On a Tactile Organ in the Cheek of the Mole, Scalops Aquaticus
ON A TACTILE ORGAN IN THE CHEEK OF
THE MOLE, SCALOPS AQUATICUS

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

JAMES EDWARD ACKERT

ENTITLED ON A TACTILE ORGAN IN THE CHEEK OF THE MOLE,

SCALOPS AQUATICUS

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF

MASTER OF ARTS

In Charge of Major Work

Head of Department

Recommendation concurred in:

Committee on Final Examination

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INTRODUCTION

In June, 1909, Mr. F. E. Wood of the Illinois State Laboratory of Natural History called my attention to the presence of a protuberance containing vibrissae, in the cheek of the shrew-mole, Scalops aquaticus machrinus, Rafinesque. The abundant nerve supply of this organ, the remarkable development of its vibrissae, and the ease with which these animals may be obtained and kept in captivity, led me to investigate the structure. This work deals with (1) a comparison of the external appearance of this protuberance in the mole, with more or less similar structures in the cheeks of white-footed mice, rats, bats, and opossums; (2) the histology and the innervation of this organ in the mole; and (3) experiments on the living mole.
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MATERIAL AND METHOD OF PROCEDURE

The material for the comparative study consisted of adult live specimens, from which the tissues were removed immediately after killing, placed in corrosive-acetic fixing fluid, and mounted in balsam.

**Killing and Fixing Fluids**

For the histological preparations of the organ the following fluids were used:

1. Müller's Fluid.
2. Tellysnecky's Fluid.
3. Formic acid.
4. Corrosive sublimate and acetic acid.

**Stains.**

1. Delafield's Haematoxylin and Eosin.
2. Mayer's Paracarmine and Lyon's Blue.
4. Gold Chloride.
5. Mayer's Hemalum.

**Fluids for the Preparation of Anatomical Specimens.**

The following fluids were used in preparing specimens for dissection:

1. Alcohol 85%
2. Formalin 10%
3. 95% alcohol......3 parts.
    Water.............3 parts.
    Glycerine.......3 parts.
4. Nitric acid...10%
5. Parker and Floyd Mixture.

The Parker and Floyd fluid was satisfactory for general preservation, but for the dissection of nerves, nitric acid and van Gehuchten's proved more satisfactory.

The work was carried on at the Zoological Laboratory of the University of Illinois, Urbana, Ill., under the direction of Dr. Frederic W. Carpenter, and Mr. William F. Allen.

LITERATURE

Much valuable work has been done upon the nerve endings in the roots of so-called touch- or sinus-hairs, particularly in the snouts of mammals. The groups of tactile hairs occurring upon the cheeks of many mammals have been mentioned (Bonnet, p.331), but have not been described. Bonnet investigated the "Haarbalge" of horses, sheep, oxen, dogs, cats, swine, rats, and mice. He found these tactile hairs in nearly all mammals, in different degrees of development, and in varying numbers on the snout, the cheeks, the lower jaw, and the eyelids.

Wood (Wood and West, p.6) briefly mentions the pres-
ence of this tactile organ in the mole. He says, "Between the eye and the ear is a protuberance containing vibrissae, and probably functioning as an organ of touch."

COMPARISON OF TACTILE ORGANS

In the animals studied, the positions of these tactile organs are identical, viz., directly between the eye and the base of the ear, and a little dorsocaudad of the posterior angle of the mouth. Upon each tactile organ, there are three kinds of hairs: A large vibrissae; B hairs about one-half the length of vibrissae and similar to the long hairs of the pelage; C short downy hairs closely resembling those which constitute the general covering of the body.

MOLE.—

The tactile organ in the cheek of the mole, Scalops aquaticus machrinus (Fig. 5) is approximately 3 mm. in diameter and 1/2 mm. in height. It contains 5 large tactile hairs (Fig. 5, T), many B, and a number of C hairs.

RAT.—

While the common rat, Mus norvogicus, is somewhat larger than the mole, never-the-less, this structure in the former is more imperfectly developed. For, instead of 5 strong vibrissae, there are but 3 slender ones (Fig. 4, T). Both of the other kinds of hairs, however, are more numerous.
WHITE-FOOTED MOUSE.—

The white-footed mouse, Peromyscus leucopus, approximately 1/4 the size of the rat, has in this organ I vibrissa (Fig. 2, T) nearly equal in length to those of the rat. As might be expected, the other two types of hairs are correspondingly less abundant.

BAT.—

In the examination of a cave bat, which had been brought into the laboratory, it was surprising to find a well developed tactile organ containing 2 vibrissae (Fig. 3, T). There was a liberal supply of B hairs, but the C hairs were almost entirely wanting. The organ itself was noticeably larger in proportion to the size of the body than those in any of the other animals except the mole. Other cave bats studied later were similar in these particulars.

OPOSSUM.—

This structure in the opossum, Didelphys virginiana, is of unusual interest. The enormously developed tactile hairs (Fig. 6, T), which are 8 in number, measure 70 to 80 mm. in length. The hairs of type B are extremely few or absent entirely, while those of C are well represented.

A comparison of these organs with the respective animals shows that, in proportion to length of body, the number of vibrissae in the organ is greatest in the mole.
Animal | Length of Body (mm) | Vibrissae in Tactile Organ
--- | --- | ---
White-footed mouse | 168. | 1
Cave bat | 89.4 | 2
Rat | 350. | 3
Mole | 181. | 5
Opossum | 600. | 8

A plausible explanation for this difference in development may be given. In fig. I, it is seen that the anterior portion of the snout is naked. It is this part of the head that the mole utilizes so advantageously in digging its burrow. Hoggan (p. 547) suggests that these hairs have been torn out so often that they have become suppressed. From an examination of the specimens at hand, it has been found that, as a rule, those animals with numerous well developed snout vibrissae have small tactile organs in the cheek. The common rat, for example, has numerous vibrissae in its snout, and, as has been seen, the tactile organ of the cheek is meagrely developed, there being but 3 vibrissae. The snout of the white-footed mouse, likewise, is supplied with an abundance of these hairs, while in the cheek organ, there is but a single tactile hair. The mole, on the other hand, with no vibrissae at all on its snout, has a well developed tactile organ in the cheek, containing 5 vibrissae.
HISTOLOGY OF THE TACTILE ORGAN IN THE MOLE

Having considered the external appearance of this structure in a number of animals, the attention will now be directed briefly to the histology of this organ in the mole. A deep frontal section (Fig. 7) discloses cross sections of the 5 characteristic tactile hairs, of several class B hairs (Fig. 7, PH), and of numerous short hairs (Fig. 7, P) similar to those constituting the pelage. Among the other structures commonly found in the skin, there may be noted blood vessels (Fig. 7, Bd), connective (Fig. 7, C), and sebaceous glands (Fig. 7, G). From a careful study of the roots of the vibrissae within the organ, their structure has been found to be very similar to that of the so-called "Sinus-haaren" in the snout of the dog (Ksjunin, Pl. XXII). Perhaps the most striking homology is that of the enormously developed blood sinus (Fig. 7, S), bounded externally by the thick outer connective tissue layer (Fig. 7, OC), and internally by the thin inner connective tissue layer (Fig. 7, IC). Other homologous parts are the hyaline membrane, the outer epithelial sheath, the inner epithelial sheath, and the shaft or hair (Fig. 7, Hn, OE, IE, and SH). There present, also, other structures, which with the exception of Huxley's layer (Fig. 7, La) of the inner epithelial sheath, do not appear in these drawings. They are Henle's layer, likewise of the inner epithelial sheath, the sheath and hair cuticulae, the cortical substance, and the medullary substance of the hair.
It may be of interest to note the extremely crowded condition of the tissues immediately surrounding the sinus hairs, as contrasted with the sparsely situated blood vessels, hairs, glands, etc., in the periphery of the tactile organ (Fig. 7). The massing of the tissues is doubtless caused, to a considerable extent, by the subsequent growth of the vibrissae and sheaths. Then, too, the need for greater support of the roots of these tactile hairs accounts in part for the increased amount of connective tissue at this point; and, it seems altogether probable that the unusual development, both of the blood sinuses, and of the roots of the tactile hairs, together with the increased amount of connective tissue, are the causes for the elevation of a portion of the tactile organ above the surface of the cheek.

INNERVATION OF THE TACTILE ORGAN IN THE MOLE

A dissection of the head of the mole (Fig. 8) shows the innervation of the tactile organ, the larger branches of the mandibular nerve, and some of the adjacent muscles, bones, and foramina.

Nervus mandibularis.—

This large trunk, the third division (Fig. 8, D) of the fifth cranial nerve, takes its origin by a strong root from the semilunar (or Gasserian) ganglion and, after separating from the ganglion, receives the smaller ventral root (portio minor) of the trigeminus.
That the mandibular nerve is both sensory and motor will be shown later. This nerve now passes out through the foramen ovale (Fig. 8, ov) and divides into several branches, some of which will be considered in this connection.

Nervus auriculotemporalis.

The comparatively large auriculotemporal nerve (Fig. 8, AR) arises immediately distad of the foramen ovale and passes distad, emerging at the caudal border of the masseter muscle, where it divides into two main branches, the auricular and the temporal nerves.

Auricular branch.

This nerve (Fig. 8, N) passes dorso caudad along the cranial border of the cartilaginous auditory meatus and is distributed to the integument of the small external ear.

Temporal branch.

The larger of the two, the temporal branch (Fig. 8, TN), passes cephalad approximately to the point, where it passes over the zygomatic arch (Fig. 8, z). Here it gives off a strong branch (Fig. 8, Y) to the tactile organ (Fig. 8, TO). The temporal then continues ventrocephalad almost to the angle of the mouth where it is distributed to the buccinator muscle (Fig. 8, 5)
The distribution of the remaining branches of the mandibular nerve are of interest and will be given as follows:

**Nervus massetericus.**

The mandibular now gives off the masseteric nerve (Fig. 8, M), which passes dorsocraniad ending in the masseter muscle (Fig. 8, S)

**Nervus buccinatorius** (Fig. 8, B). This nerve passes cephalad along the dorsolateral surface of the pterygoid muscles, into the buccinator muscle. Its distribution has not been worked out in detail.

**Nervus lingualis** (Fig. 8, L). After passing laterad approximately 1/2 mm., the mandibular nerve separates into 3 divisions, the lingual and the inferior alveolar. The former passes anteriorly between the external and internal pterygoid muscles into the tongue.

**Nervus alveolaris inferior** (Fig. 8, A). This nerve has been traced only to the mandibular foramen. Shortly after its origin, it gives off a large branch, the mylohyoid (Fig. 8, H), to the mylohyoid (Fig. 8, 7) and the digastric (Fig. 8, 6) muscles.

**EXPERIMENTS ON THE LIVING MOLE**

The moles in captivity were kept in boxes containing from 4 to 6 inches of moist dirt and supplied with food and water daily. Before being experimented upon, each animal was
removed from its box and placed in an empty one from which it could not escape. In no instance was an experiment begun un-
10 or 15 minutes after the mole had become accustomed to its new enclosure.

Experiment I. - Tactile Stimulus.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Part of Body Stimulated</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eraser on lead pencil</td>
<td>Snout</td>
<td>Vigorous movement of head</td>
</tr>
<tr>
<td>&quot;</td>
<td>Tail</td>
<td>Slight movement of tail</td>
</tr>
<tr>
<td>&quot;</td>
<td>Hind foot</td>
<td>Slight movement of foot</td>
</tr>
<tr>
<td>&quot;</td>
<td>Pelage on back</td>
<td>Twitching of skin on back</td>
</tr>
<tr>
<td>&quot;</td>
<td>Pelage on head</td>
<td>Slight movement of head</td>
</tr>
<tr>
<td>&quot;</td>
<td>Vibrissae in tactile organ</td>
<td>Strong movement of head</td>
</tr>
</tbody>
</table>

From experiment I, it is seen that responses resulted from all parts of the body that were touched. Judging from the strength of response, the snout is first in degree of sensitivity to tactile stimulus, the tactile organ, second, the tail, third, hind foot, fourth, and pelage, fifth. The experiment, however, loses some of its significance from the fact that only
one stimulus was used, and that the experiment was performed upon but two specimens.

RELATION OF TACTILE ORGAN TO DETECTION OF FOOD

During the last two years, several experiments have been performed upon the mole to ascertain what part, if any, the tactile organ plays in the finding of food. Up to the present time, the results fail to show more than that this organ has a simple tactile relation to the locating of food. When any object touches the vibrissae, the mole assumes a fighting attitude. It turns its snout quickly in the direction of the object and at the same time strikes at the latter with the correspond-fore foot. Likewise, when a live earthworm, or a May-beetle larva touches the tactile hairs, it is thrown cephalolaterad by the paddle-like foot to where it is either detected by the nostrils, or passed by unnoticed. In this connection it may be of interest to note the method employed by one of the captive moles in obtaining its food. This specimen came regularly to the mouth of its burrow for earthworms, but, if to obtain the morsel, it became necessary for the mole to reach out of the burrow a distance of more than one-half the length of its body, the little animal would dodge back quickly, dig through the earth to a point immediately below the worm, reach up into the air an inch or more, and seize its prize. This feat was per-
formed repeatedly and with wonderful accuracy during the three weeks of captivity. While this has no direct bearing upon the function of the tactile organ, it shows that the mole possesses a keen faculty for the detection of food.

EXPERIMENT 2.- TO DETERMINE THE CHARACTER OF THE NERVE SUPPLYING THE TACTILE ORGAN

The temporal branch of the auriculotemporal nerve lies immediately beneath the superficial muscles of the face. When the skin on the lateral surface of the head is laid back, these muscles adhere to it, thus baring the temporal nerve.

After administering chloroform to the mole, the skin and superficial muscles on the side of the side of the head were laid back and nerves TN, Y, and X (Fig.8) were dissected out for several millimeters, and stimulated electrically. The results were as follows:

1. Temporal branch (Fig.8,TN), motor response.
2. Nerve (Fig.8,Y) to the tactile organ, no response.
3. Nerve (Fig.8,X) continuation of temporal, motor response.

From this experiment the following conclusions were drawn:

(a) The mandibular nerve is both sensory and motor in function.
(b) The temporal branch of the auriculotemporal nerve is also mixed.

(c) The branch supplying the tactile organ is sensory.

(d) That portion (Fig. 8, X) of the temporal nerve which is distributed to the buccinator muscle contains motor fibers.

THE FUNCTION OF THE ORGAN

It has been shown that there is present in the cheek of the mole a well developed protuberance supplied with large vibrissae and innervated by a strong sensory branch. The question of its function naturally arises. As is well known the major portion of the life of the mole is passed in its burrow.

Enemies.-

Of the enemies of moles, Wood (Wood and West, p. 13) has the following to say: "But little is known definitely in regard to the enemies of moles. Cats and dogs kill but do not eat them. Weasels, skunks, and foxes probably kill them occasionally and, when hard pressed for food, may eat them. In Dr. Fisher's study of the contents of 2615 stomachs of birds of prey, moles were found only 4 or 5 times". In trapping, the writer has found the burrows in pastures, gardens, and cemeteries so flattened by cattle, horses, and rollers, respectively, that the moles would have been crushed had they been in
their burrows at the time. Thus it would appear that the mole must guard particularly against enemies that pursue it, and against agencies that close the burrow with pressure sufficient to inflict injury.

**Vision.**

In regard to vision, Wood (Wood and West, p.6) states that the eye of the mole is so degenerate that distinct vision is impossible, and at most it can only serve to distinguish light from darkness. It is obvious then that the eye can aid neither in locating food, nor in informing the mole of the approach of enemies.

**Hearing.**

There is no doubt but that this animal, in captivity, responds to tones similar to the human voice and to sounds such as those caused by persons walking upon the floor; but in view of the fact that practically all of a mole's natural life is spent below the surface of the earth, it seems highly improbable that the sense of hearing plays an important part in acquainting the mole with the outside world.

**Smell.**

The sense of smell is doubtless the chief means by which the mole detects not only its food, but also the approach of some of its enemies. There are, however, certain mechanical foes whose advent must be discovered by some other means.
That the mole is extremely sensitive to touch was shown in the experiment in which responses to a tactile stimulus were obtained from various parts of the body. Captive moles in boxes upon the floor were disturbed by the approach of a person, even though the latter made no sound audible to the human ear. A mole was disturbed by having the corner of its box quietly lifted. It is evident then that even slight vibrations of the earth surrounding the burrow, are detected by these animals. In the first experiment upon the living mole, it was noted that the structure in the cheek is markedly responsive to a tactile stimulus. The position of this structure upon the head, and the length of its vibrissae are such that in digging a new burrow or in traversing an old one, the distal ends of the vibrissae are brought in contact with the surrounding earth, thereby enabling the mole better to locate a wriggling worm or to detect a vibration caused by the approach of an enemy. It is therefore to be inferred that this protuberance containing 5 large vibrissae, and innervated by a strong sensory nerve, functions as a tactile organ.

CONCLUSIONS

1. A protuberance containing five vibrissae is present in the cheek of the mole.

2. Similar structures occur in the cheeks of white-
footed mice, bats, rats, and opossums.

3. Of the animals examined, those with well-developed snout vibrissae have small tactile organs in their cheeks.

4. The projection of a portion of the protuberance above the surface of the cheek of the mole is probably caused by the subsequent growth of the vibrissae, the enormous blood sinuses, and the increased amount of supporting tissue at this point.

5. This organ in the mole's cheek is very sensitive to mechanical stimuli.

6. A sensory branch of the temporal portion of the auriculotemporal branch of the mandibular division of the trigeminal nerve innervates this organ.

7. Unquestionably, this protuberance in the cheek of the mole functions as a tactile organ.
BIBLIOGRAPHY

Bonnet, Robert

Hoggan, George and Frances (Mrs.)

Ksjunin, P.

Wood, Frank E. and West, J.A.
LIST OF ABBREVIATIONS USED IN THE FIGURES

A  Nervus alveolaris inferior
AR Nervus auriculotemporalis
B  Nervus buccinatorius
Bd Blood vessel
C  Connective tissue
D  Nervus mandibularis
E  External auditory meatus
G  Gland
H  Branch of Nervus alveolaris inferior to musculi mylohyoideus and digastricus
Hn Hyaline membrane
IC Inner connective tissue layer
IE Inner epithelial sheath
L  Nervus lingualis
La Huxley's layer (Inner epithelial sheath)
M  Nervus massetericus
m Mandible
N  Auricular branch of nervus auriculotemporalis
OC Outer connective tissue layer
OE Outer epithelial sheath
ov Foramen ovale
P  Short hairs of pelage
PH Long hairs of pelage
S  Blood sinus
SH Shaft (Hair)
T  Tactile hair or vibrissa
TN Temporal branch of nervus auriculotemporalis
TO Tactile organ
X  Motor portion of the temporal branch of nervus auriculotemporalis
Y  Sensory portion of the temporal branch of nervus auriculotemporalis (Innervates the tactile organ
Z  Zygomatic arch
I  Musculus temporalis
2  Musculus occipitofrontalis
3  Musculus clavotrapezius
4  Musculus stylohyoideus
5  Musculus buccinator
6  Musculus digastricus
7  Musculus mylohyoideus
8  Musculus masseter
EXPLANATION OF FIGURES

I. Is a photograph of an adult mole. The arrow indicates the position of the tactile organ. X 2/3

2-5, Which were drawn to a scale from whole mounts, represent lateral superficial views of tactile organs in the cheeks of white-footed mice, bats, rats, and moles, respectively. X 5. Reduced 5/12

6. Is a dorsolateral view of this organ in the cheek of the opossum. X 2. Reduced 1/2

7. Microscopical view of a frontal section through a tactile organ in the cheek of the mole, showing the general histology of the structure. The outline was made by the aid of the camera lucida and the details were filled in afterward. X50. Reduced 1/2

8. Drawing made from dissections of the heads of several moles. X 3. Reduced 1/5