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MIROSŁAWA KULAWIK

Institute of Zoology
Poznań University of Life Sciences

THE TONGUE OF THE RACCOON DOG (*NYCTEREUTES PROCYONOIDES*) AND ITS TASTE STRUCTURES

JĘZYK JENOTA (*NYCTEREUTES PROCYONOIDES*)
I JEGO STRUKTURY SMAKOWE

Abstract
Background. The aim of the study was to investigate the tongue of the raccoon dog (*Nyctereutes procyonoides*), which is a popular farm animal. The article describes the structure of its taste papillae.
Material and methods. The tongues of 11 raccoon dogs were fixed in 10% formalin. Then the length and width of the apex, body and root of the organs were measured. Samples of the taste papillae were dehydrated in ethanol, embedded in Paraplast® and cut into 5-µm-thick sections. Masson-Goldner staining was applied in the study. The taste papillae of the tongue were examined with a light microscope.
Results. The study showed three types of taste papillae on the raccoon dog's tongue, i.e. fungiform, foliate and vallate papillae. The most numerous, fungiform papillae were distributed on the dorsum of the apex and body of the tongue and on the margins of the tongue. Two foliate papillae were located dorso-laterally in the posterior part of the lingual body. The vallate papillae were arranged in a V-like manner, 3–4 papillae on each side of the tongue. Numerous fungiform papillae were distributed irregularly on the tongue. The foliate papillae were composed of 3–7 folia of papillae, arranged parallel to one another. Individual folia of the foliate papillae were separated with deep furrows. Each vallate papilla was surrounded by a deep furrow, around which a marked circular outer wall of the papilla was found. Occasionally two vallate papillae were surrounded by a common furrow and an outer wall.
Conclusions. The study presents the structure and the distribution pattern of taste papillae on the raccoon dog's tongue.

Keywords: *Nyctereutes procyonoides*, tongue, taste papillae

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Introduction

The tongue is an organ whose structure can adapt to perform numerous functions in different animal species and in humans. The tongue, hard palate, lips and cheeks generate negative pressure in the oral cavity of mammals, thanks to which they can suck and take up liquid food. The tongue also helps to take up solid food, as it secures, comminutes and mixes food with saliva to form morsels which can be swallowed. In some animal species the tongue is necessary to ensure thermoregulation. It is also used for touching and thanks to the presence of taste buds in its epithelium it enables selection of food and evaluation of its taste. The tongue is used by animals to clean their skin surface and groom their coat.

Apart from many common structural features, the tongue also exhibits species--specific traits in vertebrates. There have been many studies on diversity in the shape of the tongue, its metric traits and the varied structure of the mucosa on the dorsum in different animal species and in humans (De Paz Cabello et al., 1988; Griffiths and Criley, 1989; Gupta et al., 1990; Iwasaki et al., 1988). The literature provides data on quantitative changes in lingual papillae and taste buds (Gupta et al., 1990; Ojima, 1998; Robinson and Winkles, 1990), information on the results of studies on the development of papillae in the tongue (Iwasaki et al., 1996a; Kulawik, 2005a, 2005b; Kulawik et al., 2013a, 2013b; Tichý, 1993; Tichý and Černý, 1987) as well as taste buds and their ultrastructure (Miller and Chaudhry, 1976a, 1976b; Witt and Reutter, 1996). Some authors studied lingual papillae in carnivorous animals, e.g. in cats (Boshell et al., 1982; Iwasaki, 1990) and dogs (Iwasaki and Sakata, 1985; Singh et al., 1980). Little is known about the morphology of the raccoon dog's tongue. The aim of this study was to investigate the raccoon dog's tongue and structure of taste papillae.

Material and methods

11 tongues of raccoon dogs (*Nyctereutes procyonoides*) were used in this study. The material came from animals of both sexes (6 males and 5 females) and was collected after they were slaughtered at a fur animal farm.

On removal the tongues were placed in 10% neutralised formalin. After fixation the length of the apex, body and root of the tongue and the width of its individual parts were measured. The arithmetic means (X), minimum (Min) and maximum values (Max) were calculated for the traits under analysis. Next, smaller samples with lingual papillae were collected from the tongues and then they were dehydrated in a series of alcohols with increasing concentrations (50–96%), embedded in Paraplast and sliced into 3–5-µm--thick sections with a Leica RM 2055 rotation microtome. The tissue samples were sliced in three planes, i.e. sagittal, transverse and horizontal. Masson-Goldner staining was applied in the study.

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Results

The raccoon dog's tongue is elongated and has a rounded apex. The sulcus medialis can be seen on its dorsum, but it is distinctly visible only on the apex of the tongue, whereas it is shallow on the body and root of the tongue (Fig. 1). The measurements showed that the body of the tongue was the longest and widest, followed by the apex and root of the tongue (Table 1).

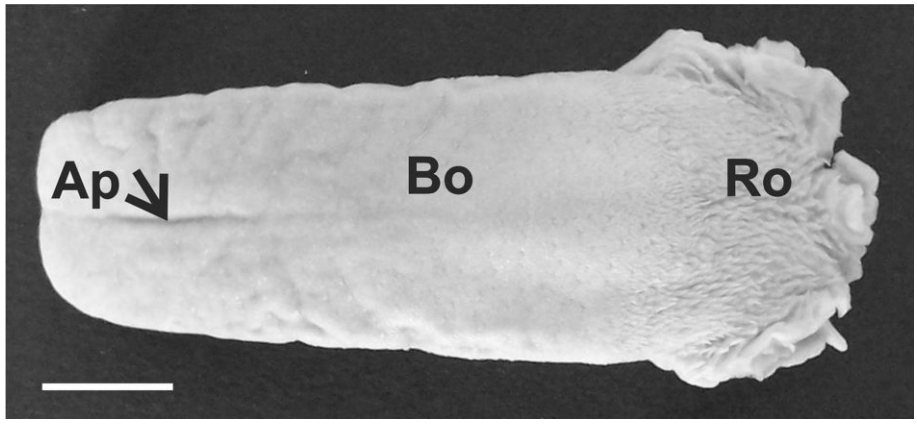

Fig. 1. A view of the dorsal surface of the raccoon dog's tongue: the arrow shows the sulcus medialis, Ap – apex, Bo – body, Ro – root of the tongue, bar = 10 mm

Table 1. The values of the features of the apex, body and root of the raccoon dog's tongue

Feature	Part of tongue	X (cm)	Min (cm)	Max (cm)	SD
Length	Apex	2.2	2.0	2.4	0.1
	Body	3.5	3.3	3.6	0.1
	Root	1.4	1.3	1.5	0.1
Width	Apex	1.9	1.7	2.0	0.1
	Body	2.3	1.9	2.5	0.2
	Root	2.0	1.7	2.2	0.1

Three types of taste papillae were found on the raccoon dog's tongue, i.e. fungiform, foliate and vallate papillae. The fungiform papillae were the most numerous and were distributed irregularly on the dorsum of the apex and body as well as the margins of the tongue. The papillae were most concentrated at the top of the apex of the tongue. The fungiform papillae were covered with keratinised stratified squamous epithelium, in which taste buds were observed. The fungiform papillae were markedly separated from the other papillae by an encircling depression (Fig. 2).

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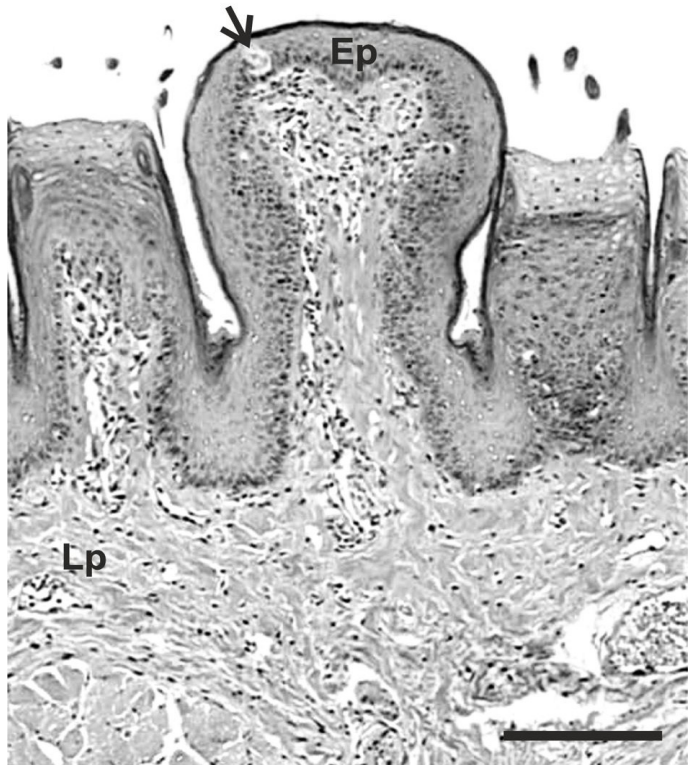

Fig. 2. A transverse cross-section of the fungiform papilla: the arrow indicates the taste bud, Ep – epithelium, Lp – lamina propria mucosae, bar = 200 μm

The foliate papillae were found on the dorso-lateral side of the posterior part of the tongue body. These papillae consisted of folia papillae, which were arranged parallel and separated from one another with deep furrows of the papillae. There were 3–7 folia in one foliate papilla. The shape of the foliate papillae varied, as was observed in their transverse cross-sections. They were covered with non-keratinised stratified squamous epithelium. Taste buds were found both in the epithelium covering individual foliate papillae on the side of the furrows and in the epithelium surrounding the foliate papillae from the outside (Fig. 3). Occasionally, individual taste buds were observed in the epithelium covering the dorsal aspect of the foliate papillae.

Excretory ducts of posterior serous lingual glands (Ebner's glands) opened on the bottom of furrows of the foliate papillae. Some excretory ducts of these glands opened also directly onto the surface of folia of the foliate papillae (Fig. 3). Pars secretory of glands were arranged in the lamina propria of the mucosae and in the folia of the papillae.

The vallate papillae were arranged in a V-like manner on the dorsum of the tongue, in its posterior part. There were 3–4 vallate papillae on each side. Each vallate papilla on the raccoon dog's tongue was surrounded by a deep furrow, around which there was

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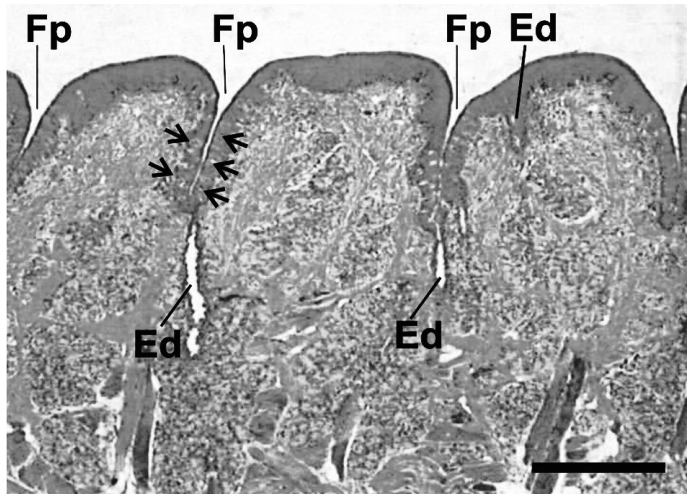

Fig. 3. A transverse cross-section of folia in the foliate papillae: arrows – taste buds, Fp – furrows of papilla, Ed – excretory ducts of posterior serous lingual glands, bar = 200 μm

a distinct circular outer wall of the furrow. The vallate papillae were covered with non-keratinised stratified squamous epithelium. Taste buds were found in the epithelium covering the papillae on the side of the furrow. Occasionally individual taste buds were observed dorsally in the epithelium covering the vallate papillae and in the epithelium of the furrows of the papillae. The surface of vallate papillae was uneven (Fig. 4). Nu-

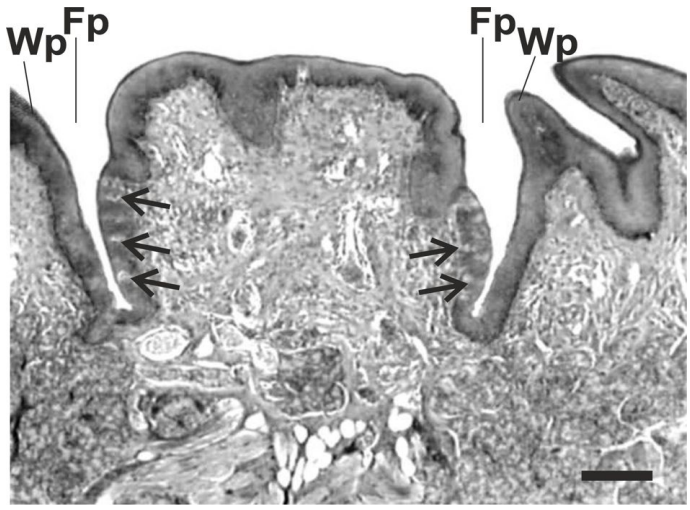

Fig. 4. A sagittal cross-section of the vallate papilla: arrows – taste buds, Fp – furrows of papilla, Wp – outer walls of furrow of papilla, bar = 200 μm

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merous excretory ducts of the posterior serous lingual glands (Ebner's glands) opened on the fundus of the vallate papillae furrows. In two cases there were two vallate papillae close to each other. They were surrounded by a common furrow and outer wall (Fig. 5).

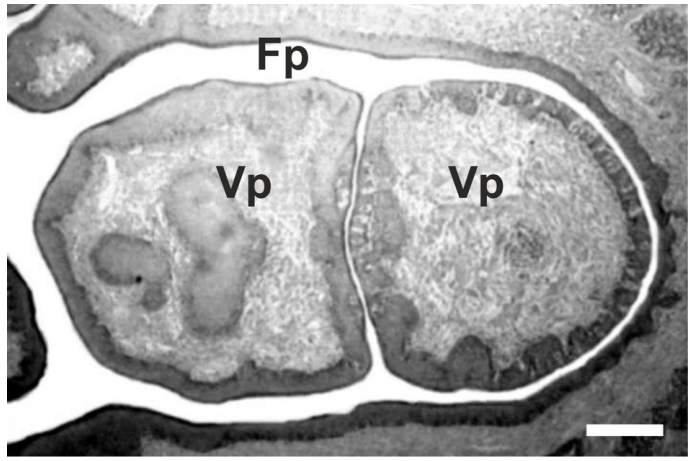

Fig. 5. A horizontal cross-section of two vallate papillae Vp, Fp – a common furrow, bar = 200 μm

Discussion

In many animal species taste papillae can be found on the dorsal surface of the tongue (De Paz Cabello et al., 1988; Gupta et al., 1990; Kumar et al., 1998). Taste papillae are connected with taste buds located in their epithelium. However, as it is known, the presence of gustatory papillae is not a prerequisite for animals to sense different tastes. There are animal species which do not have gustatory papillae and their taste buds are dispersed on the tongue and other organs of the oral cavity. However, taste buds are always located intraepithelially (Reutter and Witt, 1993). The absence of taste papillae from the tongue was shown e.g. in *Elaphe climacophora* and *Elaphe quadrivirgata* (Iwasaki and Kumakura, 1994; Iwasaki et al., 1996b). Gustatory papillae cannot be found in birds, either (Kobayashi et al., 1998).

Studies on the raccoon dog have shown that fungiform papillae are distributed irregularly on the dorsum of the apex and body and at the margins of the tongue. A similar distribution of fungiform papillae was observed in many other animal species e.g. beagle dogs (Iwasaki and Sakata, 1985), Japanese monkeys (Iwasaki et al., 1992), Jamunapari goats (Kumar et al., 1998), rabbits (Kulawik, 2005a), and in humans (Jung et al., 2004).

The horizontal cross-sections of the raccoon dog's vallate papillae were round in shape, similarly to those found in bats (Azzali et al., 1992) and Formosan serows (Atoji et al., 1998). By contrast, the only vallate papilla found on the tongues of mice (Iwasaki et al., 1996a; Utiyama et al., 1995) and rats (Iwasaki et al., 1997) were oval.

Taste buds were located in the epithelium covering vallate papillae on the side of the furrow, similarly as in sheep (Tichý and Černý, 1987), bat (Azzali et al., 1992) and

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Formosan serows (Atoji et al., 1998). By comparison, in hamsters (Miller and Chaudhry, 1976a) taste buds were observed both in the epithelium covering vallate papillae on the side of the furrow and in the epithelium of the outer wall of the papillae.

In several cases the raccoon dog's taste buds were observed in the epithelium covering dorsally vallate papillae. The same location was observed in goats (Kumar et al., 1998).

It was interesting to observe two vallate papillae surrounded by a common furrow and outer wall on the surface of the raccoon dog's tongue in our study. No information on similar findings was found in literature on the subject.

The raccoon dog's foliate papillae are composed of 3–7 folia papillae, which are arranged parallel to one another and separated by deep furrows. Kobayashi (1992) reported a total of 15–20 ridge-like protrusions forming foliate papillae in rabbits, whereas Emura et al. (1999) observed 34 crests separated by deep furrows in flying squirrels. Foliate papillae are characterised by a parallel system of structures, but their number varies in individual animal species (Azzali et al., 1992; Emura et al., 1999; Kobayashi et al., 2004; Utiyama et al., 1995).

The taste buds of foliate papillae in the raccoon dog were located in the epithelium covering folia papillae on the side of the furrow, as well as in the epithelium directly surrounding foliate papillae. The same location was observed in rabbits (Fujimoto et al., 1993), hamsters (Miller and Chaudhry, 1976b; Miller and Smith, 1988) and bats (Azzali et al., 1992).

The study showed that the distribution of taste papillae on the raccoon dog's tongue was similar to the distribution observed in other carnivorous animals. However, the microscopic structure of lingual papillae revealed numerous species-specific features. It proves the morphological diversity of lingual papillae in different animal species.

Conclusions

1. There were three types of taste papillae in the raccoon dog: fungiform, foliate and vallate.

2. The fungiform papillae were the most numerous. They were followed by the vallate and foliate papillae.

3. Occasionally two vallate papillae were surrounded by a common furrow and an outer wall.

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JĘZYK JENOTA (*NYCTEREUTES PROCYONOIDES*) I JEGO STRUKTURY SMAKOWE

Abstrakt

Wstęp. Celem pracy było zbadanie języka jenota (*Nyctereutes procyonoides*), który jest popularnym zwierzęciem hodowlanym. W pracy określono strukturę brodawek smakowych.

Materiał i metody. Języki 11 jenotów utrwalono w 10-procentowej formalinie. Następnie wierzchołek, trzon i korzeń języka zmierzono. Próbki brodawek smakowych odwodniono, zatopiono w Paraplaście® i pokrojono na skrawki o grubości 5 µm. W badaniu zastosowano barwienie Massona-Goldnera. Brodawki smakowe języka badano za pomocą mikroskopu świetlnego.

Wyniki. W pracy wykazano na języku jenota trzy typy brodawek smakowych: brodawki grzybowate, liściaste i okolone. Najliczniejsze – brodawki grzybowate – były rozmieszczone na grzbiecie wierzchołka i trzonu języka, jak również na brzegach języka. Dwie brodawki liściaste były zlokalizowane na grzbietowo-bocznej tylnej części trzonu języka. Brodawki okolone były ułożone w kształcie litery V, 3–4 brodawki po każdej stronie języka. Liczne brodawki grzybowate były rozmieszczone nieregularnie na języku. Brodawki liściaste były utworzone z 3–7 liści brodawek, układających się równolegle jeden do drugiego. Poszczególne liście brodawek były oddzielone głębokimi rowkami. Każda brodawka okolona była otoczona przez głęboki rowek, dokoła którego zaznaczał się kolisty wał brodawki. Sporadycznie dwie brodawki okolone były otoczone przez wspólny rowek i wał brodawki.

Wnioski. Niniejsze badania prezentują strukturę i wzór rozmieszczenia brodawek smakowych na języku i jenota.

Słowa kluczowe: *Nyctereutes procyonoides*, język, brodawki smakowe

Corresponding address – Adres do korespondencji:
Mirosława Kulawik, Instytut Zoologii, Uniwersytet Przyrodniczy w Poznaniu, ul. Wojska Polskiego 71 C, 60-625 Poznań, Poland, e-mail: kulawik@up.poznan.pl

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