

THE TRACHEA OF THE HAWAIIAN GOOSE

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The unfortunate death of one of a pair of S. Dillon Ripley's Hawaiian Geese (*Branta* ["*Nesochen*"] *sandvicensis*) has given me the rare opportunity of examining a fresh specimen of this interesting species. Other than Miller's (Univ. Calif. Publ. Zool., 42, 1937:1-80) study of the "Structural Modifications of the Hawaiian Goose (*Nesochen sandvicensis*)," there has been no study of the morphology of the Hawaiian Goose. Miller's study was confined to an analysis of hindlimb locomotor adaptations. It is regrettable that the specimen available to me was damaged so severely as to make studies of pterylosis, digestive tract, and certain other aspects of the anatomy of this specimen impossible. The posterior half of the trachea, however, was undamaged. Since this structure and its associated musculature have never been described for the Hawaiian Goose, I take this opportunity of making a record of them.

This specimen of the Hawaiian Goose was a year old and probably a male, although I was unable to identify the testes with any certainty. Post-mortem examinations revealed indications that the bird may have been weakened by hepatitis before being attacked and partly eaten by rats. The lining of the empty gizzard was bright chrome yellow in color, and the gall bladder was greatly enlarged. The death of one of Dr. Ripley's Australian Black Swans (*Cygnus atratus*) in 1957 was attributed to hepatitis; this bird had an enlarged gall bladder and a yellow gizzard lining. The fact that one of the Hawaiian Geese was attacked by rats while none of the many healthy birds in the pen was attacked lends further support to the idea that the goose was in a weakened condition.

I am grateful to Dr. Ripley for his helpful suggestions and for permission to examine this valuable specimen. For his help in making a detailed photographic record of the anatomy of the trachea of the Hawaiian Goose, I am very much indebted to Rudolph Zallinger. I wish to thank Shirley Glaser for assistance with figure 1 and lettering figure 2 and Jean Richards for typing the manuscript. This study was undertaken in the course of a survey, supported by the National Science Foundation, of the anatomy of the trachea of ducks and of the classification of that group.

ANATOMY OF THE TRACHEA AND ASSOCIATED STRUCTURES

Trachea.—The trachea of the Hawaiian Goose extends along the ventral surface of the neck in close association with the esophagus. The trachea diverges from the esophagus approximately 3 cm. anterior to the arms of the furculum and proceeds ventrally along the membrane of the interclavicular air sac at an angle of 45 degrees. At a point 12.9 mm. dorsal to the hypocleideum and 30 mm. ventral to the esophagus the trachea enters the interclavicular air sac and proceeds dorsally at an angle of 45 to 50 degrees from the vertical. Counting from the posterior end of the trachea, tracheal ring 30 lies at the level of the hypocleideum. The trachea touches the anterior dorsal margin of the body of the sternum in passing. The lateral margins of the trachea between the furculum and the anterior margin of the body of the sternum are joined by membranes to the ventrolateral walls of the interclavicular air sac. The dorsal surface of the caudal termination of the trachea is 3 mm. ventral to the esophagus and lies dorsal to a point 30 mm. caudad of the anterior margin of the sternum in the midline (see fig. 1).

The dimensions of the trachea as it passes between the arms of the furculum are: lateral diameter, 10.6 mm.; dorsoventral diameter, 7.9 mm. The trachea gradually decreases in size posteriorly; 10 mm. anterior to the posteriormost extremity of the tympanum it measures 6.4 mm. in dorsoventral diameter and 6 mm. in lateral diameter.

The tympanum may be incompletely fused in this individual. Its measurements are: greatest length along ventral surface, 5 mm.; greatest length along dorsal surface, 5 mm.; dorsoventral diameter at anterior end, 7 mm.; lateral diameter at anterior end, 6 mm.; smallest lateral diameter, 5 mm.; greatest dorsoventral measurement at posterior end of tympanum, 10 mm. Adult specimens of *Anser* and *Branta* have tympanums which are four or five times as long as the tympanum of this year-old specimen of *B. sandvicensis*. I do not have the material to determine the relation of age to variation in fusion and length of the tympanum in geese.

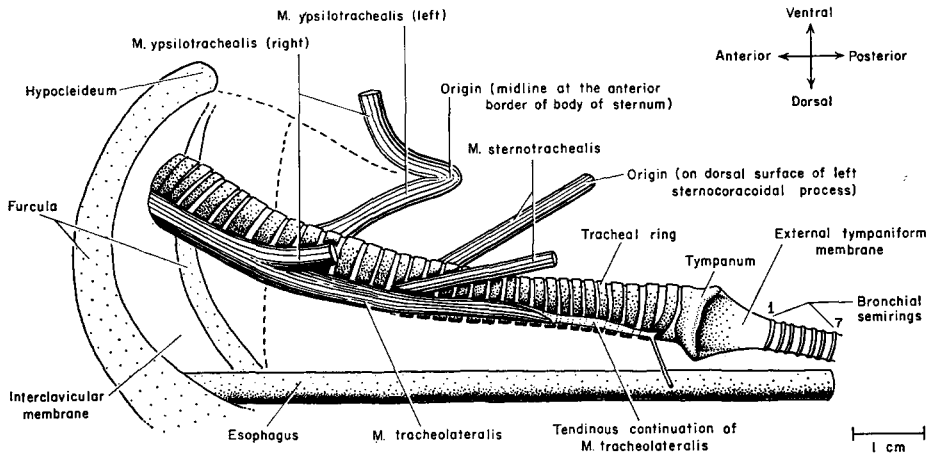


Fig. 1. Lateral view of the posterior end of the trachea of *Branta* ("*Nesoche*n") *sandvicensis*. The trachea has been moved slightly dorsal so that the Mm. ypsilotracheales and Mm. sternotracheales could be shown to better advantage. The ventral limit of the interclavicular air sac between the hypocleideum and the anterior border of the sternal body is indicated by a dashed line.

Bronchi and syrinx.—The right and left bronchi are of equal size and neither is enlarged nor has any enlargements. The right bronchus (the left was not measured) was 3.9 mm. in dorsoventral diameter throughout its length from the first bronchial semiring caudad of the trachea to the posteriormost bronchial semiring. The right bronchus has 7 semirings; there are 6 semirings in the left. Each bronchus diverges from the midline at an angle of about 50 degrees. The bronchi consist largely of transparent membrane; the bronchial semirings are not very prominent. The distance between the middle of the first semiring and the lateral posterior margin of the tympanum (the caudal end of the trachea) is 9 mm.

The paired external and internal tympaniform membranes and their supporting structures comprise the syrinx. The external tympaniform membrane is supported anteriorly by the caudal margin of the lateral wall of the bronchial opening at the caudal end of the tympanum; this margin measured 9.3 mm. in length. The first bronchial semiring forms the posterior support for the external tympaniform membrane. Compared to waterfowl other than geese, the Hawaiian Goose has an external tympaniform membrane which is very extensive in area. The dorsal and ventral margins of the external tympaniform membranes attach imperceptibly to the corresponding margins of the right and left internal tympaniform membranes, respectively. The internal tympaniform membrane receives support anteriorly from the margin of the mesial wall of the

bronchial opening at the caudal end of the tympanum. The internal tympaniform membranes terminate caudally by fusing with one another in the midline. On looking through the interbronchial opening between the right and left internal tympaniform membranes one can see the ventral surface of the esophagus which is 2 or 3 mm. dorsal to the dorsal margins of the bronchi anterior to the first bronchial semiring. Dorsally and ventrally this interbronchial space opens into the interclavicular air sac.

Tracheal muscles.—The Hawaiian Goose possesses in common with other Anseres two pairs of extrinsic tracheal muscles, Mm. sternotracheales and Mm. ypsilotracheales, and one pair of intrinsic tracheal muscles, Mm. tracheolaterales.

The sternotrachealis is a very narrow, thin band of muscle uniformly 2 mm. in width for most of its length; it is slightly wider at its origin. The origin of the sternotrachealis is on the dorsal side of the anteromesial margin of the sternocoracoidal process of the sternum. The muscle extends 30 mm. anteromesially to its insertion on the lateral surface of the trachea at tracheal rings 18 and 19 (the posteriormost pre-tympanic tracheal ring being counted as the first). The insertion measured 3 mm. in length and its anterior limit was 37 mm. distant from the caudal margin of the tympanum and 17 mm. distant from the posterior limit of the fleshy part of the tracheolateralis. The sternotrachealis inserts on the trachea ventral to the body of the tracheolateralis.

The ypsilotrachealis diverges from the lateral surface of the trachea at tracheal rings 23 and 24 and runs directly to the origin 20 mm. caudad. It is a very thin muscle 3 mm. in width throughout its length. The origins of the two ypsilotracheales meet at the midline at the anterior border of the body of the sternum. The origin of each ypsilotrachealis is 3 mm. in maximum width.

The ypsilotrachealis and the tracheolateralis together extend anteriorly along the lateral surfaces of the trachea and presumably have their anterior attachments on the ventral surface of the cricoid cartilage. Because the anterior part of the trachea was missing in this specimen, the relations of the ypsilotrachealis and tracheolateralis in that region could not be determined.

The tracheolateralis terminates as a narrow tendon on the lateral surface of the trachea at the second pre-tympanic tracheal ring 6.5 mm. anterior to the posterior margin of the tympanum. The fleshy part of the tracheolateralis terminates on the lateral surface of the tenth tracheal ring 19 mm. anterior to the posterior margin of the tympanum. The tracheolateralis passes dorsal to the insertion of the sternotrachealis.

DISCUSSION

I have examined the tracheas of *Branta bernicla hrota*, *B. canadensis*, *Anser* ("Chen") *caerulescens caerulescens*, *A. c. hyperboreus*, and *A. c. atlanticus*. In all these species the trachea diverges ventrally from the esophagus and approaches the hypocleidium before entering the interclavicular air sac. The arrangement of the tracheal muscles, the shape of the tympanum, and the orientation of the bronchi and tympaniform membranes is the same in the Hawaiian Goose and other geese that I have examined except for minor variations.

Although not enough specimens have been examined to enable me to comment on variability, there appear to be two differences between *Anser* and *Branta* with respect to the anatomy of the trachea. These are (1) in the number of bronchial semirings, and (2) in the location of origin and width of the ypsilotrachealis. "*Nesochen*" agrees with *Branta* in both these characters. Whether or not examination of series of specimens of these and additional species of geese will show that these characters consistently reflect the limits of the genera as they are currently understood (Delacour and Mayr, Wilson

Bull., 57, 1945:3-55) remains to be seen. It would be particularly interesting to examine specimens of additional species of *Anser*, including "*Philacte*," "*Eulabeia*," and "*Cygnopsis*."

Specimens of *Branta* and "*Nesothen*" at my disposal had fewer bronchial semirings than did specimens of *Anser*. They also had a narrow ypsilotrachealis originating on the anterior margin of the sternal body near or at the midline. Specimens of *Anser*, with one possible exception, (see fig. 2), had ypsilotracheales which originated anterior to the sternum and were either narrow (2 specimens) or wide (2 specimens).

	Number of specimens	Number of bronchial semirings		Origin of ypsilotrachealis on sternum	Origin of ypsilotrachealis anterior to sternum	Ypsilotrachealis narrow	Ypsilotrachealis wide
<i>Branta sandvicensis</i>	1	6	7	+		+	
<i>Branta bernicla</i>	1	6	6	+?		+	
<i>Branta canadensis</i>	1	7	7	+		+?	
<i>Anser c. caerulescens</i>	1	-	11		+	+	
<i>Anser c. caerulescens</i>	1	-	9		+		+
<i>Anser c. atlanticus</i>	1	?	?	+?			
<i>Anser c. atlanticus</i>	1	-	11		+	+	
<i>Anser c. hyperboreus</i>	1	-	9		+		+

Fig. 2. Number of bronchial semirings and characteristics of M. ypsilotrachealis of several specimens of *Anser* and *Branta*.

Bearing in mind that more material should be examined to determine the variability of these characters, I can conclude that "*Nesothen*" and *Branta* are in structure of the trachea more similar to one another than to *Anser*. This conclusion is in agreement with Miller's (*op. cit.*: 60) statement that "*Nesothen* is most closely related to *Branta* . . ." With regard to tracheal characters I cannot agree with Miller's statement (*loc. cit.*) that *Nesothen* "is as distinct from *Branta* as is *Chen*." The structure of the trachea of "*Nesothen*" bears out Delacour and Mayr's (*op. cit.*) opinion that the genus should be merged with *Branta*.

SUMMARY

1. The caudal portion of the trachea and tracheal musculature, and the bronchi of the Hawaiian Goose are described.
2. The trachea and tracheal musculature, and bronchi of the Hawaiian Goose are identical (except in minor detail) with those structures in other species of *Branta* and only slightly different from those in *Anser*.

3. The bronchi of *Branta* and "*Nesochen*" each have 6 or 7 bronchial semirings; those of *Anser* each have 9 to 11 semirings.

4. The ypsilotracheales of *Branta* and "*Nesochen*" are narrow and originate on the anterior margin of the body of the sternum near the midline; those of *Anser* may be either narrow or wide and originate (with one possible exception) anterior to the sternum.

5. More specimens of *Branta* and *Anser* should be examined to determine more precisely the variability of their tracheal characters.

6. The structure of the trachea of "*Nesochen*" bears out Delacour and Mayr's opinion that the genus should be merged with *Branta*.

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