TASTE BUDS IN THE PITS AT THE POSTERIOR DORSUM OF THE TONGUE OF *STENELLA COERULEOALBA*

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ABSTRACT

There are five to eight pits that form a V-shaped row opening anteriad at the posterior dorsum of the tongue of *Stenella coeruleoalba*. The pits have five to ten warty projections protruding from their bottoms. Epithelium covering the projections is markedly thinner than that of the dorsum. Taste buds resembling those of other mammals can be found in the epithelium of the projections and in that of the thinned side wall of the pits of young dolphins. However, taste buds are considerably few in number. They cannot be observed in adults.

INTRODUCTION

It is not known whether Cetacea possess a gustatory sense because taste buds have not been identified in all cetacean species. Yablokov (1961 ; 1972) has suggested that depressions located on the V-shaped line on the root of the odontocete tongue might act as chemoreceptors. Sokolov and Volkova (1971) investigated the tongues of *Stenella coeruleoalba*, *Phocoena phocoena*, *Tursiops truncatus*, and *Delphinus delphis*, but they failed to find taste buds. Neither could Sokolov and Kuznetzov (1971) find taste buds in *Lagenorhynchus acutus*, *Tursiops truncatus*, and *Phocoena phocoena*. However, these authors suggested that the dolphins must have a gustatory sense according to examinations in which specimens responded well to several chemical substances dissolved in sea water. Recently, taste buds have been observed within the epithelium of the papillae of the pits located on the root of the tongues in *Delphinus delphis* and *Tursiops truncatus* (Suchowskaja, 1972) and in *T. truncatus* (Donaldson, 1977). We have found taste buds, which resemble those of the gustatory cells in other mammals, lying in the epithelium of the pits in *Stenella coeruleoalba*. The follwoing brief report on this dolphin should help to disseminate knowledge of the gustatory sense of Cetacea.

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MATERIALS AND METHODS

The materials examined were taken from fetal, young and adult stages of the striped dolphin, *Stenella coeruleoalba* (body length 60, 98, 115, 150, about 200, 237, and 238 cm), collected off the Pacific coast of Izu peninsula in Japan. Materials were fixed in 10% formalin solution at the site of collection and sent to our laboratory. After macroscopical observations, pieces corresponding to the pits were embedded in paraffin or celloidin. Serial sections were made and then stained with hematoxylin and eosin. Typical sections were selected for photomicrography.

OBSERVATIONS AND DISCUSSION

The dorsum of the tongue of *Stenella coeruleoalba*, as shown in Fig. 1, exhibits a V-shaped row with five to eight pits opening anteriad at the posterior about one-fourth of the whole length of the tongue (from apex to the epiglottis). Sokolov and Volkova (1971) observed three to nine in this dolphin. The angle of the V is about 100° in adults, and is somewhat blunter in younger specimens. No pits exist on the mid line, and their number is not always the same on both sides. The shape of the opening of the pits is round in the early stage becoming long and narrow, and trench-like in adults. In the adult, the pit is approximately 2 to 8 mm in length, 1 to 2 mm in width and 1 to 1.5 mm in depth. The size, shape,

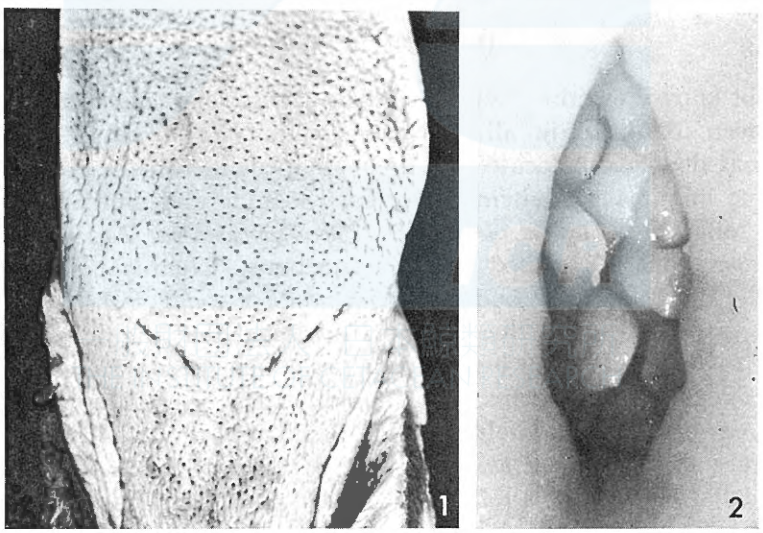

Fig. 1. The posterior dorsum of the tongue of *Stenella coeruleoalba* (body length, 238 cm) viewed from the dorsal aspect. Five pits are present forming a V-shaped row. Lingual glands are well developed except around the circumference of the pits, and gland orifices are clearly visible as black spots on the dorsum. ×1.1.

Fig. 2. Dorsal view of the one of the pits of the 150 cm calf. Warty projections are clearly visible in the pit. ×20.

and number of the pits vary considerably from specimen to specimen in the *Stenella* observed. The pits may be variable in appearance in the same species in other dolphins as illustrated by the following description in *Tursiops truncatus*: three to nine fossae (Sokolov and Volkova, 1971); small cavities (Suchowskaja, 1972); distinct cavities rather than a groove (Caldwell and Caldwell, 1972); an 8 to 12 mm long continuing groove on the left and three shorter sections on the right (Donaldson, 1977). These seem to be due to individual differences and the degree of development. In *Delphinapterus leucas*, five shallow, oval hollows were demonstrated at the corresponding region by Yablokov (1972). Therefore, the appearance of the pits also seem to differ in interspecies. However, in the observed cases of Platanistidae (*Platanista*, *Pontoporia* and *Inia*), no pits could be found in that region (Yamasaki *et al.*, 1976a).

As shown in Fig. 2, there are five to ten warty projections, conical in shape, protruding from the bottoms of the pits in the 115 and 150 cm calves. However, there are only one or two projections in each small pit. They are approximately 0.3 to 0.8 mm in diameter at their bases and about 0.3 to 0.6 mm in height. The upper limit of the projections never reaches the surface of the tongue. The projections are remarkably visible in the young stage, and in the adult they become rather indistinguishable besides being often hard to observe from the dorsal aspect because of the elongation and narrowing of the pit orifice. Aggregations of lymphocytes are present in places in the lamina propria of the pits. It is likely that the projections correspond to conical-shaped papillae in the *Tursiops truncatus* observed by Donaldson (1977) and possibly to the 'globular bodies' in *Delphinapterus leucas* described by Sonntag (1922).

Pits can already be recognized in a 60 cm fetus. Since the developmental degree of each pit varies considerably, various stages of development of the pits can be observed in a 98 cm fetus. At first, a hollow develops in the area corresponding to the future pit and breaks away from the circumference. It then sinks and the broken blocks, which are covered by thin epithelium, form warty projections.

Lingual glands, sero-mucous in nature, are well developed from the mid part of the dorsum of the tongue to the epiglottis in the 115 cm calf and they are extremely well developed in the adult. The glands open on the dorsal surface, except for the circumference adjacent to the pit orifice. The galnds also open at the bottom of the pit around projections almost with no gland ducts. In some projections the glands open at their tips with a short duct. The glands are not always well-developed at the bottom of the pit as compared with those of the rest of the tongue. Sokolov and Volkova (1971) used the term 'fossa' for the opening of the lingual glands seen on the dorsum and also used this term in considering the pit to be a deeper and larger fossa. Donaldson (1977) has suggested that the pits may be derived from the gland ducts, based on the observation of the marsupial tongue (Kubota *et al.*, 1963). In the abovementioned observation of the fetal tongues of the *Stenella*, we could not clarify whether the pits are derived from lingual gland ducts. Further studies on this subject will be made in the near future.

The dorsum of the tongue of the calves observed is covered by a thick stratified squamous epithelium, approximately 600 μm or more in thickness, of which the superficial layer shows a tendency toward cornification but without complete disappearance of nuclei. The epithelium thins remarkably at the inside of the pit (projection, its side wall and bottom), and measures 40 to 100 μm (Fig. 3a). Papillae of connective tissue of the dorsum are well developed but those on the inside of the pit are not. Taste buds resembling those of other mammals can be clearly observed lying in the epithelium of the projection and the side wall of the pit in the 115 cm and 150 cm specimens (Fig. 3b). Taste buds are always present within the thin part (40 to 50 μm) of the epithelium. Some projections of the 115 cm specimen are covered by a layer consisting of two or three elongate cells

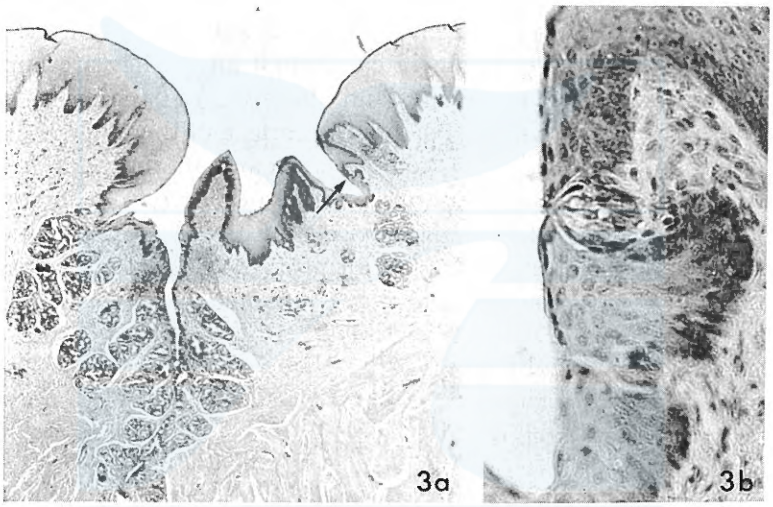

Fig. 3a. Photomicrograph of a vertical section of one of the pits of the 150 cm calf. The epithelium covering the projections and the side wall of the pits is remarkably thinner than that of the dorsum. Two taste buds (arrow) are observed in the thin epithelium. Lingual glands open at the bottom of the pit. ×25.

Fig. 3b. A view of the part indicated by the arrow in Fig. 3a under higher magnification. Taste buds lie in the thin part of the epithelium. The outer taste pore can be seen in the upper taste bud. ×325.

without an upper stratified squamous epithelial layer. No taste buds are present in these areas. Taste buds extend from the basement membrane almost to the epithelial surface. An outer taste pore and two kinds of cells, taste and supporting, can be recognized. The long axis of the buds is approximately 40 to 45 μm in length, and about 30 to 40 μm across. In the specimen of approximately 200 cm body length, taste buds, about 20 to 30 μm in diameter, are located in the lower one-third of the epithelium without an outer taste pore. Cells forming the buds are rather irregular in arrangement, probably due to degeneration. These findings are similar in appearance to those observed by Donaldson (1977) in the adult

Tursiops truncatus. We suppose that larger taste buds having an outer taste pore will be found in the younger *Tursiops*. Taste buds could not be found in the specimens of the adult *Stenella* (237 and 238 cm). In the 98 cm fetus, the part corresponding to the pits is covered with thin epithelium (20 to 40 μm, about one-tenth of the thickness of that of the dorsum), and is on almost the same level as the tongue surface. A few primordial taste buds, similar to those of fetal fur seals observed by Kubota (1968), could be found within this area. Features of the pits, warty projections, and taste buds in the *Stenella* we observed are essentially similar to those of the *Tursiops* and *Delphinus* reported by Suchowskaja (1972), although the author used other terms of reference*.

Although taste buds in the *Stenella* can be clearly observed in the pits of the young stage (115 cm and 150 cm), they are considerably few in number, and may degenerate with age. This may be one reason that taste buds have not been found in Cetacea since examinations have been done only on few sections or in adults. There is a possibility of finding taste buds in other cetacean tongues when detailed observations are done on all parts of the pits with consideration of age. There are no descriptions concerning the body length of the *Tursiops* and *Delphinus* in Suchowskaja's article (1972). The examination on the time sequence of taste buds will be expected in other odontocetes.

Pit-formation may precede the appearance of the taste buds because typical taste buds have not been observed in the developing stages of the pits of fetuses. Since the calves of the *Stenella* start feeding on solid food at the age of about 0.5 year, at a body length of about 140 cm (Kasuya, 1972), it seems that there is some relations between feeding time and the formation of the taste buds. Adult dolphins may depend upon some other senses, possibly cultivated with age, for taking food if taste buds are realy nonexistent in adults. Donaldson (1977) also supposed that young dolphins might first learn which fish to eat by taste and gradually these acceptable-tasting fish might come to be recognized by appearance.

Sokolov and Volkova (1971) have stated that papillary projections along the anterolateral margin of the tongue in Odontocete evidently have a receptor function. However, these projections of the *Stenella* have no taste buds and nerve fiber bundles are inconspicuous. Therefore, we have considered the projections to be structures with a mechanical function for suckling rather than as a sensitive part of the tongue (Yamasaki *et al.*, 1976b ; 1978).

Absence of lingual papillae is another characteristic of the cetacean tongue. Of course, there are no vallate papillae seen in other mammals. Donaldson (1977) thinks that the linguopharyngeal groove (corresponding to what we call a pit) might be a variation of the circumvallate papilla. The pits, at least in position, may correspond to the vallate papillae of other mammals. The tast buds in mammals, for example in man, usually lie within the thinner side surface epithelium of the foliate and circumvallate papillae. The dorsum of the tongue of dolphins has a much thicker epithelium than that of other mammals. The epithelium cover-

* Suchowskaja called the warty projections and the taste buds as 'taste buds' and 'gustatory papillae', respectively.

ing the inside of the pits is markedly thinner than that of the dorsum of the tongue. This fact may be the reason that the existence of the taste buds is only limited to the pits.

Generally, in other mammals, there is a V-shaped sulcus terminalis just behind the vallate papillae by which the tongue is divided into the body and root. No sulcus terminalis and no trace of the foramen caecum there can be seen on the dolphin's tongue. It should be adequate to consider that the body and the root of the tongue meet at the point of the V-shaped row with pits, although it is necessary that embryological observations (*e.g.* as for the location of the dividing line between the first and second pharyngeal arches) and examinations of the innervation be made. In Platanistidae, as mentioned above, no V-shaped mark can be seen on the dorsum of the tongue, and taste buds are lacking in all parts of the tongue (Yamasaki *et al.*, 1976a). Further observations are expected concerning the gustatory sense of Platanistidae.

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