Original article

# Epiglottal taste buds and different feeding habits of mammals

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## Abstract

**Introduction**: Taste buds which occur on the laryngeal surface of epiglottis of mammals share many similarities with lingual taste buds, although their function is different. These taste buds mediate reflex action to close the laryngeal opening or initiate the cough reflex when food comes in contact with the posterior surface of the epiglottis.

**Methods**: Repeated microscopic studies were carried out on 6 µm serial haematoxylin and eosin stained sections of epiglottides of buffalo, guinea pig, house rat, human, lamb and rabbit. Quantitative investigation was carried out on the taste buds on the rostral, middle and caudal regions of the epiglottides of each of these mammals. Relative frequency of occurrence value for comparative assessment of taste buds is proposed here.

**Results**: The average number of taste buds was found higher in the herbivorous buffalo, goat and rabbit; while the number was lower in the omnivorous guinea pig, house rat and the human. The density of taste buds was found to be directly proportional to the feeding behaviour of mammals, showing their significant role in inducing reflexes for safe passage of bolus through the oesophagus and for prevention of the respiratory tract congestion.

**Conclusion**: Since the number of taste buds was found higher in the herbivorous mammals, it was concluded that the bigger the volume of the bolus the higher is the density of epiglottal taste buds. These taste buds are adapted to protect the respiratory passage during swallowing and drinking by initiating the reflex action.

**Keywords**: Food bolus, Herbivores, Laryngeal reflexes, Omnivores, Relative Frequency of Occurrence.

## Introduction

Taste buds occur in several receptive fields of the oral cavity of mammals. They are located on the tongue, soft palate, cheek, palatoglossal arches and epiglottis. The laryngeal taste buds in epiglottis are present in several species of mammals including monkeys[1], hamsters[2], sheep[3], horses[4], cats[5], rats[6], lambs[7], house shrew[8], human[9,10,11] and buffalo[12]. Taste buds present on the laryngeal surface of epiglottis of mammals show many similarities with the lingual taste buds although their role is more significant in protective laryngeal reflexes[3,8]. The reflexes apparently prevent the respiratory tract congestion while ensuring safe passage of food bolus through the oesophagus. The epiglottal taste buds act as chemosensory sentinels that protect the animals from accidentally aspirating ingested foods and fluids[7]. According to the feeding habit, the size of food bolus in mammals is different and the density of epiglottal taste buds shows different characteristics in different mammals depending on the type of food they ingest[12]. A newborn human carries numerous taste buds[1]and as the age advance, the human epiglottal taste buds tend to decrease. Quite interestingly, the epiglottal taste

buds are alternately termed as laryngeal chemosensory clusters because they are composed of two to three chemoreceptor cells[13]. The mechanoreceptors of laryngeal taste buds respond to a number of chemical stimuli and to water[14].The light microscopic structure of innervations of epiglottal taste buds in monkeys was described for the first time by Khaisman[1]. The present study aims at quantitative investigation of taste buds in some mammals including human. The study is based on the hypothesis that there is a strong correlation between the number of epiglottal taste buds and the feeding habit of mammals. Hence the mammals included in the study were herbivorous as well as omnivorous.

## Methods

Experiments were carried out on epiglottal taste buds of buffalo, guinea pig, house rat, human, lamb and rabbit. Among these, guinea pig, house rat and human were omnivorous whereas buffalo, lamb and rabbit were herbivorous. The epiglottides of buffalo and goat were obtained from a butcher's shop and were fixed in 10% formalin. Human epiglottal taste buds were obtained from the donated bodies undergoing post-mortem examination at the Forensic Department of Tribhuvan University Teaching Hospital, Maharajgunj, Nepal, after a written consent was made available from the hospital authorities. The samples were fixed in 10% formalin. The guinea pig, house rat and rabbit were fully anesthetized by peritoneal injection of 0.4 ml of sodium pentobarbital solution (30mg/kg), and then infused with 100 ml of normal saline containing 0.1 ml of heparin, followed by 10% formalin. The procedure was in accordance with the ethical standards as set by Helsinki Declaration 2000. The epiglottides were then dissected out and post-fixed in 10% formalin. The fixed samples were decalcified with 4.5% ethylene-diamine-tetra-acetic acid (EDTA) for two days. Subsequently, the samples were dehydrated through an ascending series of ethanol, cleared with xylol and embedded in paraffin wax at $58^0$ C. Transverse sections of all the blocks were cut in a rotary microtome to obtain 6-8 µm sections, and were stained with haematoxylin and eosin. The stained serial sections were examined under different magnifications of an Olympus CX21 binocular medical microscope. Digital images of histological features of the epiglottis were obtained (Figure 1) and studied in detail.Under the surface area of 100 X magnification of the microscope, taste buds were counted at the rostral, middle and caudal regions of epiglottis with great care to avoid double counting. Average number of taste buds was calculated for each mammal included in the study, and their relative frequency of occurrence (RFO) value was also designated, using the following formula given below.

$$\text{RFO (\%)} = \frac{\text{(No.of taste buds of one mammal)}}{\text{(Total no.of taste buds of entire mammals studied)}} \times 100$$

The data were summarized in a table (Table 1).

## Results

The histological examination of sections revealed that the epiglottis had two surfaces, the anterior and posterior, with the central core of elastic cartilage. The proximal two-thirds of both surfaces were lined with stratified squamous epithelium, whereas the distal one-third of posterior surface was provided with respiratory epithelium. The thickness of epithelium and submucosa was thicker towards the anterior or oral side whereas it was thinner towards the posterior or respiratory side. Lateral margins of both the surfaces on the distal portion were also lined with stratified squamous epithelium. In almost all samples, the taste buds were found solitarily distributed along the stratified squamous epithelium at the posterior side. The histological features were uniform in all the epiglottides studied (Figure 1).

**Appendix**

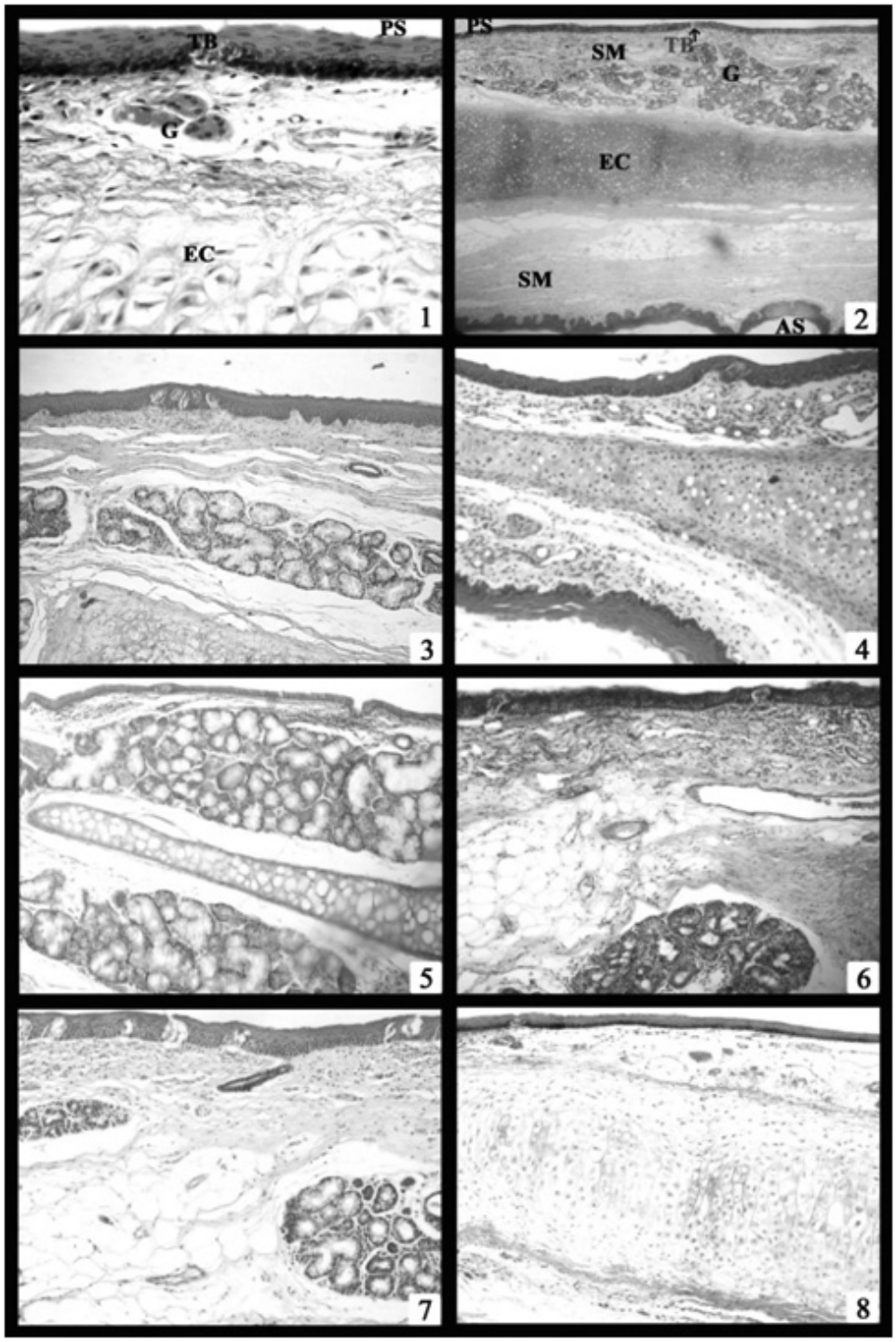


Figure 1. Stained sections of epiglottides. 1. A typical taste bud (TB) embedded in stratified squamous epithelium. 2. A section showing both surfaces: anterior surface (AS), elastic cartilage (EC), gland (G), posterior surface (PS), submucosa (SM). 3. Section of buffalo epiglottis. 4. Section of guinea pig epiglottis. 5. Section of house rat epiglottis. 6. Section of human epiglottis. 7. Section of lamb epiglottis. 8. Section of rabbit epiglottis. Magnification: 400X in 1, 40X in 2, 100X in 3-8.

However, the density of taste buds was found variable in the rostral, middle and caudal regions of the posterior epiglottis of the same mammal, and the average number of taste buds also varied among the mammals in these regions (Figure 2).

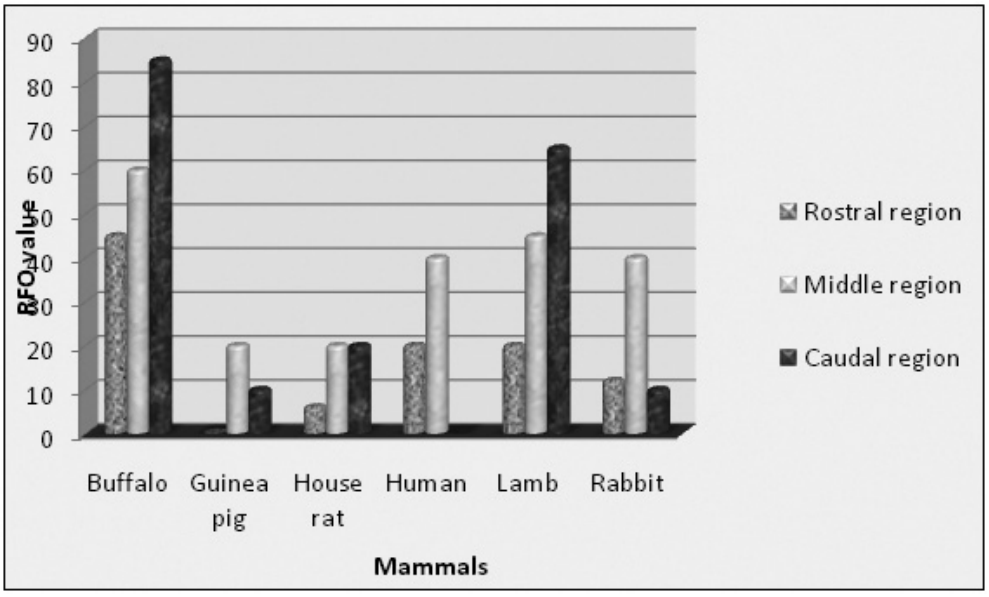


**Figure 2.** Distribution of taste buds in different regions of epiglottis of mammals.

In buffalo, the highest number of taste buds was observed in all three regions, while in guinea pig, the number was the lowest (Figure 3).

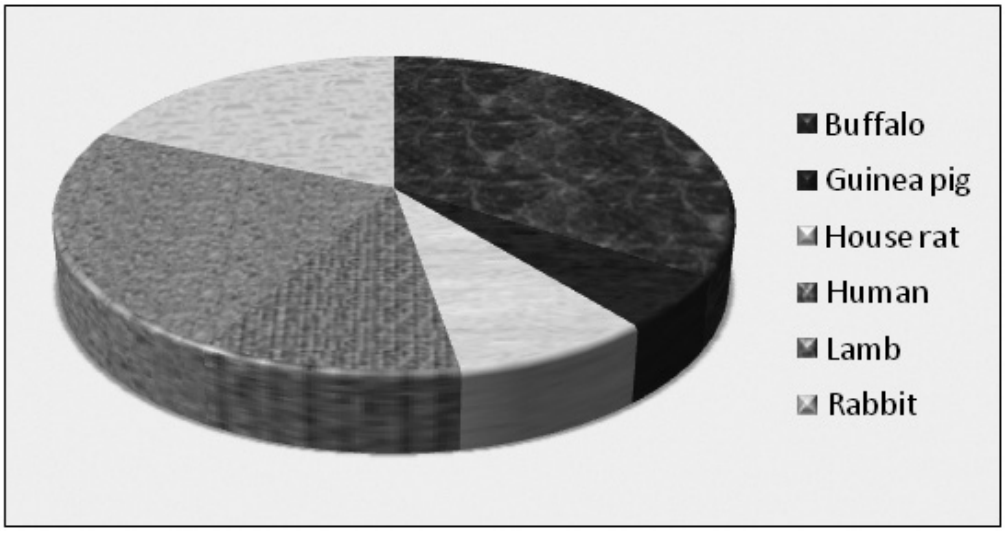


**Figure 3.** Relative frequency of occurrence (RFO) value of each mammal.

In all the samples, taste buds were encountered in the middle region. The caudal region of human sample and rostral region of the guinea pig sample were devoid of the taste buds. In house rat, most of the taste buds were confined to both the middle and caudal region, while in rabbit they were more confined to the middle region. Furthermore, in the samples of buffalo and lamb, taste buds were more numerous in the caudal region. The relative frequency of occurrence (RFO) values showed that the buffalo sample showed the highest value, while the guinea pig sample

showed the lowest value (Figure 3). These values of herbivores were higher than those of the omnivores (Table 1).

**Table 1: Distribution of taste buds in epiglottis of different mammals.**

| Animal Name | Average no. of taste buds | | | Relative frequency of occurrence (RFO) value |
|---|---|---|---|---|
| | Rostral region | Middle region | Caudal region | |
| Buffalo | 45 | 60 | 85 | 36.38 |
| Guinea pig | 0 | 20 | 10 | 5.79 |
| House rat | 6 | 20 | 20 | 8.88 |
| Human | 20 | 40 | 0 | 11.58 |
| Lamb | 20 | 45 | 65 | 25.10 |
| Rabbit | 12 | 40 | 10 | 20.46 |

Among the two herbivores, the value is higher in buffalo sample than in the lamb one. Similarly among the omnivores, the value is highest in the human sample and lowest in the guinea pig sample.

## Discussion

Among the mammals studied, the average number of taste buds is found highest in the herbivorous buffalo and lowest in the omnivorous guinea pig. The number is higher in the herbivores because their food bolus would be more voluminous than those of the omnivores, hence they need more reflexes. The insectivorous house shrew contains still less number of laryngeal taste buds[8], probably because of the small volume of food it consumes. Several afferent myelinated fibres have been found in the innervation of each epiglottal taste buds of monkey[1], contributing to the reflexes for defensive function of these organs. The epiglottal taste buds play an important role in facilitating the unforced flow of bolus through the oesophagus and prevent the respiratory congestion during passage of food and fluid. The protective mechanism has been attributed to the fact that the laryngeal taste buds act as chemoreceptors[6, 13], more specifically as $CO_2$ receptors[5,6]. However the chemoreceptor cells would be distributed everywhere on the laryngeal surfaces, hence these buds specifically act more for the reflexes rather than for the chemical stimulus. The involuntary pharyngeal phase of deglutition might need more reflexes rather than taste or chemical reception[12]. The fact that the density of laryngeal taste buds has been found higher in the ruminating and regurgitating herbivores such as buffalo and lamb, has suggested again that these mammals, because of their bigger food bolus, need more reflexes to prevent the respiratory congestion[12]. Among the two again, the buffalo shows a higher number of taste buds, probably because the bolus is bigger than that of the lamb. Unlike lingual taste buds, the laryngeal taste buds might play a role in respiratory modulation or airway protection rather than gustation, because they are adapted to detect chemicals that are not saline-like in composition[6,14]. Among the omnivores, human's food bolus is more voluminous than that of the guinea pig and house rat, hence there is a larger number of taste buds in the human sample than in the other two. However, aged human epiglottis has been found to carry fewer numbers of taste buds suggesting their less significant role in protecting the respiratory airway[9]. Similarly, the histomorphometrical analysis has also shown that human epiglottal taste buds tend to decrease in both male and female humans as age advances[11].The reason again is probably related to the food intake of the aged humans whose natural tendency is to consume less with the advancing age.

## Conclusion

Structurally, the laryngeal taste buds resemble the lingual taste buds; but the fundamental difference lies in their functions. Unlike lingual ones, the laryngeal taste buds function more in protective reflexes, which are important in respiratory modulation. The density of taste buds depends on the feeding habit of different mammals. Among the herbivores, the ruminating and regurgitating mammals such as buffalo and lamb are found to have more laryngeal taste buds than the non-ruminating ones such as rabbit owing to the fact that,

because of their cudding habit, there is double chance of food bolus coming in contact with the epiglottis. Obviously, they would need more reflexes.The omnivores such as guinea pig, house rat and human carry lesser number of epiglottal taste buds because they would need lesser reflexes due to less voluminous bolus.

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**Conflict of interests:** None Declared

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