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THE PATTERNS OF FACIAL ARTERIES IN THE SUIFORMES

SCHEMAT TĘTNIC TWARZY U SUIFORMES

Abstract

Background. Information about the course and branches of the facial arteries in the Suidae, Tayassuidae and Hippopotamidae families may be useful both for the classification of species and in veterinary practice. The system of arteries in the intermandibular, mental, masseteric, buccal, labial and nasal regions of the face was described in species of the Suiformes suborder, Artiodactyla order.

Material and methods. Six species of the Suidae, Tayassuidae and Hippopotamidae families were studied. In total, 30 specimens of head arteries were used for observations. The specimens were prepared by injecting acetone-dissolved stained vinyl superchloride or stained latex LBS3060 into the arteries.

Results. Blood in the facial regions of the representatives of the Suiformes suborder was supplied by facial, sublingual, mental, transverse facial, buccal and infraorbital arteries. Our research confirmed the fact that the facial artery of the Suiformes ran only medially and did not enter the lateral surface of the mandible. The transverse facial artery diverged in the common trunk with the masseteric branch. The buccal artery was very well developed and reached the inferior labial region. It was part of the infraorbital artery in the vascular system of the superior labial region.

Conclusions. The research proved that the arterial pattern of the face of Suiformes was characteristic of this suborder and it was different from the arterial patterns found in the other Artiodactyla.

Keywords: Suiformes, facial arterial supply, arterial patterns of the face

Introduction

Detailed knowledge of the body vascular system, especially in the head, is essential for clinical needs due to the fact that very important organs are located in this part of the body (Milgram et al., 2010; Dias et al., 2012). Nickel and Schwarz (1963) described

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arteries in the heads of farm animals. This publication was a source material for textbooks. The knowledge of this vascular area in other species provides comparative anatomical information, which shows the biodiversity of animals. In general terms, this information may even be useful for discussions on animal taxonomy and phylogenesis (Shoshani and McKenna, 1998). The taxonomy of species places domestic animals in different orders. Cattle, small ruminants, pigs and camels are classified into different suborders of the Artiodactyla order, whereas horses are classified as a separate order of the Perissodactyla order. Kowalczyk and Frąckowiak (2017) presented a detailed comparative description of facial arteries in representatives of all families of the Perissodactyla order, whereas the study by Frąckowiak (2003) provided general information about these arteries. Zdun et al. (2014) compared facial arteries in various species of the Ruminantia (one of the three Artiodactyla suborders) with the pattern of these vessels in domestic ruminants. Apart from that, more general information about the arterial system in the head of various representatives of the Ruminantia suborder were presented by Godynicki (1972) and Frąckowiak (2003). Information on the arterial pattern in the head of the camel, which belongs to the Tylopoda suborder, can be found in the camel anatomy textbook by Smuts and Bezuidenhout (1987). Godynicki (1972) and Frąckowiak (2003) provided a general pattern of these arteries in other Camelidae species. The vascular patterns in the head of representatives of the Camelidae family were also studied by Tayeb (1951), Badawi et al. (1977), Jerbi et al. (2013), and Kiełtyka-Kurc et al. (2014). O'Brien (2017) published an original study on the alpaca's head arteries. Kowalczyk et. al. (2018) (in press) studied arterial patterns in the head of Camelidamorpha. The domestic pig's head arteries were described by Nickel and Schwarz (1963). Some information about the arterial pattern in the head of other species of the Suiformes suborder can be found in studies by Godynicki (1972) and Frąckowiak (2003).

The aim of the study was to compare the divergences, courses, connections and branches of the facial artery, sublingual artery, mental artery, transverse facial artery, buccal artery and infraorbital artery, which supply blood to individual facial regions of selected species of the Suidae, Tayassuidae and Hippopotamidae families.

According to our research hypothesis, the arteries supplying blood to selected facial areas in representatives of the families of the Artiodactyla order similarly diverge from the arterial trunk and have similar course patterns, which are characteristic of the Suiformes.

Material and methods

The research was conducted on six species of the Suiformes suborder, including three species of the Suidae family, one species of the Tayassuidae family, and two species of the Hippopotamidae family. In total, 30 specimens of the head arteries of animals of both sexes were analysed. The animals belonged to the collection of the Department of Animal Anatomy, Poznań University of Life Sciences, Poland. Most of the animals were adult. Only 4 pig foetuses were about 100 days old and 2 hippos were about 1 week. The animal material was acquired from domestic zoological gardens and slaughterhouses. These animals had died, had been euthanised or slaughtered for other reasons, independent of our research. Corrosion test specimens (n = 17) were prepared

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by injecting acetone-dissolved stained vinyl superchloride into the common carotid arteries by means of a syringe with an airbag under a pressure of 60–80 kPa (Godynicki, 1970). After the polymerisation of the material filling the vessels, the specimens were subjected to enzymatic maceration in water with washing powder at 38°C for 40 days. The procedure resulted in corrosion casts of the arteries on osseous material. Latex preparations of the heads of a wild boar and 12 domestic pigs were made by injecting stained latex LBS3060 into the common carotid arteries by means of a medical syringe. Next, they were fixed in 10% formalin and prepared manually. The preparations were used for observations of the divergence, connections and course of the arteries supplying blood to the intermandibular (*regio intermandibularis*), mental (*regio mentalis*), masseteric (*regio masseterica*), buccal (*regio bucalis*), superior and inferior labial (*regio labialis superior et inferior*) and lateral and dorsal nasal (*regio lateralis et dorsalis nasi*) regions in different species of animals of the Suiformes suborder. The observations were documented graphically and photographically. The nomenclature of arteries followed the standards of Nomina Anatomica Veterinaria (2012) and Illustrated Anatomical Nomenclature of the Heart and the Arteries of Head and Neck in the Domestic Mammals (Simoens et al., 1978–1979). The mammal classification followed the pattern provided by McKenna and Bell (1997). Table 1 lists the animal species and the number of preparations subjected to analysis.

Table 1. Species of examined animals, short taxonomy and numbers of preparations

Family	Species	n = 30 (male, female)
Suidae	*Phacochoerus aethiopicus* – Desert Warthog	2 (1, 1)
	Sus scrofa – Wild Boar	3+1* (2, 2)
	Sus scrofa f. dom – Domestic Pig	4+12* (7, 9)
Tayassuidae	*Pecari tajacu* – Collared Peccary	5 (1, 4)
Hippopotamidae	*Hexaprotodon liberiesis* – Pygmy Hippopotamus	1 (0, 1)
	Hippopotamus amphibious – Common Hippopotamus	2 (1, 1)

* Preparations obtained using latex.

Results

The facial regions under analysis were covered by the facial, sublingual, mental, transverse facial, buccal and infraorbital arteries. The external carotid artery branched directly into the facial artery and transverse facial artery. When the external carotid artery passed into the maxillary artery, it branched directly into the buccal artery and infraorbital artery. The arterial patterns of the animal species of the Suidae, Tayassuidae and Hippopotamidae families looked as follows (Fig. 1, 2, 3):

The facial artery (*a. facialis*) diverged directly from the external carotid artery and it ran towards the abdomen, first along the angle of the mandible and then along its body.

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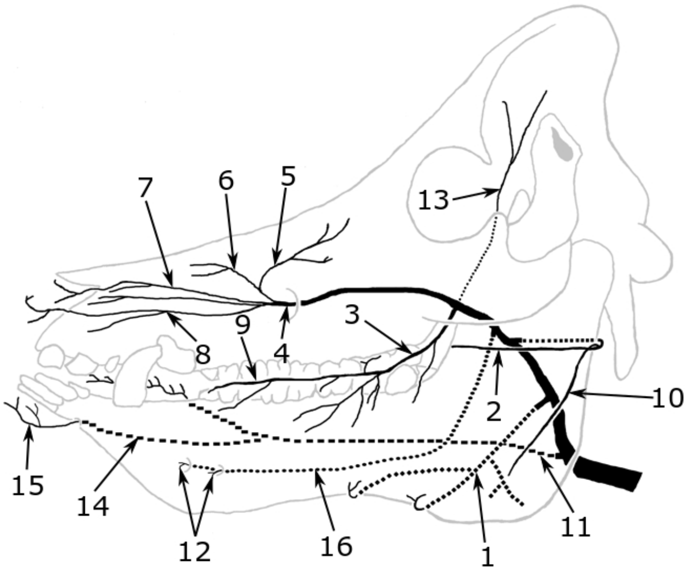

Fig. 1. Arterial blood supply of the face in Suiformes: 1. *A. facialis*, 2. *A. transversa faciei*, 3. *A. Buccalis*, 4. *A. Infraorbitalis*, 5. *A. angularis oculi*, 6. *A. dorsalis nasi*, 7. *A. lateralis nasi*, 8. *A. labialis superior*, 9. *A. angularis oris*, 10. *Ramus massetericus*, 11. *A. lingualis*, 12. *Rami mentales*, 13. *A. temporalis profunda*, 14. *A. sublingualis*, 15. *A. mentalis*, 16. *A. alveolaris inferior*

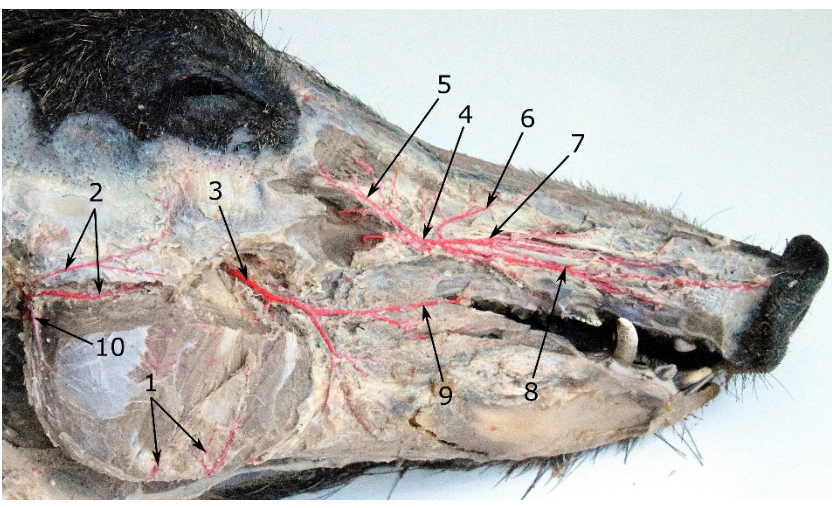

Fig. 2. Latex preparations of arteries of the head from Sus scrofa: 1. *A. facialis*, 2. *A. transversa faciei*, 3. *A buccalis*, 4. *A. infraorbitalis*, 5. *A. angularis oculi*, 6. *A. dorsalis nasi*, 7. *A. lateralis nasi*, 8. *A. labialis superior*, 9. *A. angularis oris*, 10. *Ramus massetericus*

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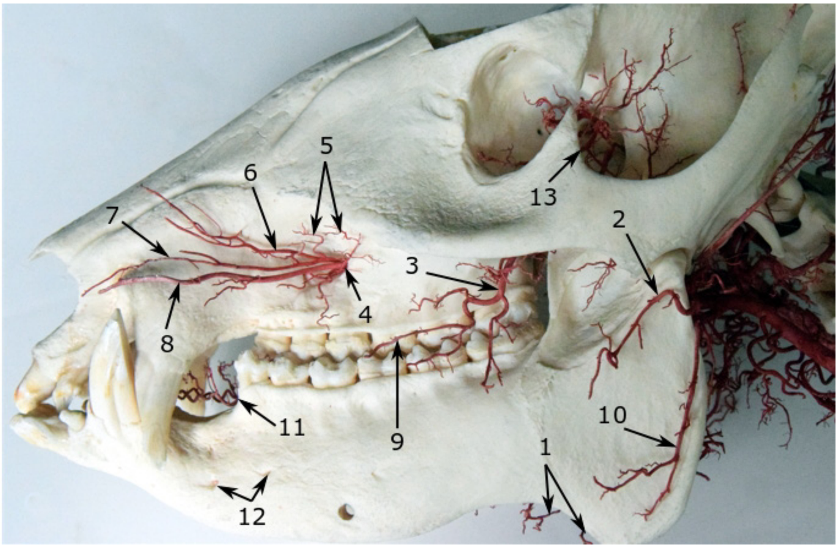

Fig. 3. Arterial blood supply of the face in Pecari tajacu – corrosion casts: 1. *A. facialis*, 2. *A. transversa faciei*, 3. *A. buccalis*, 4. *A. infraorbitalis*, 5. *A. angularis oculi*, 6. *A. dorsalis nasi*, 7. *A. lateralis nasi*, 8. *A. labialis superior*, 9. *A angularis oris*, 10. *Ramus massetericus*, 11. *A. lingualis*, 12. *Rami mentales*, 13. *A. temporalis profunda*

It had numerous branches and formed vessels in the medial region of the mandible up to half of the length of its body. Some branches of the facial artery bent at the angle of the mandible and passed to its lateral surface, reaching the masseteric muscle.

The sublingual artery (*a. sublingualis*) was an intra-abdominal branch of the lingual artery, which diverged directly from the external carotid artery. The sublingual artery diverged from the lingual artery at half of its length and ran parallel to the body of the mandible, forming vessels in the intermandibular region. Next, it passed through the medial mental foramen and appeared on the anterolateral surface of the mandible as the mental artery (*a. mentalis*). It supplied blood in this region and ran towards the lower lip.

The mental branches (*rami mentales*) separated from the inferior alveolar artery (*a. alveolaris inferior*), which diverged from the maxillary artery and ran through the mandibular canal (*canalis mandibulae*). The branches appeared in lateral mental foramina and supplied blood in the region of the body of the mandible.

The transverse facial artery (*a. transversa faciei*) diverged from the external carotid artery in the common trunk with a branch to the masseteric muscle (*ramus massetericus*). When it passed to the lateral surface of the mandible, it ran parallel to the zygomatic arch, supplying blood to the upper part of the masseteric muscle.

The buccal artery (*a. buccalis*) diverged directly from the maxillary artery and passed to the lateral surface of the mandible between the anterior ramus of the mandible and the maxillary tuber. The buccal artery was well developed. It branched in the buccal region into vessels of the body of the mandible. Next, it ran rostrally to the angular

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region of the mouth. The buccal artery in peccaries and hippopotamuses diverged from the maxillary artery together with the deep temporal artery (*a. temporalis profunda*).

The infraorbital artery (*a. infraorbitalis*) was an extension of the maxillary artery. At the infraorbital foramen it branched into the angular artery of the eye (*a. angularis oculi*) and the lateral and dorsal nasal arteries (*aa. nasale lateralis et dorsale*). Next, it ran rostrally to the supralabial region and the snout disc.

Discussion

The analysis of the pattern of selected facial arteries in representatives of the Suidae, Tayassuidae and Hippopotamidae families confirmed our research assumptions. The course and branches of the facial arteries in the Suiformes differed from the patterns of these arteries observed in the Camelidae (O'Brien, 2017; Jerbi, 2013) and Ruminantia (Zdun et al., 2014).

Our study showed that the facial artery in the Suiformes diverged independently from the external carotid artery and ran only along the medial side of the mandible, reaching half the length of its body. Only few branches of the facial artery curved on the angle of the mandible and passed to its lateral surface, reaching the masseteric muscle. Godynicki (1972), Frąckowiak (2003), and Nickel and Schwarz (1963) presented similar descriptions of the facial artery in representatives of this suborder. The facial artery in the Camelidae diverged with a common trunk from the auricular caudal artery (Godynicki, 1972; Frąckowiak, 2003; Kowalczyk et al., 2018), whereas the auricular caudal artery in the Suiformes diverges directly from the external carotid artery and it is its last branch (Frąckowiak, 2003). Most ruminants have the linguofacial trunk (*truncus linguofacialis*) (Nickel and Schwarz, 1963; Godynicki, 1972; Frąckowiak, 2003; Zdun et al., 2014), which was also found in species of the Equidae family, Perissodactyla order (Kowalczyk and Frąckowiak, 2017). The direct divergence of the facial artery from the external carotid artery was only described in two representatives of the Ruminantia suborder, i.e. the giraffe and reindeer (Frąckowiak, 2003; Zdun et al., 2014) and in the species of the Tapiridae and Rhinocerotidae families belonging to the Perissodactyla order (Kowalczyk and Frąckowiak, 2017). According to Godynicki (1972), Frąckowiak (2003) and our observations, the facial artery in the Suiformes was poorly developed and did not reach the labial region. Only the final branches of the mandible reached the facial surface of the mandible and penetrated the masseteric muscle. Both in the Camelidae (O'Brien, 2017; Kowalczyk et al., 2018) and most ruminants, the facial artery passes to the lateral surface of the mandible and participates in the vascular system of the labial region (Godynicki, 1972; Frąckowiak, 2003; Zdun et al., 2014). Likewise, the facial artery passed to the lateral surface of the mandible and formed the vascular system of the labial region in the Perissodactyla (Kowalczyk and Frąckowiak, 2017).

In our study the sublingual artery in the Suidae, Tayassuidae and Hippopotamidae diverged from the lingual artery at half of its length and it formed the vascular system in the intermandibular region. According to Godynicki (1972), the lingual artery in the wild boar and domestic pig runs orally, whereas the sublingual artery, which diverges from the lingual artery runs through the mental region of the mandible to its lateral surface as the mental branch. In our study the sublingual artery also ran from the rostral mental foramen. It formed the mental artery and reached the lower lip. Like in the Suiformes, the sublingual artery which diverged from the lingual artery supplied blood to the intermandibular region in the Camelidae (O'Brien, 2017). As far as the Ruminantia except the giraffe are concerned, it was the submental artery that supplied blood to the intermandibular region. It branched from the facial artery before it passed to the lateral surface of the mandible (Zdun et al., 2014). According to Godynicki (1972), the sublingual artery is well developed in the Artiodactyla. It transforms into the mental artery in species of the Strepsicerotini and Boselaphini tribes. The vascular system of the intermandibular region was diversified in the Perissodactyla. In the Equidae family it was the submental artery that supplied blood to this region. This artery branched from the sublingual artery, which branched from the facial artery. In the Tapiridae family the submental artery branched from the inferior alveolar artery, whereas in the Rhinocerotidae family it branched from the facial artery (Kowalczyk and Frąckowiak, 2017).

Apart from the sublingual artery, which passed through the mental foramen and formed the vascular system in the frontal part of the mandible in the Suiformes, mental branches also supplied blood to this region. As we observed, in the Suidae they diverged from the inferior alveolar artery, which branched directly from the maxillary artery and ran through the mandibular canal. Godynicki (1972) described a similar pattern of divergence and course of the mental artery in representatives of the Suidae family. He observed that the inferior alveolar artery, which diverged from the maxillary artery, ended in mental branches, which could be seen on the lateral surface of the body of the mandible. In the Ruminantia (Godynicki, 1972; Zdun et al., 2014), Camelidae (Godynicki, 1972; Jerbi et al., 2013, Kowalczyk et al., 2018) and all the Perissodactyla under study (Kowalczyk and Frąckowiak, 2017) the mental artery was an extension of the inferior alveolar artery and it appeared in the mental foramen.

As we observed, the transverse facial artery diverged from the external carotid artery with the common trunk with the branch to the masseteric muscle. Godynicki (1972) and Frąckowiak (2003) suggested that the transverse facial artery in the Suiformes was an extension of the superficial temporal artery, which diverged from the external carotid artery. The divergence of the superficial temporal artery marks the border where the external carotid artery transforms into the maxillary artery (Frąckowiak, 2003). The common divergence of the facial artery, inferior alveolar artery and superficial temporal artery is a distinguishing feature in llamas of the Camelidae family. Camels also have the deep temporal artery, which comes out of the common trunk (Kowalczyk et al., 2018). The transverse facial artery in the Ruminantia diverged from the superficial temporal artery (Nickel and Schwarz, 1963; Godynicki, 1972; Frąckowiak, 2003, Zdun et. al., 2014). The transverse facial artery in the Perissodactyla diverged from the external carotid artery together with the superficial temporal artery and the rostral auricular artery (*a. auricularis rostralis*). Tapirs and rhinoceroses also had the masseteric branch diverging from this trunk. Additionally, rhinoceroses had the occipital artery (*a. occipitalis*) (Kowalczyk and Frąckowiak, 2017). The transverse facial artery in the Suiformes ran along the zygomatic arch and supplied blood to the masseter muscle without reaching the labial region. The course of this artery was similar in the Camelidae (Godynicki, 1972; Jerbi et al., 2013, Kowalczyk et al., 2018), big ruminants (Zdun et al., 2014) and Perissodactyla (Kowalczyk and Frąckowiak, 2017). The transverse facial artery was well developed in some species of small ruminants. It supplied blood to the upper and lower lips. The artery reached the supralabial region in medium ruminants (Zdun et al., 2014).

The buccal artery was well developed in representatives of the Suidae, Tayasuidae and Hippopotamidae families. It diverged from the maxillary artery, branched in the buccal region and ran rostrally to the angular region of the mouth. According to Godynicki (1972), the buccal artery in wild boars and pigs diverged from the maxillary artery and when it passed to the facial surface, it branched into labial arteries. This artery was also a branch of the maxillary artery in the Camelidae (Jerbi et al., 2013; O'Brien, 2017; Kowalczyk et al., 2018), Ruminantia (Frąckowiak, 2003), Equidae and Rhinocerotidae (Kowalczyk and Frąckowiak, 2017). However, in contrast to the Suiformes, the buccal artery did not reach the labial region in these Artiodactyla (Frąckowiak, 2003; O'Brien, 2017; Kowalczyk et al., 2018) and Perissodactyla suborders (Kowalczyk and Frąckowiak, 2017).

The infraorbital artery in the Suiformes was an extension of the maxillary artery. It supplied blood to the angular region of the eye, the lateral and dorsal nasal region, the supralabial region and the snout disc region. Our observations were in agreement with other researchers' descriptions of this artery in the Suiformes (Godynicki, 1972; Frąckowiak, 2003). The infraorbital artery in the Ruminantia extended into the superior labial artery (*a. labialis superior*) in the giraffe, roe deer and reindeer. In the Camelidae (Godynicki, 1972; Frąckowiak, 2003; O'Brien, 2017; Kowalczyk et al., 2018), Tapiridae and Rhinocerotidae (Kowalczyk and Frąckowiak, 2017) the infraorbital artery was also well developed and it supplied blood to the nasal and supralabial regions.

Our analysis confirmed the fact that the Suiformes had the suborder-specific pattern of facial arteries, which was different from the patterns observed in other Artiodactyla animals. The description of the course and branches of facial arteries in the Suiformes may be useful for species classification and in veterinary practice.

Conclusions

1. The arteries supplying blood to the selected facial regions in the representatives of the Suidae, Tayassuidae and Hippopotamidae families had similar patterns of divergence from the arterial trunk in the head and they ran along similar courses.
2. The pattern of the facial arteries in the Suiformes distinguished this suborder from other Artiodactyla suborders.
3. Detailed knowledge of the course and branches of the facial arteries in the Suiformes may be useful in veterinary practice. It also provides information about the biodiversity of animals.

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SCHEMAT TĘTNIC TWARZY U SUIFORMES

Abstrakt

Wstęp. Informacje na temat przebiegu i odgałęzień tętnic twarzy u rodzin *Suidae*, *Tayassuidae* i *Hippopotamidae* mogą być przydatne zarówno w taksonomii gatunków, jak i praktyce weterynaryjnej. U gatunków reprezentujących podrząd Suiformes z rzędu Artiodactyla opisano unaczynienie tętnicze następujących okolic twarzy: międzyżuchwowej, bródkowej, żwaczowej, policzkowej, wargowej oraz nosowej.

Materiał i metody. Badania przeprowadzono łącznie na sześciu gatunkach należących do rodzin *Suidae*, *Tayassuidae* i *Hippopotamidae.* Obserwacje przeprowadzono ogółem na 30 preparatach tętnic głowy, które przygotowano, dokonując iniekcji tętnic barwionym acetonowym roztworem superchlorku winylu lub lateksem LBS3060.

Wyniki. Analizowane okolice twarzy u przedstawicieli podrzędu Suiformes zaopatrywane były przez tętnice: twarzową, podjęzykową, bródkową, poprzeczną twarzy, policzkową i podoczodołową. Potwierdzono, że tętnica twarzowa u przedstawicieli Suiformes przebiegała tylko przyśrodkowo i nie przechodziła na boczną stronę żuchwy. Tętnica poprzeczna twarzy odchodziła wspólnym pniem z gałęzią żwaczową. Tętnica policzkowa była bardzo dobrze rozwinięta i docierała do okolic wargi dolnej, a w unaczynieniu okolic wargi górnej brała udział tętnica podoczodołowa.

Wnioski. Wykazano, że wzór tętnic twarzy u Suiformes jest charakterystyczny dla tego podrzędu i różni się od schematów tętnic opisywanych u pozostałych Artiodactyla.

Słowa kluczowe: Suiformes, tętnicze zaopatrzenie twarzy, wzór tętnic twarzy

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