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OBSERVATIONS ON THE STRUCTURE OF THE GUSTATORY ORGANS OF THE BAT (*Vesper- tilio subulatus*).

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THE present paper contains a description of the anatomy of the taste organs of a single species of Chiroptera. It is highly probable that further study of these organs in other species of this interesting group of animals will reveal important variations, respecting both position and structural characters, from the results embraced in this short memoir.

It will be of interest first to notice briefly the form and general appearance of the tongue of this mammal.

GENERAL DESCRIPTION OF THE TONGUE.

The organ measures 13.5 mm. in length, its greatest transverse diameter is 5 mm., and at its thickest part it measures 4 mm. Anteriorly, it is free from the floor of the mouth for 6 mm., or nearly half its length. The upper posterior surface is slightly convex, and has a nearly uniform breadth. In the anterior half of the organ the lateral margins gradually converge, blending at the tip in a slightly rounded or pointed extremity. The upper surface of this portion of the tongue is marked by several sub-parallel, transverse rugæ or folds, with corresponding depressions between them. These folds decrease in size as they approach the anterior extremity of the organ, and cease altogether at 1.5 mm. from its apex. The dorsal surface is unmarked by any

median groove or raphé, except at the extreme posterior region. Here there is a wide and rather deep mesial groove, 2 mm. in length, beginning in front of the epiglottis and terminating midway between the two circumvallate papillæ.

In one of my specimens, near the line of union of the posterior and middle third of the tongue, is a rounded eminence, showing a tendency to a raised posterior part, as seen in the tongue of the Rodentia. This feature, however, is wanting in other tongues of *Vespertilio* which I examined.

The upper surface, including the lateral margins, is covered with closely-set tactile and mechanical papillæ, the points of which are directed backwards and inwards.

The fungiform papillæ are only fairly numerous, and are distributed with some degree of uniformity over the dorsal surface and upon the sides of the tongue. Posteriorly they terminate in front of the gustatory area, and they cease anteriorly a short distance from the tip. Those scattered over the anterior third of the dorsum are usually larger than those occurring elsewhere.

On each lateral half of the tongue, 2 mm. from the base, is situated a circumvallate papilla. The two papillæ are placed quite near the median line, the distance between them being only 0.6 mm. They are oval in form, of nearly equal size, and are placed obliquely to the long axis of the tongue, their anterior extremity being directed outwards.

A papilla of similar type to those just mentioned, but less developed and apparently in a transitional stage, is present at the posterior limit of each lateral border. Further investigation will be necessary to determine whether these papillæ are constant or not. In the specimens which I have examined I have always found them, although exhibiting striking variations in form, general appearance, and structure, from normal circumvallate papillæ. No papilla foliata was found.

The under surface of the tongue is perfectly smooth. Anteriorly there is a median ridge, with sloping sides, extending from the frænum to the tip.

GUSTATORY STRUCTURES.

The Circumvallate Papillæ. — These papillæ show no indications of lobation. Their upper surfaces are rounded, and they measure 0.30 mm. in their transverse diameter, and are 0.22 mm.

in height. Where they join the tongue, the transverse diameter is only 0.12 mm. Each papilla is encircled by a rather shallow and very wide trench. In some sections this extreme width of the trench (as shown in Fig. 1) is confined to its upper part, the lower portion curving beneath the papilla and becoming quite narrow. The ridge surrounding the trench, and forming its outer wall, has elongated tactile papillæ projecting from its surface (Fig. 1). The general surface adjoining this gustatory area is covered with large and small papillæ, quite symmetrical in arrangement, but presenting a great variety of forms. Serous glands are fairly numerous in the gustatory area, but none were found within the papillary body itself. The ducts of the serous glands open into the trench at its base and sides. The papilla at its upper part bears many secondary papillæ, the depressions between which are filled by the epithelium. The nerves are chiefly non-medullated and ramify throughout the papilla, but I was unable to trace their terminal branches with any distinctness. The large ganglion described by Poulton¹ in the circumvallate papilla of *Perameles*, and observed by me² in the circumvallate papilla of *Fiber*, I failed to detect any indications of here.

The two lateral circumvallate papillæ are asymmetrical, the right one being much less developed than the left. The latter, as seen in vertical section, is elliptical in shape, and joins the tongue by a narrow pedicel. The trench which surrounds this papilla is very wide at its upper part, and narrow and of uniform breadth at its lower. Serous glands are sparingly scattered through this region, and are entirely wanting within the papillary body.

The taste-bulbs are not very numerous in the circumvallate papilla of *Vespertilio*. They are disposed at the sides in a girdle of seven or eight tiers, the uppermost tier being nearly on a level with the top of the trench. From horizontal sections, made at different levels, I estimated the average number of bulbs in a tier at fifty. If we allow for eight tiers, we shall have four hundred bulbs for each papilla. I did not succeed in finding bulbs in the epithelium investing the upper surface of the papilla, nor was I able to detect them in the outer wall of

¹ Quart. Journ. Micr. Sci., Vol. XXIII., 1883, p. 73.

² Journ. of Anat. and Physiol., Vol. XXII., 1888, p. 136.

the trench. The bulbs vary somewhat in shape, and in point of size they are the smallest I have yet observed, the nearest approach to them in this respect being those of the circumvallate papilla of the mouse. They vary in length from 0.025 to 0.030 mm., and their breadth is about 0.015 mm. Usually in a bulb of this area, the diameter of the peripheral end of the bulb exceeds that of the central. The latter is also curved slightly downwards. This form of bulb I have not observed before, although it is seen in those figured by Lovén in the circumvallate papilla of the calf. I did not succeed in finding a bulb with the peripheral processes of its gustatory cells projecting beyond the pore. One bulb (in vertical section) shows a fissure, 0.015 mm. long and 0.0015 mm. wide, caused by a separation of the edges of two adjoining peripheral cells.

I was unable to isolate the central or gustatory cells of the bulbs sufficiently well for study, but the peripheral cells do not differ materially from those already described in the taste organs of other mammals. They are elongated, slightly flattened, nucleated cells, with their two extremities tapering gradually to a point.

The number of bulbs in the left lateral circumvallate papilla could not be estimated from my sections with any degree of accuracy. The most noteworthy thing about them in this region is their very unusual arrangement (Fig. 3). They occur only on one side of the papilla; but here they form a continuous chain, seventeen tiers deep, extending from the base of the papilla nearly to its summit. Bulbs are likewise present in the lower half of the outer wall of the trench. Here I counted eight tiers. The bulbs of this region measure 0.024 mm. in length and 0.015 mm. in breadth, being thus a little smaller than those of the normal circumvallate papilla.

The Fungiform Papillæ. — These papillæ are distributed quite regularly over the dorsum and sides of the tongue, from the gustatory area nearly to the tip. Interspersed among those of the posterior part of the dorsum are a few which appear to be undergoing transition to the circumvallate type of papilla (Fig. 6).

In several instances taste-bulbs were present in the epithelium at the upper part of these papillæ. They are usually placed vertically, directly in the long axis of the papilla. By

far the most interesting specimens (which are shown in Fig. 6) were found in a papilla from the posterior region of the tongue. In this papilla there are two well-formed bulbs, and placed between them is a third, which is either of a low order or undeveloped.¹ The largest bulb of the three measures 0.036 mm. in length and 0.016 mm. in breadth, and its apex appears to reach the free surface of the epithelium, its base penetrating the mucosa. Some of the isolated bulbs met with elsewhere in these papillæ, particularly those of the anterior dorsal surface, are even larger than those shown in Fig. 6. Neither serous nor mucous glands were observed near the fungiform papillæ.

The entire upper surface of the tongue is covered with papillæ of mechanical and tactile (?) function. They are quite closely set, except at the basal region, are largest at the posterior part of the dorsum, and gradually decrease in size as they approach the anterior extremity. These papillæ, when near the tip, enlarge slightly again. One from the posterior third of the tongue measured 0.11 mm. in height and 0.04 mm. in breadth. Behind the circumvallate papillæ, and also about the tip, are numerous rather coarse, retroverted, conical papillæ. Each papilla is seated upon a single papillary upgrowth of the mucous membrane, and is invested by epithelium of a uniform thickness. The outer layers of epithelium covering the upper surface and sides are usually partly, and occasionally wholly, cornified. These papillæ vary much in shape and general appearance. Many of them are cone-shaped, while others resemble, in external structure, minute fungiform papillæ. The upper surface is now and then flat or slightly convex, but usually the papilla terminates in a retroverted, horny spinule.

¹ Figure 7 represents a vertical section through a fungiform papilla, from the anterior dorsal surface of the tongue of a pig, containing eight taste-bulbs.

EXPLANATION OF PLATE I.

LIST OF REFERENCE LETTERS.

c. e. Columnar epithelium. *g. p.* Gustatory pore. *gl. d.* Duct of serous gland. *m. m.* Mucous membrane. *p.* Elongated papilla. *p. e.* Pavement epithelium. *p. p.* Papillary processes of mucous membrane. *r.* Ridge. *s. e.* Stratified epithelium. *s. p.* Secondary papillæ. *t.* Trench. *t. b.* Taste-bulb. *t. b'.* Taste-bulb of outer wall of trench. *t. b''* Taste-bulb undeveloped or of low type.

FIG. 1. — Vertical section through one of the circumvallate papillæ. (× 100 diam.)

FIG. 2. — Vertical section through the base of the same papilla, showing overhanging side with four lowermost tiers of taste-bulbs. (× 480 diam.)

FIG. 3. — Vertical section through the left lateral circumvallate papilla. (× 125 diam.)

FIG. 4. — Horizontal section through the lower part of one of the circumvallate papillæ, representing the taste-bulbs arranged in a zone. *gl. d.* Ducts of the serous glands which open into the trench at this level. (× 160 diam.)

FIG. 5. — Vertical section through a fungiform papilla of the mid-dorsal surface of the tongue, showing a single taste-bulb at its upper part. (× 400 diam.)

FIG. 6. — Vertical section through a fungiform papilla of the posterior dorsal surface of the tongue, which is probably undergoing transition to the circumvallate type. (× 480 diam.)

FIG. 7. — Vertical section through a fungiform papilla of the anterior lateral dorsal surface of the tongue of a pig. (× 200 diam.)