On the Panniculus Carnosus of the Bridled Dolphin
(Stenella Frontalis)

Kazumoto YOSHIDA*

Department of Anatomy, Faculty of Medicine,
Nagasaki University, Nagasaki, Japan

Received for publication, February 1, 1971

Apparently little work has been done on the anatomy of Cetaceae, particularly of Odontoceti, in contrast to the comparatively large number of studies on their classification and ecology.

The author was fortunate to have had the opportunity to perform dissection of bridled dolphin (Stenella frontalis, cuvier), of Odontoceti. Moreover, this author was able to examine more material of the same species than any other previous investigator. This first report will deal with the cutaneous muscle.

In view of the unavailability of reports on the cutaneous muscle of not only this species, but also of the genus to which it belongs, it is hoped that these findings will serve to supplement the meager information available on this subject.

MATERIAL AND METHOD

The Odontoceti examined consisted of a total of 9 adult bridled dolphins (6 male and 3 females), including 3 cases caught in October 1961 along the coast of Arikawa (Goto Island) of Nagasaki Prefecture and 6 cases landed at the fish market in Nagasaki City in September 1963.

An immediate attempt had been made to inject 10% formalin solution into the carotid artery, but satisfactory results could not be obtained. Therefore, the subcutaneous fat layer was stripped and 10% formalin solution injected intramuscularly into the major muscles, after which the material was preserved in a tank containing 10% formalin solution.

Examination was done primarily by gross inspection, but magnifying lenses were used or histologic sections prepared for some areas to insure accuracy of the findings.
FINDINGS

The cutaneous muscle, that is, the panniculus carnosus of Cetacea is exposed by stripping the subcutaneous fat layer (blubber) and is a well developed, membranous structure present over almost the entire body.

The neck of Cetacea can not be distinguished as clearly as in other mammals in general so that the classification of NAKAYAMA was used in which the area on the cranial side of the cranial edge of the scapula is considered to be the neck. In this case, the cutaneous muscle (panniculus carnosus) may be classified by site into the following 3 regions:

A. Mandibular and cervical cutaneous muscle (Pars Mandibulo-cervicalis) – The cutaneous muscle that extends lateralward from the lower surface of the jaw and neck.

B. Lateral cutaneous muscle of trunk (pars lateralis) – The cutaneous muscle on the lateral side of the body that extends from the cranial edge of the scapula (which generally corresponds to the level of the outer opening of the ear) toward the tail.

C. Abdominal cutaneous muscle (pars abdominalis) – The cutaneous muscle on the ventral side which extends caudalward from the level of the axillary region to the anus.

A. Mandibular and cervical cutaneous muscle (figures 1, 2)

This muscle group, which arises from the subcutaneous tissue of the lower lip and runs across the lower surface of the jaw, is present over an area involving about half the length of the lower part of the snout.

Furthermore, the muscle fibers are increased in thickness at the mid-ventral line on the lower surface of the jaw, but no raphe formation is noted.

The caudal margin of this cutaneous muscle is at the level of the external auditory meatus, where it separates into 2 fasciculi to both sides which run to the lateral surface of the neck and gradually continue into the lateral cutaneous muscle of the trunk. Thus, a triangular aponeurotic region is present in this area with the Mm. thoracis superficialis forming the base.

This muscle may be separated from the underlying M. mylohyoideus for a distance of about 6 cm from the hyoid bone toward the snout, beyond which the muscle fibers of both are so markedly interwoven that separation is not possible.
Fig. 1 Panicaulus carnosus of the bridled dolphin (lateral view, ♂)

pars lateralís (paniculus carnosus)

pars præescapularis
(m. pect. prof.)

eye

ext. aud meatus

pars mandibulo-cervicalis
(paniculus carnosus)

m. pectoralis superficialis

pars ventralis
(paniculus carnosus)

anus

external genitalia
Fig. 2 Paniculus carnosus of the bridled dolphin (ventral view, δ)
B. Lateral cutaneous muscle of trunk (figure 1)

This cutaneous muscle, located in the superficial layer of the aponeurosis of the chest and abdomen, is continuous with the maxillary and cervical cutaneous muscle at the lateral surface of the neck. It is a band-like muscle which begins in the area of the external auditory meatus and extends caudalward to the level of the caudal margin of the muscular ring around the genital slit.

The cranial portion of this muscle gradually increases in width as it runs toward the level of the fore limb and then decreases in width as it runs to its termination at the genital slit.

In the area of the external auditory meatus, the muscle fibers appear to converge upon the external auditory meatus from both the ventral and dorsal sides which is different from the course of the muscle fibers in other areas. In other words, except for this area near the outer opening of the ear, the muscle fibers run from the dorsal side in cranio-ventral direction. To be more exact, the course is almost vertical in dorso-ventral direction in the area between the outer opening of the ear to the caudal edge of the scapula, beyond which the course of the muscle fibers is inclined more toward the tail.

Examination of the insertion of this muscle showed that in the cervical region, as mentioned above, there is gradual continuation into the maxillary and cervical cutaneous muscle at the lateral side of the neck. Farther caudad, in the dorsal area of the fore limb, there is tendinous termination into the surface of the aponeurosis of the M. deltoideus.

In the axillary region, as shown in figure 1, there is separation into 2 parts: 1) The part on the cranial side becomes tendinous and penetrates to the inner side of the M. pectoralis superficialis where it fuses with the pars humeralis of the M. pectoralis profundus; and 2) the part on the caudal side joins with a part of the M. pectoralis superficialis and this united membrane radiates into the subcutaneous tissue of the fore limb in the axillary region.

Thirdly, in the part located more caudal, one area near the cranial side interweaves with the abdominal cutaneous muscle to form a raphe. This interweavement is soon lost, and this muscle becomes increasingly separated from the abdominal cutaneous muscle and inserts into the aponeurosis.

Moreover, in the area between these 2 divisions of the lateral cutaneous muscle of the trunk in the axillary region, the pars praescapularis of the M. pectoralis profundus emerges from the inner side of the abdominal cutaneous muscle and radiates over the aponeurosis of the M. deltoideus at the base of the fore limb.
C. Abdominal cutaneous muscle (figures 2, 3)

The caudal edge of the M. pectoralis superficialis, as shown in Figures 1, 2 and 3, gradually changes to cutaneous muscle and forms the abdominal cutaneous muscle.

This cutaneous muscle is separated to the left and right sides by several centimeters at the level of the axillary line. As this muscle runs caudalward, its width decreases and the parts on each side gradually come closer together until they finally unite near the pudendum, after which the muscle continues to the muscular ring of the pudendum and terminates into the muscular ring of the anus.

The course of these muscle fibers is opposite to that of the lateral cutaneous muscle of the trunk and all are inclined slightly cranialward as they run in dorso-ventral direction. These are, as mentioned above, interweavement with the muscle fibers of the lateral cutaneous muscle of the trunk in the area of the axillary region, but no evidence of continuation or interweavement is seen in any other part.

Moreover, there is a sex difference in the course of the muscle fibers in the area around the genital slit and anus (figure 3).

In the male, the abdominal cutaneous muscle on each side unite and there is interweavement of the fibers at about the caudal side of the muscular ring around the external genitalia. It then penetrates

Fig. 3 Paniculus carnosus in the genital areas of the bridled dolphin (ventral view)
to the lower layer in the area of the muscular ring of the pudendum, at the caudal edge of which the muscle fibers of each side simply runs adjacent to each other without interweavement. There is fusion with one part of the caudal area of this muscular ring, but the two are completely separable elsewhere.

As it runs farther beyond the muscular ring of the pudendum, the muscle rapidly decreases in width to become a narrow band which ends by fusion into the caudal part of the muscular ring of the anus.

In the female, the abdominal cutaneous muscle on each side unite and there is interweavement of the fibers as it approaches the anterior commissure of the labium, but in the area beyond this, the muscle radiates to each side from the anterior and posterior commissures toward the muscular ring of the teats so that no muscle fibers are present between the labium and teats.

Therefore, a diamond shape area without muscle fibers is formed by the anterior and posterior commissures and the teats on each side.

This muscle in the area between the posterior commissure of the labium to the anus gradually merges from each side so that there is no raphe formation by interweavement, and the most caudal part of the muscle fibers terminates by fusion into the cranial side of the muscular ring around the anus.

**DISCUSSION**

The muscle called the cutaneous muscle is present to a varying degree of development in almost all mammals except anthropoid apes and man. Since the description by Ruge, it has generally been considered to have differentiated mainly from the Mm. thoracis. Ura studied the differentiation of the Mm. thoracis superficialis, particularly the cutaneous muscle of mammals and concluded that it had differentiated as a part of the Mm. thoracis superficialis.

The purpose of the present paper is not to discuss the differentiation of this cutaneous muscle, but simply to describe the morphology of the cutaneous muscle in Stenella frontalis which has not been reported previously and to present the similarities and differences in comparison with previously reported findings on Odontoceti.

**A. Mandibular and cervical cutaneous muscle**

Among the Odontoceti that have been examined with respect to the extent of this cutaneous muscle, it is reported in Neomeris phocoenoides to arise from the midventral line on the lower surface of the jaw and run dorsalward to the midlateral line where it inserts just before the eye or base of the ear (HOWELL). Thus, this muscle is developed considerably farther dorsalward than in the cases of the author.
Furthermore, in some species, a cutaneous muscle not found in Stenella seems to be present in this area. In other words, in the illustration of the head of Neomeris there appears to be a complicated facial cutaneous muscle, and even in Monodon monoceros, an independent cutaneous muscle is illustrated as being present around the angle of the mouth. However, no fasciculi corresponding to these were found in my cases of Stenella. Otherwise, there is almost no difference from my cases of Stenella.

With respect to the condition of this muscle on the lower surface of the jaw, a well developed muscle bundle which runs sideways without raphe formation has been described in this area in Globicephalus, while in Tursiops, which belongs to the same family as Stenella frontalis examined by this author, there is a triangular aponeurosis on the ventral surface of the neck in the area between the cutaneous muscle of each side. The base of this triangular aponeurosis is located at the level of the edge of the Mm. thoracis superficialis on the side toward the snout, and its apex is at the level of the outer opening of the ear on the lateral surface. Furthermore, a part of the muscle bundle caudad to the angle of the mouth runs upward and ends in the connective tissue covering the M. maseter. These findings are in complete agreement with that of the author for Stenella. It has been further mentioned that the cutaneous muscle on the lower surface of the jaw adheres with the subcutaneous tissue of the lip and covers the ventral margins of the jaw, and that only a small portion of the muscle bundle in the deep layer inserts into the lateral surface of the mandibula. These findings are almost the same as the author’s for Stenella except that no muscle fibers were seen attaching to the mandibula.

In Kogia, however, the triangular aponeurosis on the ventral surface of the neck extends farther dorsalward than in the Stenella of this author. That is it extends to the lateral surface of the neck. It can be said that there is a difference between the two in this respect.

The description of the cutaneous muscle on the lower surface of the jaw in Delphinus phocaena also is in agreement with the findings of this author.

Therefore, in the comparison with the 6 species mentioned above, the condition in the cases of the author was found to be most similar to the findings in Tursiops even though there are some differences with respect to the development and distribution of this muscle. This is to be expected since the Stenella examined by the author belong to the same family of Delphinidae as do Tursiops.

No report could be found on such interweavement and fusion of the cutaneous muscle of the lower surface of the jaw with one part of the underlying M. mylohyoideus as found in my study, but this in combination with the finding that the nerve supply to both is by the N. facialis may be an indication that they both may have differentiated
from the same anlage.

B. Lateral cutaneous muscle of trunk and abdominal cutaneous muscle

In most of Odontoceti, raphe formation is seen at the mandibular region between the lateral cutaneous muscle of the trunk and the abdominal cutaneous muscle due to the interweavement of their muscle fibers, but the condition farther caudad can be classified into that in which the lateral cutaneous muscle of the trunk is completely separated from the abdominal cutaneous muscle with no continuation at all, and that in which the two are continuous so as to form a single muscular sheet.

a) Those having raphe formation at the axillary region include Neomeris phocaenoides, Monodon monoceros, Kogia breviceps, Tursiops and Delphinus phocoena. i) Among these, the lateral cutaneous muscle of the trunk is separated from the abdominal cutaneous muscle without any continuation of the muscle fibers in Kogia brevis, Tursiops and Delphinus phocoena, and the Stenella frontalis studied by the author also belongs to this group. ii) In contrast to this, the cutaneous muscle located on the lateral side of the trunk caudad to the axilla in Neomeris phocaenoides and Monodon monoceros continues with the abdominal cutaneous muscle. iii) On the other hand, neither raphe formation nor separation of the lateral cutaneous muscle of the trunk from the abdominal cutaneous muscle is seen in Globiocephalus scammonii and Globiocephalus melas.

Schute and Smith, however, have noted raphe formation in the fetus of Globiocephalus melas which is in contrast to the findings of Murie.

Therefore, a detailed comparison was made with Neomeris phocaenoides and Monodon monoceros, which are similar to the Stenella studied by the author in that there is raphe formation but differ in that the lateral cutaneous muscle of the trunk can be separated from the abdominal cutaneous muscle. Further, an attempt was also made to determine whether there are any other similarities and differences.

a) The raphe at the axillary region in Neomeris phocaenoides is a tendinous raphe, extending dorso-caudalward from the axilla, where the muscles which run cranialward from the dorsal and ventral sides intersect.

In Monodon, however, there is no definite raphe formation. Moreover, in both Neomeris and Monodon, there is gradual continuation with the abdominal cutaneous muscle so that the two are indistinguishable in the area caudad to the axillary region.

In contrast to this, raphe formation was present in the Stenella
examined by the author, but was only half as long in length. Further, it was not tendinous, but formed by interwoven muscle fibers.

(b) The condition of the muscle fibers on the dorsal side of the fore limb in Neomeris has been described as being adhered to the powerful tissue of the superficial layer of the fore limb. In the Stenella of the author, it becomes a narrow tendinous band which converges moderately and attaches to the surface of the aponeurosis of the M. deltoideus without extension to as far as the fore limb. With respect to this point, the condition in Monodon is in agreement with Stenella.

(c) In Neomeris, the muscle fibers are simply described as extending to the mid-ventral line in the axillary region but not in the area farther caudal, and there is no discussion of the relation to the M. pectoralis superficialis. In the Stenella, although there was gradual continuation with the M. pectoralis superficialis at the level of the cranial edge of the sternum as mentioned above, the muscles on each side were separated from each other by several centimeters. Furthermore, in some of the material, it appeared to slightly overlap the M. pectoralis superficialis.

(d) At the mid-ventral line, this muscle in both is separated into the left and right sides by the aponeurosis covering the M. rectus abdominalis so that the muscle fibers do not reach the midventral line.

(e) Although Neomeris phocaenoides has no dorsal fin, in the area corresponding to the location of the fin in other species, the muscle fibers running cranio-ventralward from the mid-dorsal line are seen parted from the cutaneous muscle located farther lateral. They are similarly parted even in Monodon. In the area farther caudal, it first runs cranio-ventralward from the mid-dorsal line, but at a point on the extension line from the raphe, it changes its course to ventro-caudal direction and continues uninterrupted to the lateral abdomen. Farther caudal to this, a cutaneous muscle which runs toward the tail is seen on only the lateral abdomen.

In contrast to this, the lateral cutaneous muscle of the trunk in Stenella can be completely separated from the abdominal cutaneous muscle. The muscle fibers of the lateral cutaneous muscle of the trunk all are inclined caudalward, while the abdominal cutaneous muscle is inclined cranialward.

According to Nakayama, this muscle seems to be associated with the movement of the dorsal fin. In the Stenella examined by the author, however, even though it has a fin, this muscle never arose from the middorsal line which is in contrast to the view of Nakayama.

(f) At the region of the external genitalia, an independent muscle is seen converging to the anus and vulva in Monodon and Neomeris.
Such an independent cutaneous muscle could not be found converging to the anus and vulva in the Stenella of the author, but the abdominal cutaneous muscle continued from the axillary region to ultimately end by fusion with the muscular ring around the anus.

(2) As mentioned before, the condition in Kogia breviceps, Tursiops and Delphinus phocaena is most similar to the cases studied by the author with respect to the formation of the raphe near the axillary region and the complete separation of the lateral cutaneous muscle of the trunk from the abdominal muscle in the area beyond the axillary region. The direction of the muscle fibers of the cutaneous muscle in these 3 species is also largely the same as in the Stenella of the author except that, strictly speaking, the condition in Kogia is a little different. That is, the muscle fibers in Delphinus phocaena are reported to run upward or downward toward the aponeurosis located between the lateral cutaneous muscle of the trunk and abdominal cutaneous muscle, while the lateral cutaneous muscle in Tursiops is said to gradually change its course at about the shoulder to become inclined caudalward, and in Kogia it is reported to run in cranio-dorsal direction.

Although the course of the muscle fibers is slightly different from that in the author’s Stenella, the condition in Kogia appears to be the most similar to Stenella among these 3 species when the separation of the lateral cutaneous muscle into 2 heads at the axillary region is considered.

In addition, all are in general agreement with respect to the moderate development of the cervical cutaneous muscle on the lower jaw and the absence of the facial cutaneous muscle such as found in Monodon and Neomeris, as well as that the cutaneous muscle of the trunk does not arise from the mid-dorsal line.

Therefore, although it is only natural that the condition in Stenella is most similar to Tursiops since they both are members of the same Delphinidae family, a great similarity was also found to the condition in Delphinus among Phocaenidae and in Kogia among Kogiidae.

(3) In Globiocephalus, there is neither raphe formation at the axillary region nor separation of the cutaneous muscle into the lateral and abdominal parts. This is different from the condition in any of the above mentioned species. In addition, the area occupied by this cutaneous muscle in Globiocephalus is extensive reaching to as far as the region between the anus and tail shaft (Peduncle). Moreover, there is the unique finding that the cutaneous muscles on the lateral and abdominal sides are continuous, and the muscle fibers of each side are interwoven to form a raphe at the midventral line.
CONCLUSION

The following conclusions were obtained from a morphological study on the cutaneous muscle of 9 cases of Stenella frontalis for which no report had been available until now.

(1) The panniculus carnosus of Stenella frontalis is comparatively well developed, and may be classified by site into three regions, the mandibular and cervical cutaneous muscle, the lateral cutaneous muscle of the trunk and the abdominal cutaneous muscle.

(2) The mandibular and cervical cutaneous muscle transversed the lower surface of the jaw to the neck where it separates to each side and gradually continues with the lateral cutaneous muscle of the trunk. Moreover, one part of the cutaneous muscle in this area fuses with the underlying M. mylohyoides.

(3) The lateral cutaneous muscle of the trunk is a band-like muscle located on the lateral surface of the body that extends from the level of the external auditory meatus to the level of the genital slit.

At the axillary region, the muscle fibers are interwoven with those of the abdominal cutaneous muscle so as to form a raphe which runs caudalward. Caudad to this raphe, the lateral cutaneous muscle is separated from the abdominal cutaneous muscle by aponeurosis.

The course of the muscle fibers is nearly vertical in dorsoventral direction in the cranial area, and as the muscle extends farther caudalward there is increasingly greater inclination toward the tail.

Also, at the neck, this muscle gradually continues with the mandibular and cervical cutaneous muscle.

At the axillary region, there is separation into 2 parts. That on the cranial side becomes tendinous and penetrates to the inner side of the M. pectoralis superficialis where it fuses with the pars humeralis of the M. pectoralis profundus which attaches to the olecranon of the ulna. The part on the caudal side unites with a part of the M. pectoralis superficialis and radiates by tendon into the subcutaneous tissue of the fore limb at the axillary region. The pars preaescapularis of the M. pectoralis profundus which emerges from the inner side of the abdominal cutaneous muscle passes between these 2 divisions of the muscle in the axillary region and radiates into the aponeurosis of the M. deltoideus.

(4) At the axillary region, the abdominal cutaneous muscle, which continues with the caudal edge of the M. pectoralis superficialis, runs along each side of the abdomen. Both sides unite near the pudendum and terminate at the muscular ring around the anus. The muscle fibers run in a direction which intersects with that of the lateral cutaneous muscle, but a sex difference is noted in the course of the muscle fibers around the genital slit and anus.
In comparison with the findings reported for other Cetaceae, the distribution, morphology, etc. of the panniculus carnosus in *Stenella frontalis* was found to be the most similar to the condition in *Tursiops*.

REFERENCES


