

TOTAL DISTRIBUTION OF TASTE BUDS ON THE TONGUE OF THE PUP¹

JOHN C. HOLLIDAY
Department of Zoology,
Ohio University²

INTRODUCTION

This paper reports the results of the second of a series of proposed studies from this laboratory on the distribution and innervation of taste buds; the first having been published by Elliott ('37).

A search of the available literature indicated that information on taste buds was limited. As Elliott ('37) has given a brief review of the literature, reference to previous research will be considered in a comparative way in the portion of this paper devoted to the discussion of the present investigation.

I wish to express my appreciation to Dr. Rush Elliott, who directed the problem, for his initial suggestion of this research and for the timely suggestions given during the course of the investigation which saved needless loss of time and waste of material; to Dr. F. H. Kreckler for use of laboratory material and equipment; and to Mr. Lawrence Goldberg for the photographic work appearing in this paper.

MATERIALS AND METHODS

The material for this study consists of tongues taken from six pups which varied in age from one to five days. Three of these tongues which were used in the histological work were from five-day old pups of the same litter. These tongues were fixed in 10% formalin for ten days and washed in running water for twenty-four hours. The tongues were dehydrated in a graduated series of ethyl alcohol to 70%.

One tongue was dehydrated and infiltrated by the dioxan method as outlined by Guyer ('36). Difficulty due to hardening was encountered in sectioning the tongue dehydrated by this method. The other two tongues were dehydrated and infiltrated by a modification of the normal butyl alcohol technique described by Lee ('37). These three tongues were sectioned serially at 20 micra. Mallory's triple stain and iron hematoxylin were tried, but a dilute solution of Delafield's hematoxylin proved most satisfactory and was used for nearly all of the sections. Euparal was used for the mounting medium.

By a careful study of several taste buds it was found that all buds appeared in two sections and some appeared in three sections; it seems

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from this that a bud must be nearly forty micra in thickness. A figure to show the total distribution of the taste buds over the dorsum of the tongue was prepared by dividing the tongue into twenty-six divisions. The reasons for using this number of divisions were that the circumvallate papillae of all tongues fell into comparable areas, and the average number of sections in each division was a whole number. A record of the number of taste buds exclusive of the circumvallate papillae was made and a table prepared (Table I) to show the localization in each region.

TABLE I
TABLE OF NUMBER OF TASTE BUDS FOUND IN THE FUNGIFORM PAPILLAE OF THE THREE TONGUES STUDIED

DIVISION	TONGUE 1	TONGUE 2	TONGUE 3	AVERAGE ALL TONGUES
1	13	18	16	16
2	42	33	57	44
3	65	44	81	63
4	62	52	94	69
5	75	34	89	66
6	83	27	91	67
7	80	51	101	77
8	91	33	101	75
9	117	49	89	85
10	90	49	84	74
11	101	58	87	82
12	51	59	77	62
13	53	48	86	62
14	60	70	91	74
15	49	85	93	76
16	66	83	90	80
17	84	101	97	94
18	79	115	89	94
19	84	79	112	92
20	53	42	99	65
21	8	7	44	20
22	10	6	6	7
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
Total...	1,416	1,143	1,774	1,444

Each section is 20 micra in thickness. Each division in tongue number 1 represents 76 sections; in tongue number 2, 68 sections; in tongue number 3, 75 sections; average for all tongues, 73 sections.

It was noted that the number and the positions of the circumvallate papillae were not constant in the tongues prepared for histological study. Three more tongues were studied under the macroscopic camera lucida and the positions of the circumvallate papillae plotted. In figure 2 the positions of these papillae in the three tongues used in the histological study are represented by the figures in the top row; the lower row of figures are of those tongues which were used in the macroscopic study only.

Counts of taste buds present in the circumvallate papillae of tongue number 2 were made by use of serial projection photographs at a magnification of 200 diameters.

An outline of a tongue was prepared by projection, measurements being made of every seventy-fifth section of tongue number 3. By use of this outline a figure (Fig. 4) was prepared to show the total distribution of taste buds over the entire dorsum of the tongue. This number was reckoned by taking the average number of taste buds appearing in the fungiform papillae of the three tongues and the total number of taste buds observed in the circumvallate papillae of tongue number 2.

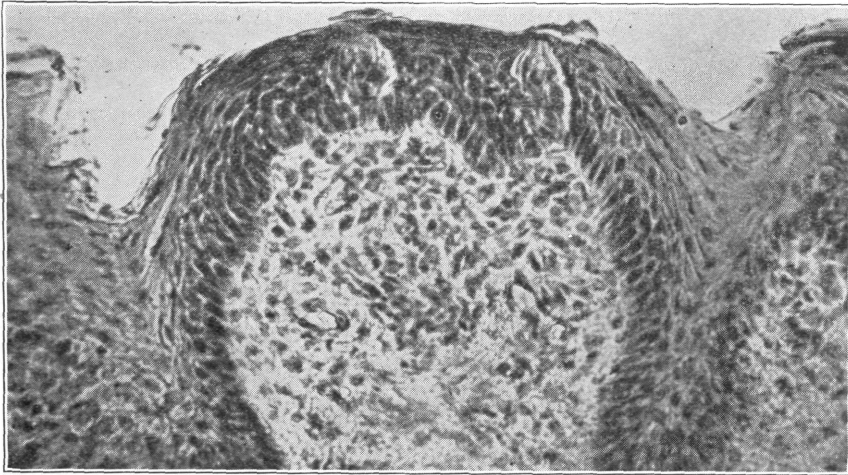


Fig. 1. Photomicrograph of a normal fungiform papilla with two taste buds in its top. $\times 350$.

DISCUSSION

Taste buds are described in textbooks of histology (Bailey, Bremer, Maximow and Bloom, and Piersol) as occurring on various parts of the tongue, on the glossopalatine arch, on both sides of the epiglottis, on the posterior wall of the pharynx down to the inferior edge of the cricoid cartilage, on the soft palate especially in the region of the uvula (Hoffman, 1875), and in the region of the palatine tonsil of the foetus (Ponzo, '07). This paper is restricted to a study of the total distribution of taste buds on the tongue.

On the dorsum of the tongue of the pup, filiform, fungiform, and circumvallate papillae were found. Considerable variation in size and shape was noted in all three types of papillae. Fungiform papillae varied from a type which resembled a filiform papilla to one which was similar to a circumvallate papilla with no moat surrounding it. They were tallest near the edges of the tongue. The fungiform papillae were found to vary in thickness from 0.2 mm. to 0.32 mm.; most of them being 0.2 mm. in diameter. This type of papilla in its typical form was found to be limited to the area of the tongue anterior to the circumvallate papillae. In the caudal region of the tongue, the circumvallate papillae were found in a "V" formation with the apex of the "V" directed caudad, as they are described by numerous histologists. They varied in diameter from 0.24 mm. to 0.62 mm. There seems to be a

great difference in size between these papillae and similar papillae of the human, for Bremer ('36) described the adult human papillae to be from 1 mm. to 3 mm. in diameter.

The taste bud of the pup was found to be an ellipsoidal shaped body with a diameter of 40 micra and a longitudinal axis of 60 micra. The taste bud in the right side of the top of the fungiform papilla illustrated in Figure 1 shows cellular relationships of the taste bud. The large peripheral lightly stained cells are the supporting cells of the bud, and the long inner darkly stained ones are the gustatory cells. The outer and inner taste pores are both distinguishable.

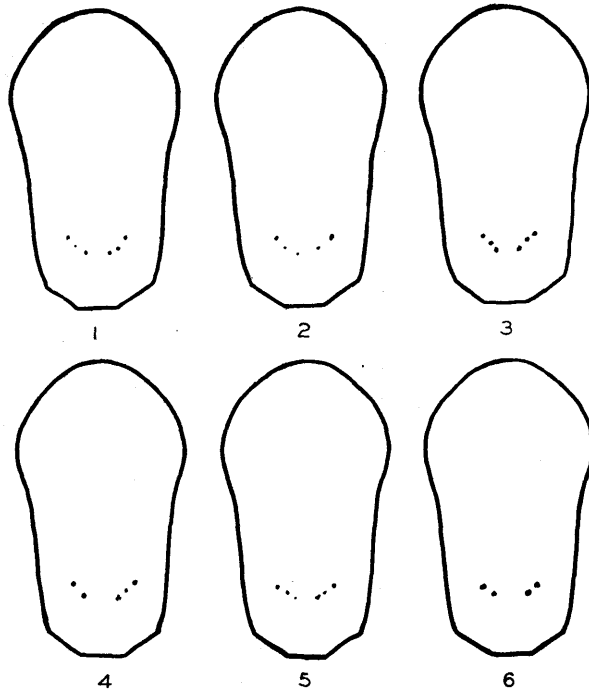


Fig. 2. Outline figures of six tongues to show uneven number and distribution of the circumvallate papillae. Figures 1 to 3 inclusive represent the tongues used in the histological study. Figures 4 to 6 inclusive represent the tongues used in the macroscopic study. (Actual size.)

In the pup, the taste buds of the tongue were found to be limited to its dorsal surface. In this area they were found only in the fungiform and circumvallate papillae. This was in agreement with the condition observed in the kitten by Elliott ('37), but it is contradictory to the location of taste buds in the child at birth as described by Bremer ('36) who states that in addition to buds being found in the two types of papillae just mentioned that they are also present in some of the filiform papillae. Schumacher ('27) describes fungiform papillae as appearing over the entire dorsum of the tongue and always possessing taste buds regardless of where they are located. The findings on the pup's tongue

are contradictory to this, for buds are found in these papillae only when they are located anterior to the circumvallate papillae.

The location of taste buds in the fungiform papillae have been described by various histologists as being present in the sides of these papillae; Elliott ('37) described them as having buds present in both the sides and tops. In this investigation buds were found to be present only in the tops of the fungiform papillae (Fig. 1). Olmsted ('21) gave four as the average number for buds present in this type of papilla of the dog. In his work on the kitten, Elliott ('37) found four to be the maximum number of buds present in any papilla. In the pup's tongue six was the maximum number of buds observed in a single papilla. This papilla was large and was located near the midline about midway between the tip of the tongue and the circumvallate papillae. In the

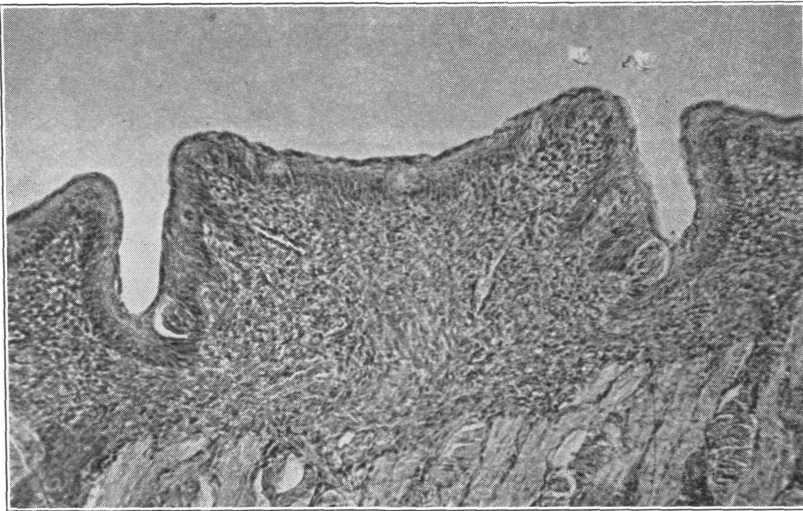


Fig. 3. Photomicrograph of a circumvallate papilla with two taste buds appearing in the floor of the trench. $\times 135$.

present study, three was the average number of buds found in a papilla of this type.

Taste buds are described as being quite numerous in the infant by Schumacher ('27) and Arey et al ('35). The last mentioned investigators described the taste buds as occurring in patches. The results of the present study confirmed both of these points. In Table I is tabulated the number of taste buds exclusive of those found in the circumvallate papilla, found on all of the tongues used in the histological study. The total average number of the buds observed was found to be 1444 with a variation from the average of approximately 330 buds.

During the histological study of the tongue, it was noted that the circumvallate papillae were not constant either in number or in position. A study was made of the number present and their exact location plotted, as mentioned previously. The number present was found to

vary from four to six. These papillae were not in symmetrical arrangement, as shown by figure 2, for in tongue number 2, for example, four papillae were found to be present on the left side while only two were present on the right side. No median papilla was observed in any of the six tongues. This was held to prove further that no symmetrical arrangement existed, for when five papillae were present, as in tongue

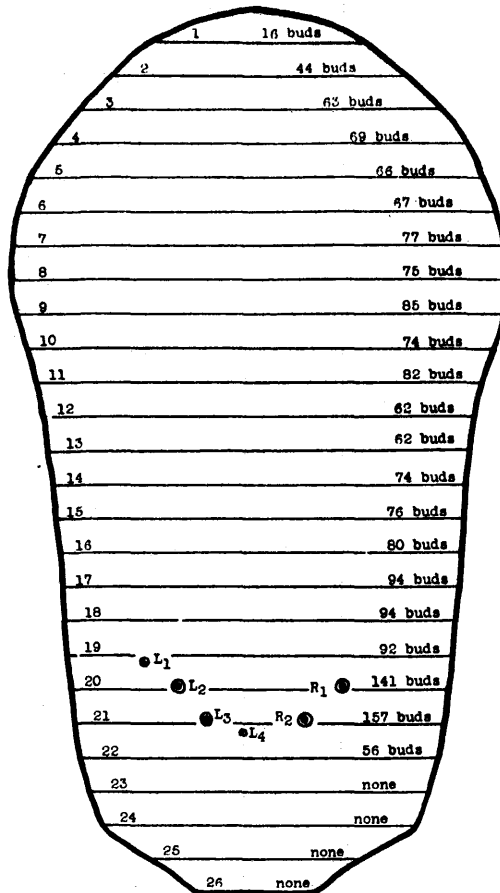


Fig. 4. Graphic representation of the average total regional distribution of taste buds over the entire dorsum of the three tongues studied for number of buds in fungiform papillae and for tongue number 2 studied for number of buds in circumvallate papillae. Each area represents seventy-three sections of a 20 micra tongue thickness. The positions of the circumvallate papillae in tongue number 2 are plotted. $\times 3$.

number 4, three were found on the right half and two on the left half of the tongue.

The presence of this variation seems to be in agreement with the condition as described by Bailey ('21) for the human in which he stated that the circumvallate papillae in man varied from nine to fifteen in

number, but it is not in agreement with the arrangement of these papillae as described by Elliott ('37) in the kitten, for two circumvallate papillae were found in a single median trench, nor does it agree with the condition observed in the monkey by Vastarini-Cresi ('15), in which he found that a median circumvallate was present on the tongue of this mammal.

The region of the circumvallate papilla has been described by various histologists as the area of the tongue which possesses the keenest sense of taste. Addison ('26) estimated that 100 to 150 was the maximum number of taste buds present in a single circumvallate papilla of the human. Arey et al ('35) found that the number present varied with the age of the individual. They gave 788 buds for the papilla and 231 buds for the outer trench wall as the highest number observed in their work.

In this investigation, a count was made of the buds which were found in the circumvallate papillae of tongue number 2. Seventy was the greatest number of buds observed in any one papilla, these being found in papilla L_2 , Figure 4; of these twenty-six were found in the top of the papilla and forty-four in the sides. The total number of buds observed in the circumvallate papillae of this tongue was two hundred sixty-two, of which one hundred twenty-one occurred in the tops, one hundred thirty-nine in the sides. Two buds were observed in the floor of the trench encircling circumvallate papilla L_3 of tongue 2 (Fig. 3). This last condition was described as rare but present in the human by Arey et al ('35). Probably the reason for the presence of a lower number in the pups than in the human is traceable to the difference in size of the papillae of these mammals, as previously mentioned. Taste buds are described as appearing in the outer wall of the trench in the human by Bailey ('21) and Arey et al ('35). None were observed in this position in the pup.

The author was interested in the shift of the acuity for lingual taste toward the region of the circumvallate papillae, as pointed out by Stahr ('01) in his work on the human and confirmed by Elliott ('37) for the case of the kitten; so, Figure 4 was prepared to obtain a more complete picture of the total number of taste buds of the different areas of the tongue. It can be noted that 1706 buds represents the average number present per tongue in this study. An area near the tip is quite well supplied with taste buds; this was mentioned for the dog by Olmsted ('21). There seems to be a slight shift in the keenness of the sense of taste toward the region of the circumvallate papillae where it would seem to be keenest by virtue of the great number of taste buds present.

CONCLUSIONS

1. In the pup all of the taste buds which are observed on the tongue are limited to the dorsal surface where they are found only in the fungiform and circumvallate papillae.

2. An average of 1706 buds per tongue was observed (Fig. 4). This average number is composed of 262 buds observed in the circumvallate papillae (of tongue number 2) and 1444 buds, the latter number being the total average number found in

the fungiform papillae of the three tongues used in this study. The total regional distribution of the buds in the fungiform papillae of all tongues studied is shown in Table I.

3. The taste buds found in connection with fungiform papillae were observed to be present only in the tops of such papillae. The greatest number of taste buds which was observed to occur in any fungiform papilla was six.

4. There is a very gradual increase in the number of taste buds from the tip of the tongue toward the circumvallate papillae. No taste buds were found caudad of the region of the circumvallate papillae (Fig. 4).

5. The circumvallate papillae were found to vary in number from four to six and this region contains the greatest number of taste buds (Fig. 4).

6. The taste buds observed in connection with the circumvallate papillae were found in the tops and sides and in the floor of the trench which surrounded the papillae (Fig. 3). Buds were found to be most numerous in the sides of such papillae.

7. In the adult human, taste buds are described as being present in the outer, trench wall (Arey et al '35). No buds were found in this position on the tongue of the pup.

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