smaller than temporal; median part horizontal; lateral parts deflexed and then curved inward, terminating on each side at base of a prominent mastoid process back of lower part of ear opening. This mastoid process is absent or but poorly developed in other Passerine genera examined as well as in other species of *Geospiza*. Posterior surface of skull receding, *i. e.*, when zygomatic bar is horizontal, it extends downward and slightly forward below lambdoidal crest.

Interorbital septum complete, very thick, and composed of a double wall. Preorbital parts of skull of ordinary Fringillid character. Rim of orbit rather thick and heavy in appearance on account of deflexion of lateral part of interorbital area on top of skull. In *Zamelodia*, *Cardinalis*, *Pipilo*, *Carpodacus*, *Astragalinus*, and in other species of *Geospiza* the interorbital surface is evenly concave, giving the orbital rim a much thinner appearance. On posterior wall of orbital cavity are three conspicuous, vertical, crest-like ridges. Lower end of outer one forms a process visible laterally projecting from lower part of crotaphyte depression.



ANATOMY OF GEOSPIZA, COCORNIS, AND CERTHIDIA.

Geospiza fortis and *G. propinqua* possess similar ridges. In *G. fuliginosa* and *G. scandens* there are only traces of them. They are present in some form, either as plates or ridges, in most Passerine skulls, varying greatly in size, but in *G. strenua* they are far larger than in any other skull examined by the writer.

The most striking feature about the skull of the thick-billed *Geospizæ* is the abrupt angle that the tomium of the upper mandible forms with the zygomatic bar. In *G. strenua* this angle is 118°. The same angle in *Cardinalis* is 140°. That is, the deflexure of the upper mandible from the horizontal is 62° in *G. strenua* and only 40° in *Cardinalis*. In *G. strenua* the distal half of the bony culmen forms an angle of 90° with the basal part of the culmen back of the nostril. This angulation is conspicuous in all the species of *Geospiza*, although not so great in the smaller-billed forms, and is characteristic of the genus. In *Cardinalis* and *Zamelodia* there is no such angulation of the culmen in these genera, as well as in smaller-billed Fringillidæ, the culmen forms an even curve from base to tip.

Nasal bones large, the inferior or descending arm of each thick, and forming nearly a right angle with zygomatic bar. Nostril triangular, of almost an isosceles shape, lower rim horizontal and on a level with upper edge of zygoma. Width of base of upper mandible contained $2\frac{1}{3}$ times in greatest posterior width of cranium; depth $1\frac{1}{2}$ times in greatest posterior depth. Internasal septum complete.

Longitudinal bars of palatines thick, diverging slightly posteriorly, outward and downward, so that posterior ends lie below level of zygomatic bar. Posterior ends blunt. Superior internal laminæ large, widened at dorsal edges and solidly fused with rostrum of sphenoid, not projecting back of anterior ends of pterygoids. Inferior internal laminæ well developed. Lower mandible extremely large, being specially deep just back of middle through coronoid process. Depth here more than a third of the length.

Geospiza fortis fortis Ridgway (Plate XVII, Figs. 4 and 5).—This is one of the species with but a moderately large bill. The interorbital area of the top of the skull is much narrower than in *G. strenua*, being contained $2\frac{1}{3}$ times in the distance between

the temporal crests. The surface is simply concave instead of doubly convex. The temporal crests are relatively small and lie far below the dorsal profile of the cranium, the space between them being strongly arched instead of flat transversely. The space between the postfrontal and squamosal processes is relatively narrower than in *G. strenua*, but the former process ends in advance of the other. The interorbital septum is thin, and is perforated at its upper posterior angle by a hole which is a part also of a foramen opening into the cranial cavity on each posterior orbital wall.

The angle of the tomium of the upper mandible with the zygomatic bar is 122°; *i. e.*, the deflexure of the mandible is 58°. This is 4° less than the deflexure in *G. strenua*. The angulation of the culmen is about the same in the two species. The internasal septum is not complete in *G. fortis*, forming simply a deep median keel on the under surface of the nasal bones.

The lower mandible is slenderer than in *G. strenua* and the coronoid process is not so high.

Geospiza fuliginosa parvula (Gould). (Plate XVII, Figs. 6 and 7.) — The structure of the skull in this species is very similar to that of *G. fortis*, but in it the points in which the *G. fortis* skull departs from the *G. strenua* skull are still more intensified. Both the temporal and lambdoidal crests are comparatively slight. The temporal crests are situated far down on the sides of the skull, and the top of the skull between them is high and roundly convex. The interorbital space is narrow and simply concave.

The angulation of the culmen is considerably less than in the other two species described. The deflexure of the upper mandible from the horizontal of the zygoma is 50°. This is 8° less than in *G. fortis*. The nasal septum is entirely lacking.

This is one of the smaller-billed species of *Geospiza* and the skull differs conspicuously from that of *G. strenua* in the much slenderer upper mandible and in the general lighter appearance of the preorbital parts. The basal depth of the upper mandible is contained $2\frac{1}{2}$ times in the greatest depth of the cranium.

Geospiza fuliginosa acutirostris (Ridgway). (Pl. XVII, Figs. 8 and 9.)— The skull of this form differs from that of *G. f. parvula* in the slightly slenderer, more tapering and less deflexed upper

mandible. The temporal crest is nearly obsolete, and the temporal area below it is less extensive than in *G. f. parvula.* The interorbital septum is so thin that it is almost membranous. The angulation of the culmen is inconspicuous. The deflexure of the upper tomium is about 48°.

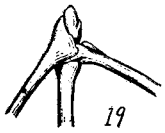
The shape of the nostril changes serially in the four skulls described. In *G. strenua* the nostril is almost an isosceles triangle with the base on a line with the upper edge of the zygoma. In the smaller-billed species, however, the upper angle becomes moved successively farther back, and the angle that the descending process of the nasal forms with the zygoma, which is almost 90° in *G. strenua*, slightly decreases. In *G. f. acutirostris* the upper angle of the nostril lies behind the vertical from the posterior basal angle.

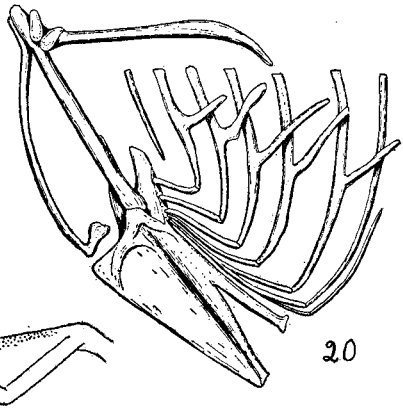
The lower mandible is very slender and there is almost no coronoid process.

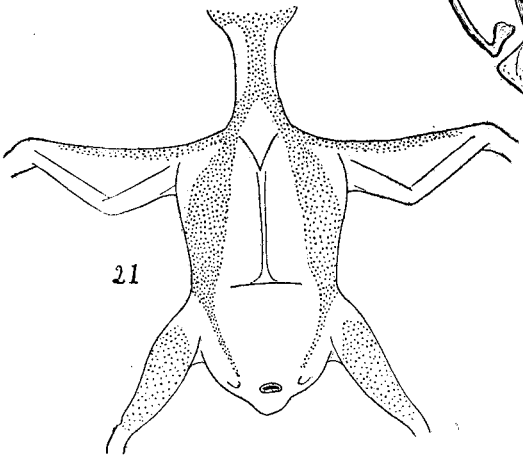
Geospiza scandens fatigata (Ridgway). (Plate XVII, Figs. 16, 17, and 18.) —The *Geospiza* group, characterized by a long slender bill, includes a number of forms that were once regarded as constituting a separate genus called *Cactornis.* The supposed species were separated on characters that have since been found to intergrade in such a manner that they can better be regarded as varieties of one species of *Geospiza.* Of this group, which has been reduced to the species *G. scandens*, the subspecies *G. s. fatigata* may be taken as typical.

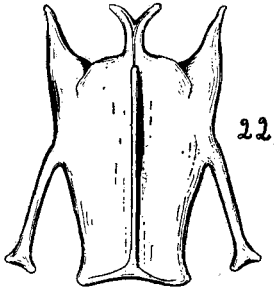
There is far less difference between the skulls of *G. scandens* and *G. fuliginosa* than there is between the skulls of the latter species and *G. strenua.* That is, the former genus *Cactornis* did not differ in cranial structure from the simpler forms of *Geospiza* nearly as much as did the species in this genus, as at first limited, differ from one another.

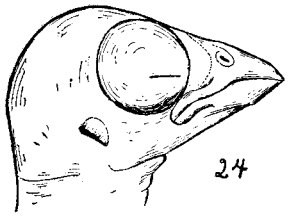
The temporal and lambdoidal crests are almost identical with those of *G. fuliginosa.* The tip of the postfrontal process lies but slightly before the tip of the squamosal process. The fronto-nasal suture is deeply concave. It is more concave than in *G. f. acutirostris*, in the latter species more so again than in *G. fortis*, while in *G. strenua* it is almost straight. The angle of the descending process of the nasal with the zygoma is still less than in *G. f. acutirostris*,

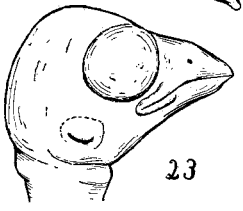


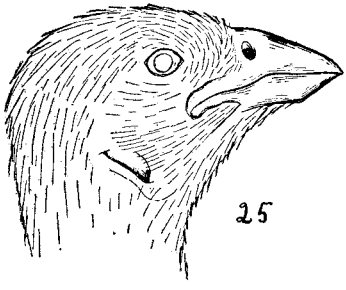


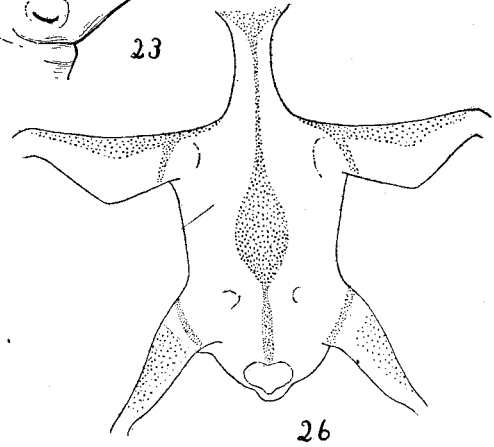












ANATOMY OF GEOSPIZA, COCORNIS, AND CERTHIDIA

and the upper angle of the nostril is correspondingly farther back. The angulation of the base of the culmen is slight, and the deflexure of the upper tomium is about 45°, being a little less than in *G. f. acutirostris*.

As will be seen later, the skull of *G. scandens* approaches most closely to that of the genus *Cocornis*. The skull of *G. f. acutirostris* is nearest in size to the *Cocornis* skull, but in structure the *G. scandens* skull is almost intermediate between the two.

A digression from the series will now be made to describe the skull of the Geospizan group having a strongly curved culmen.

Geospiza crassirostris (Gould). (Plate XVII, Figs. 14 and 15.) — This species may be taken as a typical example of the *Geospiza* species formerly included in a separate genus called *Camarhynchus*, a group characterized by having the culmen strongly curved.

The skull of *G. crassirostris* is in every way very similar to that of *G. fortis*. About the only difference is that the culmen is a little more convex than in *G. fortis*, and the upper mandible is deeper in front of the nostril. The crests of the two skulls have about the same development, the interorbital areas are the same, the upper mandibles have the same deflexure, the nostrils are alike, the descending processes of the nasals form the same angle with the zygoma, and the post-frontal and squamosal processes have the same relative positions.

A study of the *Geospiza* skulls shows, then, that the various species and varieties are related to one another mostly in a serial manner. That is, evolution in the group has not been along lines radiating from a common centre, but has consisted principally of successive modifications along one line. This same thing is evinced by a study of the color phases of the plumage.

Cocornis agassizi Townsend (Pl. XVII, Figs. 10 and 11).— The general characters of the skull are almost identical with those of *G. f. acutirostris* or *G. scandens*. The upper mandible, however, is relatively a little slenderer than in either of these, and the deflexure of the tomium is about 40°. This is about 5° less than in *G. scandens*.

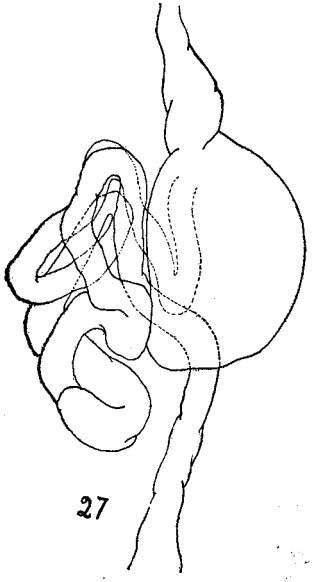
Certhidia olivacea luteola (Ridgway). (Pl. XVII, Figs. 12 and 13.)— The skull of *Certhidia* is extremely similar to that of *Cocor-*

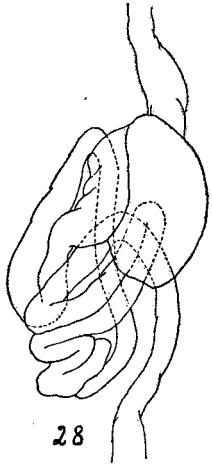
nis. It differs from the latter in about the same way that the *Cocornis* skull differs structurally from the skull of *G. scandens.* That is, the upper mandible is slenderer and less deflexed. The angle of deflexure in *C. o. luteola* (and the bill does not vary in the genus) is about 35°. This is just as much smaller than the deflexure in *Cocornis* as the latter is than the deflexure in *G. scandens.*

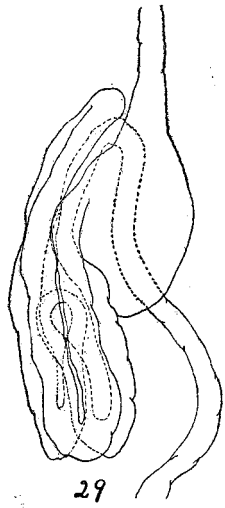
From the foregoing descriptions it is evident that the species of the three genera under consideration can be arranged in a graded series according to the structure of the skull. Such a series would begin with the members of *Certhidia,* all of which have very slender and gently deflexed bills. Following *Certhidia* comes *Cocornis* with a slender but more deflexed bill. Separated from *Cocornis* by a step no greater than that from *Certhidia* to *Cocornis* comes *Geospiza scandens.* This species, although structurally intermediate between those on each side of it, makes a digression as to size, being much larger than either *Cocornis* or *G. fuliginosa acutirostris* which otherwise follows *G. scandens* in the series. From *G. f. acutirostris* the series is uninterrupted to such forms as *G. strenua* and *G. magnirostris* in which the bill is enormously large and the upper mandible greatly deflexed, and in which the skull has an almost un-bird-like appearance on account of the curious shape and the great development of the crests.

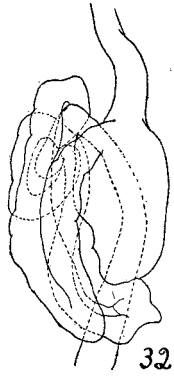
All that the writer here intends is simply to call attention to the fact that there is a gradation in the skull characters of these three genera, progressing by almost equal steps from one extreme to the other. If any phylogenic theory can be based on this fact then the classification of the three genera accepted at present cannot be correct, for *Certhidia* is regarded as a member of the Mniotiltidæ and *Geospiza* and *Cocornis* are placed in the Fringillidæ. The *Geospizæ* as birds have certainly a most Fringillid appearance. The same, however, cannot be so positively asserted concerning the skull of even the least modified species.

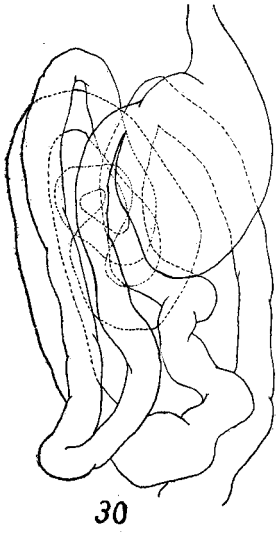
A study of the bills of nestlings would probably have little phylogenetic value. Three stages in the growth of *G. fuliginosa parvula* are shown in Plate XVIII, figures 23, 24 and 25.

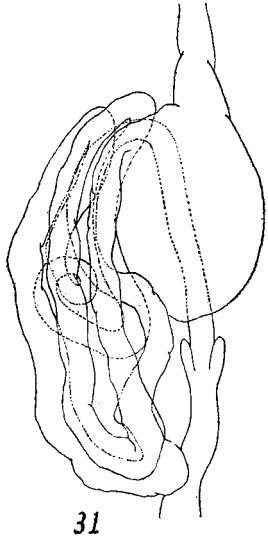


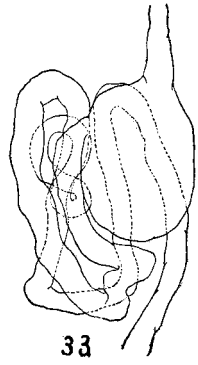












ANATOMY OF GEOSPIZA, COCORNIS, AND CERTHIDIA.

II. THE THORACIC SKELETON.

The sternum, shoulder girdle and ribs show no such modifications as does the skull. The drawings of the parts in *Cocornis agassizi* (Pl. XVIII, figs. 19, 20, 22) may be taken as typical for all three genera. The sternum and shoulder girdle are of ordinary Passerine form. The ribs are somewhat variable. There are always seven that are well developed and generally there is a small eighth rib. The latter is sometimes a mere bar lying back of the lower part of the neural arm of the seventh, but often it is composed of distinct neural and hæmal segments. The second to fifth ribs inclusive always have large uncinate processes. On the sixth rib there is sometimes present a well developed uncinate process, but it is often rudimentary and is frequently absent.

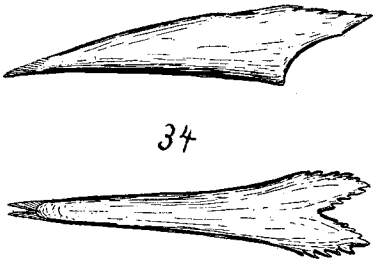
Such variations as these have no phylogenetic significance, for they take place between closely related species and also in different individuals of the same species.

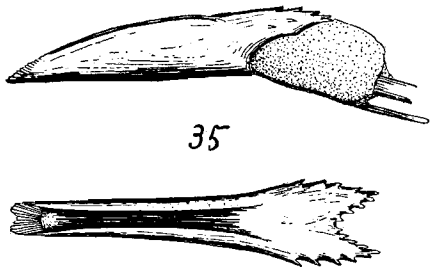
III. THE TONGUE.

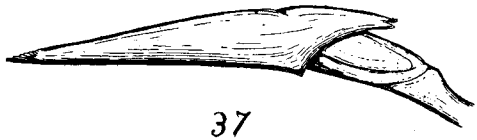
Geospiza (Pl. XX, Figs. 34–38, and 40).— The tongue of *Geospiza* has a simple tapering shape, varying in length and thickness according to the form of the bill. The thin terminal margin is bifid and somewhat frayed. The upper surface is usually convex, but it is often slightly and sometimes deeply grooved longitudinally. This last character, however, varies between closely related species and even in the same species (Figs. 34 and 37). *Geospiza* is mostly granivorous but partly insectivorous.

Certhidia (Pl. XX, Fig. 41).— The tongue in this genus is the same as in the slender-billed species of *Geospiza*, except that it is more constantly grooved above. It is slender, tapering and bifid at the tip. *Certhidia* is insectivorous.

Cocornis (Pl. XX, Figs. 39 and 42).— In this genus the tongue is very long and slender. It is deeply grooved above, and expanded, bifid and greatly frayed out at the tip (Fig. 39). It differs considerably, as the figures will show, from the tongues of both *Certhidia* and *Geospiza*. The food of *Cocornis* has not been determined, but probably consists mostly of insects.







ANATOMY OF GEOSPIZA, COCORNIS, AND CERTHIDIA.

IV. THE ALIMENTARY CANAL.

No descriptions need be given of the alimentary canals. Figures 27 to 33 on Plate XIX sufficiently show the intestinal windings in several species of *Geospiza* and also in *Cocornis* and *Certhidia*. It will be seen that there is no essential difference here between the three genera.

V. PTERYLOSIS.

The pterylosis is identical in the three genera. Figures 21 and 26 of Plate XVIII, representing the feathered areas of *Cocornis agassizi*, could serve just as well for either *Certhidia* or *Geospiza*. The dorsal tract extends down the back of the neck and between the shoulders as a narrow, median band. On the middle of the back it expands into a wide, fusiform area reaching to the anterior part of the lumbo-sacral region. Here it again contracts to a narrow band, narrowest between the acetabula, and goes caudally to the oil-gland. The ventral tract begins as a median band on the anterior half of the throat. Just below the middle it divides into two bands that go outward and caudally as wide tracts along the sides of the breast. Behind the sternum each becomes again narrow, and goes caudally and inward along the side of the abdomen, ending near the anus. At the shoulder each lateral ventral tract gives off laterally the shoulder tract which divides into the alar and humeral tracts.

EXPLANATION OF THE PLATES.

Plate XVII. SKULLS. Figs. 1 and 2, *Geospiza strenua*; 3, *Zamelodia melanocephala*; 4 and 5, *Geospiza fortis fortis*; 6 and 7, *G. fuliginosa parvula*; 8 and 9, *G. fuliginosa acutirostris*; 10 and 11, *Cocornis agassizi*; 12 and 13, *Certhidia olivacea luteola*; 14 and 15, *Geospiza crassirostris*; 16, 17 and 18, *G. scandens fatigata.*

Plate XVIII. Fig. 19, *Cocornis agassizi*, inner view of bones at shoulder; 20, *C. agassizi*, side view of thoracic skeleton; 21, *C. agassizi*, ventral pterylosis; 22, *C. agassizi*, ventral view of sternum; 23, 24 and 25, *Geospiza fuliginosa parvula*,

side view of head of three nestling stages — primaries 4 mm., 13 mm. and 32 mm. long, respectively; 26, *Cocornis agassizi*, dorsal pterylosis.

Plate XIX. ALIMENTARY CANALS.— Fig. 27, *Geospiza conirostris conirostris* (length 205 mm); 28, *G. fuliginosa parvula* (length 170 mm.); 29, *G. fortis dubia* (length 204 mm.); 30, *G. crassirostris* (length 255 mm.); 31, *G. scandens fatigata* (length 200 mm.); 32, *Certhidia olivacea luteola* (length 102 mm.); 33, *Cocornis agassizi* (length 125 mm.).

Plate XX. TONGUES.— Fig. 34, *Geospiza scandens fatigata*; 35, *G. habeli*; 36, *G. fortis fortis*; 37, *G. scandens fatigata*; 38, *G. prosthemelas*; 39, *Cocornis agassizi*, tip of tongue; 40, *Geospiza fuliginosa parvula*; 41, *Certhidia olivacea luteola*; 42, *Cocornis agassizi.*

A CONTRIBUTION TO THE LIFE HISTORY OF THE HERRING GULL (*LARUS ARGENTATUS*) IN THE UNITED STATES.

BY WILLIAM DUTCHER AND WILLIAM L. BAILY.

Plates XXI and XXII.

THE facts presented in this paper are the results of several visits to the large breeding colonies of Herring Gulls on the Maine coast, made at the following dates: by Mr. Dutcher, 1900, from June 28 to July 21; 1901, by both contributors, from June 12 to 24; 1902, by Mr. Baily, from July 18 to 20 inclusive. In 1900 visits were made to nearly all of the colonies along the Maine coast by the senior contributor, commencing at the most westerly one on No-Man's-Land Island, which is situated about seventeen miles south of Rockland, Maine, and adjoins the large island known as Matinicus. In 1901 eight days were spent at the light-house station on Great Duck Island, and subsequently nearly all of the other colonies were revisited by Mr. Dutcher. In 1902 Mr. Baily revisited the Great Duck Island colony later in the season, in order to observe the methods of feeding the young birds and the habits of the young. A description of the position and