The Facial Muscles of *Manis Pentadactyla* Linne

By

Masatake Imai

Department of Anatomy, School of Dentistry, Aichi-Gakuin University, Chikusa-ku, Nagoya 464, Japan

—Received for Publication, November 16, 1977—

Key Words: Facial muscle, Pangolin, Comparative anatomy

Summary. The author has observed the facial muscles in six pangolins (*Manis pentadactyla* Linne) and concluded as follows:

1. The facial muscles in the pangolin bear some resemblances to those in the Dasypus sexcinctus, Tatusia novemcincta and Tamandua tetradactyla, but the differences in the same muscles between the pangolin and the above-mentioned xenarthra surpass the similarity. 2. The differences in the facial muscles between the pangolin and the Bradypus tridactylus are greater than those between the pangolin and the xenartha excepting the Bradypus. 3. The comparison on the facial muscles between the pangolin and the domestic animals and the primates including human beings is meaningless because of the extreme differences between them. 4. The muscular component in the lip of the pangolin is so complex that it is incomparable with those in the xenarthra, domestic animals and primates including human beings. Moreover, the constructions in the upper and lower lips of the pangolin are different from each other. 5. The dorsal part of the lower lip bends into the oral cavity and makes a fold, Plica oralis. The lateral part of the tongue slides on the dorsal surface of this fold. Therefore, the backward and forward movements are controlled by this fold. 6. The upper lip closely overlaps the base of the Plica oralis and this mechanism presumably serves to shut up tightly the Rima oris and to keep out the ants from the oral cavity. 7. The Plica buccalis is a fold which is made inside the corner of the mouth to supplement the want of the Plica oralis. It serves to keep away the escape of the ants from the same corner. 8. The Plica alaris in the Vestibulum nasi is well developed and is extremely useful to shut out the invaders, especially live ants. 9. In addition to the muscle of mastication, the mandible in the pangolin has many muscles, and they are inserted into the lower lip, skin of the lower lip and so forth, but no M. mandibulo-auricularis.

The author has observed those muscles in the same animal and compared his views with Uekermann's.

Materials

Six pangolins, *Manis pentadactyla* Linne,
preserved in 10 per cent aqueous solution of formalin were used for this study. The late Professor S. Adachi identified this pangolin with *Manis aurita* Hodgson. The data of this study were made during 1944–1945 at the Medical College affiliated with Taihoku Imperial University.

**Observations**

A. Muscles related to the auricle.

1. M. auricularis superior (mas)

   The origin of this muscle has two types. One springs from the Galea aponeurotica (3 cases), and the other from the periosteum of the occipital bone (2 cases). The triangular insertion on the posterior face neighboring the auricular tip divides itself into two or three pieces (Figs. 2–5), while there is also a muscle in the form of a band (Fig. 1).

   Moreover, the following anomalous muscles were observed in this region.
   a. A slender muscle arised from the aponeurosis sets with long tendon on the bone of the upper part of the Porus acusticus externus (3 in Fig. 3). This muscle is asymmetrical.
   b. A muscle divided from M. auricularis superior sets on the upper part of the orbit (11 in Fig. 5). This muscle is also asymmetrical.
   c. A muscle situated over the M. auricularis superior (6 in Fig. 4). This is a bisymmetrical muscle and two parts are connected with the aponeurosis on the parietal. The posterior divided portion of the muscle ends into the connective tissue behind the tip of the auricle (c in Fig. 4). The anterior divided portion sets on the upper part of the orbit (6' in Fig. 4). This is similar to 11 in Figure 5. The anterior portions on both the sides are connected together with a tendon divided from the same muscle pieces (7 in Fig. 4).

   Actions: The auricle presumably stands straight by the contraction of the M. auricularis superior.

2. M. auriculo-occipitalis (mao)

   Two types are observed.
   a. It divides from the lower part of the M. occipitalis and ascends to the posterior root of the auricle (5 in Fig. 1).
   b. This is a short muscle arising from the temporal bone neighboring the lower part of the anterior margin of the M. occipitalis and setting on the posterior surface of the auricular cartilage (5 in Figs. 3 and 4).

   Actions: This muscle pulls the auricle backwards and downwards.
3. An unidentified muscle neighboring the M. auriculo-occipitalis.

4. M. auricularis anterior (maa)
   This is a fine muscle arising from the skin neighboring Porus acusticus externus and setting on the middle part of the posterior face of the frontal process in the temporal bone (Figs. 3, 4 and 5).
   Actions: It is probable that this muscle provides aids for the extension of the Porus acusticus externus.

5. Muscles related to the tragus
   a. A fine and short muscle arising in the skin covering the tragus sets on the anterior part of the tragus (1 in Fig. 3 and 27 in Fig. 4).
   Actions: This muscle presumably pulls the tragus to the rostro-ventral side.
   b. A fine muscle (2 in Fig. 3), having a long tendon (3 in Fig. 4) sometimes, arises on the auricular cartilage neighboring the tragus and sets on the same one.
   Actions: This muscle presumably pulls the tip of the tragus to the ventral side.
   c. A muscle arising on the bone inferior to the tragus ascends to set on the anterior surface of the tragus (6 in Fig. 1).
   Actions: This muscle presumably pulls the tragus to the ventro-rostral side.

6. M. sphincter colli (mspc)
   This muscle consists of two parts. The one is composed of many muscle bundles radiating under the skin. The muscle bundles extend over the ventral and caudal region of the auricle (Fig. 6). The other part is a thin and band-like muscle and is inserted into the caudal base of the auricular cartilage. The same muscle on both the sides is connected with each other (2 in Fig. 4).
   Actions: This muscle has the literal function and the portion in Fig. 4 depresses the auricle ventrally.

7. Platysma
   Two types of this muscle were observed.
   a. The one is composed of two pieces arising from the fascia on the neck, directing horizontally forwards and is inserted into the submandibular region (Fig. 3).
   b. A band-like muscle arising from the fascia on the neck proceeds forwards horizontally over the M. sphincter colli and is inserted into the caudal region of the tragus (1 in Fig. 4).
   Actions: The fascia on the neck is stretched by the tension of this muscle.

B. Muscles around the eye
1. M. orbicularis oculi (moo)
   The muscle fibres of this muscle arise with short tendons from the bone at the inner canthus (4 in Fig. 1) and take an annular arrangement in the upper and lower eyelids (Figs. 1, 3, 4 and 5).
   Actions: The opening and closing of the eyelid are made by this muscle.

2. A muscle at the inner canthus
   It arises on the nasal part of the ventral border of the orbit, ascends obliquely to the rostral side dividing into pieces and is inserted into the rostral portion of the upper eyelid (28 in Figs. 3, 4, 5 and 9).
   Actions: This muscle may serve to close the eyelid.

3. M. orbito-auricularis (moa)
   a. The orbital portion This portion in the pangolin is composed of several muscle pieces. The caudal portion of them consists of one (7 in Fig. 3 and 6' in Fig. 4) to three muscle pieces (4, 11 and 12 in Fig. 5) arising from the Galea aponeurotica. The rostral portion compared of two muscle pieces (2, 3 in Fig. 1, 7a, 7, in Fig. 3, 11, 12 in Fig. 4 and 7, 8 in Fig. 5) arises from the skin neighboring the dorsal and the rostral regions of the orbit. By the way, the rostral pieces are gene-
rally more slender than those of the caudal pieces.

The orbital portion (6') in Figure 4 is divided from the (6) arising on the Galea aponeurotica and (c) inserts itself into the connective tissue neighboring the caudal region of the auricle. The orbital portions (6') of both the sides are connected with a tendon (7).

Actions: The caudal muscle pieces arising from the Galea aponeurotica provide a tension on the same Galea. The rostral muscle pieces arising from the skin stretch the corresponding region of the skin.

The orbital portion (11) in Figure 5 is divided from the M. auricularis superior (9). A muscle (13) arises from the Galea aponeurotica bifurcates, and their rostral part is one of the orbital portion (12). The end of the caudal part is divided into two parts. The rostral part of them inserts itself into the caudal part of the upper eyelid (5 in Fig. 5) and the other part sets with a tendon on the bone anterior to the Porus acusticus externus (3 in Fig. 5). The part (5) is similar to the muscle (6) in Figure 3. This muscle (6) arising from the Galea aponeurotica descends to the outer canthus. The rostral part of this muscle is inserted into the caudal part of the upper and the lower eyelid, and the caudal part of the same muscle sets on the caudal border of the orbit.

An abnormal muscle neighboring the orbit is seen (10 in Fig. 4). A slender muscle arising on the bone in front of the Porus acusticus externus sets on the middle part of the dorsal border of the orbit.

Actions: The caudal muscle pieces arising from the Galea aponeurotica exert a tension of the same Galea. The rostral muscle pieces arising from the skin stretch the corresponding region of the above mentioned skin.

b. The auricular portion

Two types of this portion were observed. One of them arises on the caudal part of the upper border of the orbit and is inserted into the auricular tip (9 in Fig. 4).

The other type is 7i in Figure 3. The muscle arising from the Galea aponeurotica descends obliquely to the rostral side and is inserted on the rostral half of the upper border of the orbit. The ventral part of this muscle is connected with the rostral part of the helix (22 in Fig. 3). This part is the auricular portion.

Actions: Pulls the dorsal part of the
auricle to the rostro-ventrally side.

C. Muscles related to the wings of the nose, the nostrils and the Plicae alares

1. M. retractor plicae alaris (mrpa):
   This term is given by the author.
   This muscle consists of three pieces. They arise on the maxilla neighboring the rostral and ventral borders of the orbit and proceed forwards horizontally. The upper piece insert itself dorso-ventrally with several divided tendon on the dorsal part in the median surface of the cartilage of the Plica alaris (8 in Fig. 1, 20 in Fig. 3, 8 in Fig. 7, 4 in Fig. 8 and 8 in Fig. 9).

   The muscle fibres from the tendon of this muscle piece are inserted into the skin neighboring the nostril and some other fibres setting on the rostral part of the maxilla (10 in Fig. 1).

   The middle muscle piece passes the Sulcus alaris to set with several divided tendon on the median surface of the Plica alaris (10 in Fig. 2, 23 in Fig. 3, 20 in Fig. 4, 9 in Fig. 6, 9 in Fig. 7, 5 in Fig. 8 and 9 in Fig. 9).

   A muscle bundle divided from the tendon of this muscle piece proceeds dorsally to set on the nasal cartilage (2 in Fig. 2, 29 in Fig. 4 and 2 in Fig. 6).

   Some other muscle fibres divided from the tendon proceed ventrally to insert on the lateral part of the palatal bone (15 in Fig. 1).

   The lower muscle piece sets with a tendon on the rostral part of the basis of the Plica alaris (12 in Fig. 1, 11 in Fig. 2, 24 in Fig. 3, 21 in Fig. 4, 10 in Fig. 6, 10 in Fig. 7, 6 in Fig. 8 and 12 in Fig. 9).

   Muscle fibres from the tendon of the lower muscle piece proceed rostro-ventrally to be inserted into the bone situated in the lateral and rostral area of the palate (13 in Fig. 1).

   The upper muscle piece generally arises by one head (Figs. 1, 3 and 4), but rarely arises by two heads to fuse into one (Fig. 5). The middle and lower muscle pieces arise by one head (Figs. 1, 2, 3, 5 and 6) and soon divide into two (Figs. 1, 2, 3 and 5), but they rarely arise by two heads (Fig. 4).

   Actions: The upper and middle muscle pieces are inserted into the dorsal part in the mesial surface of the cartilage in the Plica alaris, and the plica is pulled dorso-laterally to open the breathing way in the vestibule. The lower muscle piece is inserted into the rostral base of the plica.
Therefore, the rostral end of the plica is drawn towards the bottom of the vestibule and closes the breathing way by the contraction of this muscle piece. The muscle fibres divided from the tendon are inserted into the skin neighboring the nostril, and the contraction of this muscle may serve to enlarge the nostril. Slender muscles divided from the upper, middle and lower muscle pieces are inserted into the nasal cartilage or the palatal bone. The author considers that these muscles are useful as the fulcra for the insertion of the same muscle pieces.

An unidentified muscle

There is a well developed muscle beneath the origin of M. retractor plicae alaris (A in Figs. 1, 3, 4 and 9). It arises on the maxilla and proceeds downwards to the caudal side to set on the Arcus zygomaticus (A in Figs. 3 and 4), or proceeds almost horizontally (A in Fig. 1). The origin of M. retractor plicae buccalis lies under the origin of this muscle.

2. A muscle stretches between the mesial surfaces of the cartilage in the Plica alaris on both the sides. The caudal portion of this muscle passes over the tendon of the upper muscle piece of M. retractor plicae alaris (21 in Fig. 3, 6 in Fig. 6, 4 in Fig. 7 and 2 in Fig. 8).

Actions: Both the plicae are pulled towards the mesial side to open the third breathing way.

3. Muscle fibres arising in the skin neighboring the nostril are inserted into the rostral part of the median surface of the cartilage in the Plica alaris (7 in Figs. 2 and 6).

Actions: The muscle fibres stretch the skin of the above-mentioned region.

4. Muscle fibres arising in the skin neighboring the lateral margin of the nostril proceed deeply to be inserted into the base of the Plica alaris (4 in Fig. 6 and 6 in Fig. 7).

Actions: These muscle fibres stretch the lateral margin of the nostril and may serve to open the nostril.

5. Muscle fibres arising in the skin neighboring the Sulcus alaris proceed under the tendon of the lower muscle piece of the M. retractor plicae alaris, subsequently penetrate into the M. maxillo-labialis and then set on the rostral part of the Plica alaris (26 in Fig. 9).

Actions: These muscle fibres presumably pull the skin neighboring the Sulcus alaris, and may serve to enlarge the groove.

6. A muscle arising in the skin neighboring the Sulcus alaris proceeds down-
wards to set on the caudal part of the cartilage in the Plica alaris (27 in Fig. 9).

**Actions:** This muscle presumably pulls the skin of the above mentioned region and enlarges the Sulcus alaris.

7. A muscle arising on the rostral portion of the nasal bone proceeds to the outer side and then bends forward to set on the cartilage in the Plica alaris (3 in Fig. 2).

**Actions:** This muscle dorsally pulls the plica and may serve to open the breathing way.

8. A muscle between the mesial part of the upper lip and lower margin of the nostril. It proceeds almost caudo-rostrally (8 in Fig. 2, 14 in Fig. 3, 9 in Fig. 6 and 3 in Fig. 7).

**Actions:** This muscle may serve to enlarge the nostril.

9. Muscle fibres arising from the middle part of the Cartilago naso-apicalis are obliquely inserted into the skin of the rostrum. Two fine nerves and arteries pass caudo-rostrally between the muscles on both the sides. Some muscle fibres from this muscle are inserted into the skin neighboring the mesial margin of the nostril (1 in Fig. 7, 3 in Fig. 8).

**Actions:** The muscle fibres stretch the skin in the rostrum. Some other fibres presumably serve to enlarge the nostril.

10. A muscle arising in the skin neighboring the nostril is inserted into the posterior portion of the lower margin of the nostril (5 in Fig. 6).

**Actions:** This muscle presumably stretches the skin neighboring the nostril.

11. A muscle arising on the rostral portion of the rasal cartilage is inserted into the medial margin of the nostril (13 in Fig. 4).

**Actions:** This muscle medially pulls the medial margin of the nostril and may serve to enlarge the nostril.

12. A bundle of muscle fibres arising from the lower and medial margin of the cartilage arounding the nostril is inserted into the upper lip (9 in Fig. 6).

**Actions:** These muscle fibres pull the upper lip towards the nostril.

13. Muscle fibres arising from the nasal cartilage are inserted into the skin in the caudal region of the nostril (1 in Fig. 2 and 18 in Fig. 4).

**Actions:** These muscle fibres stretch the skin neighboring the caudal region of the nostril.

14. A well developed and triangular muscle arising in the skin neighboring the caudal region of the nostril converges into the base of the Plica alaris (17 in Fig. 3).

**Actions:** This muscle stretches the skin of the above mentioned region.

**D. Muscles related to the upper lip**

1. Muscle fibres arising in the skin neighboring the middle part of the lip are inserted dorso-ventrally into the lip of the same region (16 in Fig. 4 and 2 in Fig. 7).

**Actions:** These muscle fibres presumably stretch the skin of the above-mentioned region.

2. Muscle fibres arising from the mesial part of the nasal cartilage in the rostrum are inserted into the rostral part of the upper lip (17 in Fig. 4).

**Actions:** These muscle fibres pull the upper lip in the above-mentioned region.

3. M. maxillo-labialis (mml): This term has been given by the author.

It arises on the triangular rough surface in the maxilla inferior For. infraorbitale, proceeds horizontally forwards and is inserted into a very strong intermediate tendon connecting with the corner of the mouth (Fig. 3 and 14 in Fig. 4). A bundle of muscle fibres arising from this tendon makes up about caudal half of the muscular component in the upper lip (15 in Fig. 4 and 30 in Fig. 9). An absence of the intermediate tendon is rarely observed (one case). In this case, a fine muscle piece divided from the above mentioned...
muscle is inserted into the corner of the mouth, and principal portion of the muscle is inserted into the upper lip.

Actions: The corner of the mouth is closed by the traction of the caudal portion of this muscle and the upper lip closely overlaps the dorsal part of the lower lip by the contraction of the rostral portion of this muscle.

4. Muscle fibres arising in the skin of the upper lip deeply proceed to the mucous membrane neighboring the lateral region of the palate (5 in Fig. 2). Some of the muscle fibres are inserted into the lip margin of the rostral portion (6 in Fig. 2).

Actions: The muscle fibres will stretch the mucous membrane of the above-mentioned region. The muscle fibres which are inserted into the lip margin will pull the above mentioned skin.

5. Muscle fibres arising in the skin of the ventral area of the nostril are inserted into the rostral part of the upper lip (13 in Fig. 3 and 16 in Fig. 4).

Actions: These muscle fibres will pull the above mentioned region of the upper lip.

6. Muscle fibres arising from the mesial margin of the cartilaginous nostril are inserted into the upper lip (12 in Fig. 12).

Actions: These muscle fibres stretch the upper lip.

7. A muscle arising on the lower margin of the cartilaginous nostril is inserted into the upper lip (14 in Fig. 12).

Actions: This muscle dorsally pulls the upper lip.

E. Muscles related to the lower lip

1. Muscle fibres arising in the skin of the rostral part of the lower lip are inserted into the mucous membrane in the rostral part of the bottom of the oral cavity (10 in Fig. 10).

Actions: These muscle fibres stretch the mucous membrane of the above-men-

...
3. Muscle fibres arising in the skin of the middle part of the lower lip are inserted vertically into the lower lip (4 in Fig. 12).

Actions: These muscle fibres presumably stretch the above mentioned shin.

Besides, there are three kinds of muscles arising in the mandible [See 1), 2) and 9) muscles related to the mandible].

F. Muscles related to the mandible

1. A muscle arising on the base of the Proc. spinosus in the mandible proceeds horizontally to the middle part of the lower lip (20 in Fig. 9 and 7 in Fig. 12).

Actions: This muscle pulls the middle part of the lower lip.

2. A muscle arising on the anterdorsal part of the For. mentale proceeds antero-inferiorly over the mandible and is inserted into the rostral part of the lower lip. Muscle fibres arising from a short tendon for insertion of the above-mentioned muscle proceed deeply and are inserted into the mucous membrane of the bottom of the oral cavity (12 in Fig. 11).

Actions: This muscle pulls the rostral part of the lower lip. The muscle fibres arising from the above-mentioned tendon stretch the mucous membrane of the bottom of the oral cavity.

3. Sometimes a muscle bundle with a long tendon arises on the rostral part of the mandible and proceeds to the corner of the mouth (11 in Fig. 6).

Actions: This muscle stretches the corner of the mouth.

4. A muscle arising on the mandible in front of the For. mentale proceeds vertically to the skin in the anterior part of the corner of the mouth (14 in Fig. 6).

Actions: This muscle stretches the above-mentioned skin.

5. A muscle arising on the lower surface extending from the anterior part of the For. mentale to the rostral end of the mandible is inserted into the skin of the rostral portion of the lower lip (9 in Fig. 11).

Actions: This muscle presumably stretches the skin of the above-mentioned region.

6. One to three muscle bundles arising on the mandible neighboring the For. mentale terminate on the Synchondrosis intermandibularis (18 in Figs. 9 and 10).

Actions: The Synchondrosis is presumably reinforced by these muscles of both the sides.

The muscle piece arising on the anteroinferior portion of the margin of the For. mentale is inserted into the skin of the rostral part of the lower lip. Another muscle piece arising on the anterosuperior portion of the margin of the For. mentale changes into the intermediate tendon neighboring the Proc. spinosus and soon turns into muscular substance and is inserted into the middle part neighboring the rostral end of the mandible. While, the muscles piece does not make the intermediate tendon in another case.

Actions: The muscle pieces stretch the skin of the above-mentioned region. It is impossible to presume on the actions of another muscle piece which is inserted into the mandible itself.

7. A muscle arising on the rostral region of the Proc. spinosus proceeds ventrally and is inserted into the skin of the lower lip (3 in Fig. 12).

Actions: This muscle stretches the skin of the above-mentioned region.

8. A muscle arising on the Proc. spinosus is inserted into the skin covering the mental region. The muscle is moderately thick (10 in Fig. 12).

Actions: This muscle stretches the skin of the above-mentioned region.

9. Muscle fibres arising on the rostral part in the ventral surface of the mandible are inserted into the rostral part of the lower lip (8, 9 in Fig. 10).

Actions: This muscle pulls the rostral
part of the lower lip.

10. Two muscle pieces arising from the lower part of the rostral margin of the For. B in the mandible are inserted into the skin covering the mental region (18 in Fig. 10, 2 in Fig. 12 and 1 in Fig. 13).

Actions: These muscle pieces stretch the skin of the above-mentioned region.

11. A muscle piece arising on the upper part in the rostral margin of the For. B proceeds to set on the Synchondrosis intermandibularis before For. A (18 in Figs. 9, 13 and 1 in Fig. 12)

Actions: This muscle piece presumably reinforces the Synchondrosis.

12. Muscle fibres arising on the rostral area to the Proc. spinosus in the mandible are inserted into the skin of the lower lip neighboring the same process (3 in Fig. 12).

Actions: These muscle fibres presumably stretch the skin of the above-mentioned region.

13. A muscle arising on the Proc. spinosus is inserted into the skin covering the caudo-lateral part of the mental region (10 in Fig. 12).

Actions: This muscle presumably stretches the above-mentioned skin.

G. Muscles related to the Plical buccalis

There is a fold having many bristles on the external surface. It is situated just caudally to the corner of the mouth, and its rostral part is covered by the caudal end of the Plica oralis. The author has termed this fold Plica buccalis (Figs. 9, 10, 11 and 12).

1. M. retractor plicae buccalis (mrpb): This term has been given by the author.

It arises by two pieces on the ventro-caudal area to the M. retractor plicae alaris and proceeds forwards along the M. maxillo-labialis. The upper piece of this muscle connects with a strong connective tissue at the corner of the mouth (A), and sometimes muscular fibres divided from this muscle are inserted into the
The Facial Muscles of *Manis Pentadactyla* Linne

caudal part of the upper and lower lip (B). While, in another case, the muscular fibres divided from this muscle set on the caudal part of the Plica oralis (C). Moreover, sometimes, the upper muscle piece divides some muscle fibres to set on the Plica buccalis (D) (11 in Fig. 3, 25 in Fig. 4, 13 in Fig. 6, 1 in Figs. 10 and 11, 15 in Fig. 12).

The lower piece of this muscle (E) is inserted into the Plica buccalis with a tendon (10 in Fig. 3, 2 in Fig. 11, 16 in Fig. 12). Moveover, some muscle fibres divided from the tendon at just caudal area to the corner of the mouth (F) proceed deeply and are inserted into the base of the Plica buccalis (9 in Fig. 3, 22 in Fig. 4, 5 in Figs. 10 and 11, and 11 in Fig. 12).

M. retractor plicae buccalis arising by one head was observed only in one case in this study. This divides some muscular fibres to set on the Plica buccalis and the end of this muscle terminates on the rostral part of the mandible (17 in Figs. 1 and 9).

Actions, A: Stretches the corner of the mouth. B: Pulls the caudal part of the upper and lower lip. C: Stretches the Plica oralis. D, E, F: Pull the Plica buccalis and the plica is closed to the cheek by the contraction by these muscle fibres.

By the way the M. retractor plicae buccalis and the M. maxillo-labialis construct the wall of the cheek.

2. A muscle arising on the dorsal surface of the Proc. spinosus proceeds caudodorsally to set on the rostral half of the Plica buccalis (A) and terminates on the caudal region of the Plica oralis (B) (8 in Fig. 11).

Actions, A: Pulls the Plica buccalis to the rostral side and the plica closes to the corner of the mouth. B: Stretches the caudal region of the Plica oralis.

3. A muscle arising on the region between the Proc. spinosus and the For. A in the mandible proceeds caudally to set on the lateral surface of the Plica buccalis (6 in Fig. 11).

Actions: This muscle pulls the plica to the rostral side and the plica closes to the corner of the mouth.

4. A muscle arising from the connective tissue at the corner of the mouth is inserted into the base of the Plica buccalis (10 in Fig. 6 and 6 in Fig. 12).

Actions: The Plica buccalis is fixed to the corner of the mouth.

5. Muscle fibres arising from the skin of the rostral region to the corner of the mouth proceed vertically to be inserted into the base of the Plica buccalis (15 in Fig. 12).

Actions: The skin of the above-mentioned region is stretched by these muscle fibres.

6. A muscle arising on the base of the Plica buccalis sets on the surface of the same plica (8 in Fig. 12).

Actions: This muscle pulls the plica to the lateral side.

H. Muscles related to the Plica oralis

The dorsal part of the lower lip bends into the oral cavity and forms a surface to place the lateral part of the tongue can slide over this surface. The base of this fold is closely overlapped by the upper lip from the rostral beginning to the corner of the mouth. The author has termed this fold Plica oralis (po in Figs. 9, 10 and 11).

1. A muscle arises by two layers on the rostral part of the ventral surface of the Proc. spinosus in the mandible. A portion of the superficial layer of this muscle sets on the rostral part of the Plica oralis (A) and the rest of the above-mentioned layer proceeds anteriorly and is inserted into the lower lip (B) (9 in Fig. 11). The deep layer of this muscle proceeds horizontally along the lower lip and...
is inserted into the rostral part of the bottom of the oral cavity (C) (12 in Fig. 11). But, sometimes the deep layer does not exist.

Actions A, B: Pull the Plica oralis towards the caudal side. C: Stretches the above-mentioned region.

2. A muscle arising on the rostral area of the Proc. spinosus and the base of the same process in the mandible proceeds to the dorsal side and sets on the caudal part of the Plica oralis (7 in Fig. 11).

Actions: This muscle pulls the rostral part of the plica towards the caudal side.

3. A muscle arising from the Proc. spinosus and the margin of the For. A proceeds to the rostral side to set on the lateral surface or on the rostral part of the Plica oralis (20 in Fig. 9).

Actions: This muscle pulls the rostral part of the plica towards the caudo-ventral side.

4. A muscle arising on the dorsal surface of the Proc. spinosus proceeds caudo-dorsally to set on the Plica oralis (A) and the rostral half of the Plica buccalis (B). It penetrates into the muscle 7 on the way (8 in Fig. 11).

Actions, A: Pulls the caudal part towards the rostral side. B: Pulls the rostral half of the Plica buccalis to close the corner of the mouth.

5. Muscle fibres arising in the skin neighboring the corner of the mouth are inserted into the base of the Plica oralis and the lower labial margin (7 in Fig. 10).

Actions: These muscle fibres stretch the skin neighboring the corner of the mouth.

6. A muscle arising from the Plica oralis is inserted into the mucous membrane in the bottom of the oral cavity neighboring the corner of the mouth (11 in Fig. 11).

Actions: This muscle stretches the above-mentioned region of the mucous membrane.

7 A muscle arising from the connective tissue at the corner of the mouth is inserted into the caudal base of the Plica oralis (10 in Fig. 6).

Actions: This muscle pulls the plica towards the corner of the mouth.

8. Muscle fibres divided from the tendon for insertion of the lower muscle piece of the M. retractor plicae buccalis proceed vertically and deeply to be inserted into the caudal end of the Plica oralis (11 in Fig. 11).

Fig. 14. Left wall of the nasal vestibule is removed to show the whole aspect of the Plica alaris. 1, 2: Plica alaris, 3: groove on the dorsal surface of the plica.

Fig. 15. cr: crista in the bottom of the nasal vestibule, 5: cross-section of the Plica alaris.
The Facial Muscles of *Manis Pentadactyla* Linne

orals (15 in Fig. 6).

**Actions**: These muscle fibres pull the caudal part of the plica to the caudal side and stretch the above-mentioned region.

I. Muscles related to the oral cavity

1. Muscle fibres arising from the skin covering the cheek proceed deeply to the mucous membrane of the dorsal part of the cheek (12 in Fig. 2, 15 in Fig. 3 and 1 in Fig. 6).

**Actions**: These muscle fibres stretch the mucous membrane of the above-mentioned region.

2. Muscle fibres divided from the middle muscle piece of the *M. retractor plicae alaries* are inserted into the dorso-rostral part of the mucous membrane of the cheek (see *M. maxillolabialis*).

**Actions**: These muscle fibres stretch the mucous membrane of the above-mentioned region.

3. Muscle fibres arising from the skin covering the rostral bottom of the oral cavity proceed deeply to be inserted into the mucous membrane of the lateral bottom of the oral cavity (5 in Fig. 12).

**Actions**: These muscle fibres stretch the mucous membrane of the above-mentioned region.

4. Muscle fibres arising on the caudal part of the *Plica buccalis* are inserted into the mucous membrane of the lateral bottom of the oral cavity neighboring the same plica (22 in Fig. 9).

**Actions**: These muscle fibres stretch the mucous membrane of the above-mentioned region.

5. Muscle fibres arising in the skin covering the rostral part of the cheek are inserted into the dorsal part of the wall in the cheek (15 in Fig. 3).

**Actions**: These muscle fibres presumably stretch the cheek in the above-mentioned region.

J. *Plica alaris*

There is a fold termed *Plica alaris* in the *Vestibulum nasi*. It projects downwards from the upper wall of the vestibule (1 in Fig. 14). The roof must be removed to show the full view of the fold (2 in Fig. 14). The caudal half of this fold is slender and the rostral half swells (Fig. 14). Figure 15 shows the bottom of the vestibule removing the fold. There are four cristae in the bottom and this place is divided into four areas by these cristae (cr in Fig. 15). Area 1 is a hollow and accepts the swelling part of the fold. Area 2 is a groove to accept the slender part of the fold. The areas 3 and 4 are the way for the breathing air. In addition to these ways, there is the third way for the breathing air. This way is formed between a groove on the dorsal surface of the swelled part in the fold (3 in Fig. 14) and the roof of the vestibule.

There is a groove on the ventral surface (g) to receive the crista (cr in Fig. 15) and when the swelled part of the fold puts into the hollow (area 1) and the crista (c) gets into the groove (g), the ways 1 and 2 for breathing air are closed, but the third way is always open. This is an effective mechanism to keep off the irruption of the extraneous substance into the nasal cavity. For example, the ants for the bait of the pangolin are shut out from getting into the same cavity, but the pangolin itself can breathe through the third way.

K. A special structure in the oral cavity

The *Rima oris* opens directly into the vestibule of the oral cavity in general mammalia. While, the pangolin has a fold inside of the lower lip. Namely, the dorsal part of the lower lip bends into the oral cavity presenting a fold and ends at the corner of the mouth. The base of this fold is closely overlapped by the upper lip. The author has termed the same fold *Plica oralis*. This fold forms a dorsal surface to place the lateral part
of the tongue and the tongue can slide over this surface.

Connecting with this fold there is another fold, the Plica buccalis, in the caudal region, but the same fold does not belong to the Plica oralis. The Plica buccalis is situated at the corner of the mouth, and has many bristles on the external surface but none on the internal surface. The author fosters the idea that this plica interrupts the ants for the bait from escaping from the oral cavity.

**Discussion**

1. **M. auricularis superior**
   This muscle in the pangolin is full of variety in the form and the number (one to three) and three kinds of anomalous muscles related to the M. auricularis superior were observed in this study. Ruge\(^3\) considers that the M. auricularis superior is originated from the M. orbitoauricularis. It appears to me that the second (6’ in Fig. 4) and third (11 in Fig. 5) anomalous muscles in this study are connected with Ruge's opinion.

   Uekermann\(^4\) describes on the M. auricularis superior in the Dasypus sexcinctus and the Tamandua tetradactyla but he does not make mention of the same muscle in the Tatusia novemcincta and the Bradypus tridactylus.

2. **M. auriculo-occipitalis**
   This muscle in the pangolin is short and slender, while the same muscle in the Tatusia novemcincta is well developed and those muscles in the Dasypus sexcinctus as well. The Tamandua tetradyactyla and the Bradypus tridactylus takes a form of large membrane, and does not divide in many muscle pieces as in the pangolin and the Tamandua tetradyactyla. Uekermann does not find this muscle in the Bradypus tridactylus.

3. **M. auricularis anterior and muscles related to the tragus**
   Uekermann\(^5\) makes no mention of these muscles of the Xenarthra in his study. While, the author observed the same muscles in the pangolin (Figs. 3, 4 and 5, 1 in Fig. 3 and 27 in Fig. 4, 2 in Fig. 3, 3 in Fig. 4 and 6 in Fig. 1). By the way, these muscles are very slender and short.

4. **M. sphincter colli**
   This muscle in the pangolin and the Tamandua tetradactyla has much in common. The same muscle in the Dasypus sexcinctus and the Tatusia novemcincta takes a form of large membrane, and does not divide in many muscle pieces as in the pangolin and the Tamandua tetradyactyla. Uekermann does not find this muscle in the Bradypus tridactylus.

5. **Platysma**
   This muscle in the pangolin is composed of one or two pieces and is inserted into the ventral region of the tragus (pl. in Fig. 3 and 1 in Fig. 4). The same muscle in the Dasypus sexcinctus is well developed and extremely different from that of the pangolin. Namely, the platysma in the Dasypus consists of three portions to set on the caudal base of the auricle, the caudal region of the orbit and over the cheek. Besides, the same muscle in this animal is fairly different from those of the Tatusia novemcincta, Tamandua tetradyactyla and Bradypus tridactylus, and the above-mentioned muscle in the pangolin is also different from those of the foregoing three kinds of animals. The platysma in the Tamandua tetradyactyla and the Bradypus tridactylus proceeds to the corner of the mouth and divides into a small muscle piece to the base of the auricle. The superficial portion of this muscle in the Dasypus sexcinctus also has two portions to set on the same region but the pangolin has no such a muscle.

6. **M. orbicularis oculi**
   There is no conspicuous difference in this muscle between the pangolin and the xenarthra.

7. **A muscle at the inner canthus**
   This muscle is always found in the pangolin (28 in Figs. 3, 4 and 5) and Ue-
kermann illustrates a similar one in the Tamandua tetractyla but he does not make reference to the same muscle in the Dasypus, Tatusia and Bradypus. The author considers that this muscle is probably an irregular origin of the M. orbicularis oculi.

8. M. orbito-auricularis

The orbital portion of this muscle in the pangolin is fairly complicated in structure. Namely, it is composed of several muscle pieces. The caudal portion of them consists of one to three muscle pieces. They arise on the Galea aponeurotica. The rostral portion composed two muscle pieces arises from the skin neighboring the dorso-rostral region of the orbit. The above-mentioned muscle pieces gradually become smaller from the caudal piece to the rostral one.

The auricular portion in the pangolin was observed only in two cases.

The M. orbito-auricularis in the pangolin is utterly different from the muscle of the same name in the xenarthra. Namely, the muscle in the Tamandua arising from the rostral base of the auricle proceeds forwards and is inserted into the dorsal and ventral region of the orbit. The auricular portion in the Tatusia is located in the rostral region of the auricle and it is not connected with the orbit. This animal has one large orbital portion. The Dasypus has a very large orbital portion and a very slender auricular portion. It is fairly similar to the muscle piece in the pangolin (7, in Fig. 3) but the auricular portion in the same animal is not separated from the orbital portion. While both the portions in the Dasypus keep their independence.

The orbito-auricularis in the Bradypus is absent according to the Uekermann's observation.

9. M. retractor plicae alaris

This muscle is composed of three portions and all of them are inserted into the Plica alaris in the vestibule of the nasal cavity. The term of this muscle has been given by the author basing on its function.

The dorsal muscle piece in the pangolin corresponds with the M. maxillo-labialis in the Dasypus, Tatusia and Tamandua. But this term is unsuitable, because the muscle has no relation to the lip in the pangolin. The M. levator labii superioris proprius in the domestic animals (Sisson-Grossmann) corresponds to the M. maxillo-labialis in the Dasypus, Tatusia and Tamandua. Therefore, this term is also inapplicable because of the above-mentioned reason. The author uses the term of the M. maxillolabialis in another kind of muscle.

The middle and ventral muscle pieces of the M. retractor plicae alaris correspond with the M. levator labii sup. alaeque nasi in the Dasypus, Tatusia and Tamandua, but this term is unsuitable to the pangolin. Uekermann regards the dorsal muscle piece in the Bradypus which is named the M. maxillo-labialis in the Dasypus, Tatusia and Tamandua as the M. levator labii sup. alaeque nasi.

The three muscle pieces belonging to the M. retractor plicae alaris are inserted by tendons into the cartilage in the Plica alaris. Besides, many slender and short muscles divided from the tendons are inserted into the skin, nasal cartilage, maxilla and palatal bone in the rostral region.

The author will describe on the action of the M. retractor plicae alaris later on.

10. M. zygomatico-labialis

This muscle is observed in the Dasypus, Tatusia and Tamandua by Uekermann, but this is absent in the pangolin. The Bradypus has none, either.

11. M. maxillo-labialis

This term is given to a muscle in the pangolin but it is different from the same name in the xenarthra.

This muscle in the pangolin is fairly
similar to the M. buccinator in the Dasy-
pus and the Tatusia. Although the M. buccinator is inserted into the upper and 
lower lip, only the maxillo-labialis has its 
insertion in the upper lip. (14 in Fig. 4, 
15 in Fig. 4 and 30 in Fig. 9). The M. 
buccinator in the Tamandua and the 
Bradypus is still more different from the 
M. maxillo-labialis in the pangolin.

The wall of the cheek in the pangolin 
is formed with the M. maxillo-labialis and 
the M. retractor plicae buccalis which is 
to be described later.

12. M. levator labii inferioris

This muscle in the Dasypus and the 
Tamandua is described by Uekermann but none in the pangolin. The same 
muscle in the Tatusia and the Bradypus 
is also absent. The one in the Dasypus 
diverges from the M. levator labii sup. 
alaque nasi, and the Tamandua has this 
muscle on the ventral side of the M. 
zygomatico-labialis.

13. M. orbicularis oris

Uekermann describes on this muscle 
in the Dasypus, Tatusia, Tamandua and 
Bradypus, but such a muscle is absent in 
the pangolin.

The muscular component in the lip of 
the pangolin is not so simple as in the 
xenarthra, domestic animals and pri-
mates including the human race. 
Namely, the author enumerates eight 
kinds of muscles in the upper lip and 
seven in the lower lip.

14. Plica buccalis and Plica oralis

The Plica oralis is formed by the bend-
ing of the dorsal part of the lower lip 
into the oral cavity, and the Plica buccalis 
is a fold which is made on the lateral 
part of the oral cavity to supplement the 
want of the Plica oralis at the corner of 
the mouth.

The author considers that the Plica 
buccalis will serve to prevent live ants, 
the bait of the pangolin, from escaping 
from the corner of the mouth. The Plica 
oralis controls the movement of the 
tongue. Namely, the plica plays the role 
as the railroad to slide the ventral surface 
of the lateral part of the tongue and the 
tongue slides backwards on the surface 
of the same plica keeping the live bait on 
the dorsal surface. At this time, the ants 
wrapped in viscid saliva. The ants be-
tween the palate and the dorsal surface 
of the tongue is very narrow. It is need-
less to say that the tongue slides forwards 
on the same surface of the plica. The 
upper lip closely overlaps the base of the 
Plica oralis and this mechanism also 
presumably serve to keep out the ants 
from the oral cavity. The movements in 
both the plicae and the lips are brought 
about by many muscles. The author 
enumerates nine kinds of muscles for the 
Plica oralis, six for the Plica buccalis, 
eight for the upper lip and seven for the 
lower lip.

Uekermann made a study on the facial 
muscles in the xenarthra, but could not 
find the view like the above-mentioned. 
I wish to find an observation on the 
Tamandua tetradactyla which is similar 
to the pangolin in the feed. Kühlhorn has 
described “Wangenfalte” in the Ta-
mandua tetradactyla and the Myrmeco-
phaga jubata, but is different from the 
Plica buccalis in the pangolin. He has 
also illustrated “aus Schleimhautfalten 
gebildete Gleitschiene für die Zunge” in 
the above-mentioned animals. The role 
of this fold is similar to the Plica oralis 
in the pangolin, but the structure of the 
fold in the Tamandua and the Myrme-
cophaga is different from that of the 
Plica oralis in the pangolin.

15. Plica alaris

The Plica alaris is a fold in the vesti-
bule of the nasal cavity to keep out the 
vandlers, mainly ants for the bait of the 
pangolin. As occasion demands, the pan-
golin thrusts his rostrum into the nest to 
flush out the ants to catch them. At this
time, the Plica alaris presumably provides valuable aids to keep out the invaders. Two ways are formed by the projection of the same plica between the ventral surface of the plica rostral end and four cristae on the bottom of the vestibule. These ways are too narrow to pass the ants but admit the breathing air. The above-mentioned two ways are closed by the descent of the plica but the breathing is possible through the way which is formed between the roof of the vestibule and a groove on the dorsal surface of the plica. The ants cannot invade through this way into the nasal cavity. This way comes narrower by the projection of the plica but is not closed up. By the way, this animal also eats the nest of the ants destroying it into pieces with the paw. The author observed seven kinds of muscles which were inserted into the Plica alaris.

16. Muscles related to the mandible

The mandible in the pangolin has many kinds of muscles other than the muscle of mastication. Namely, four kinds of muscles are inserted into the lower lip, two into the corner of the mouth, three into the skin covering the bottom of the oral cavity, three into the skin of the lower lip, one into the mucous membrane in the bottom of the oral cavity and three muscles arise from the mandible and are inserted on other place of the same bone.

M. mandibulo-auricularis

Uekermann has found this muscle in the Dasypus, Tatusia, Tamandua and Bradypus, but could not recognize it in the pangolin.

As mentioned above, the author observed several tens of the muscles related to the nostril, Plicae alaris, buccalis and oralis, lips and so forth. But it is impossible to term them one by one. In place of the terms, he has given them numbers.

17. Nerve supply

The nerve supply to the facial muscles is the N. facialis, however, the supply of the sensible nerve is observed in various muscles. The N. frontalis supplies the rostral muscle pieces of the Pars orbitalis in the M. auriculo-orbitalis (7, 7, in Fig. 3; 11, 12 in Fig. 4; 7, 8, 12 in Fig. 5).

The N. infraorbitalis supplies the muscle 7 and 8 in Figure 2; 14, 17 and 21 in Figure 3; 7 and 9 in Figure 6; 4 in Figure 7 and M. retractor plicae alaris. The anastomosis between the N. facialis and the N. infraorbitalis is not rare in the pangolin. Uekermann also observed the same kind of anastomosis in the Dasypus sexcinctus.

A peripheral twig of the N. maxillaris which comes out from the dorsal margin of the cartilaginous nostril supplies the muscle 1 in Figure 2, 13 and 17 in Figure 4. The branch from the above-mentioned anastomosis in the Dasypus supplies the muscle in the rostral region, and it corresponds with the above-described peripheral twigs of the N. maxillaris in the pangolin.

Acknowledgments

The author is greatly indebted to Assistant Prof. Dr. T. Mineda for help in making the text illustrations.

References


