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MORPHOLOGICAL PARTICULARITIES OF THE SNOW LEOPARD SKULL - IRBIS (*Panthera uncia* - Schreber, 1775) - CASE STUDY

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Abstract

The study describes the morphological characteristics of the panther leopard skull (Panthera uncia - Schreber, 1775). The skull particularities are valuable elements necessary for species identification. Following the analysis, the following conclusions emerged: the existence of an interfrontal fossa, elongated in an oro-aboral direction, located at the level of the interfrontal sagittal suture; the nasal extremity of the frontal ends with a sharp process; between the two processes of the rostral extremity of the nasals, lateral and medial, there is a wide and shallow incision; the naso-incisive incision is reduced; the mastoid process is reduced; a reduced accessory lacrimal foramen is present; between the maxillary and sphenopalatine foramen, an obvious vascular foramen can be observed; medio-aboral, on the edge of the jugular foramen is the hypoglossal canal; the pharyngeal tubercle is reduced and limited on the sides by two reduced fossae; the external occipital crest is well highlighted; above the ventral condyloid fossae are the deep and elongated dorsal condyloid fossae; the mental foramen is accompanied by an accessory mental foramen.

Ker words: *irbis, skull morphology, snow leopard.*

INTRODUCTION

The irbis or snow leopard (*Panthera uncia*) has its habitat in Afghanistan, the Lake Baikal region, eastern Tibet Plateau. It adapted over generations to live in the harsh, mountainous environment at altitudes of up to 5500 m. The snow leopard was included in the genus *Uncia* at the time of discovery. However, after numerous studies in which similarities with the genus *Panthera* were found, especially at the level of the hyoid bone, and after genetic research that highlighted its closeness to the tiger, it was included in the genus *Panthera* (Jackson, 2016; Johnson et al., 2006).

The IUCN in the *Red List* includes the species as vulnerable, with an estimated population of over 2,500 individuals and an estimated decline in the next three generations of at least 10%. In some areas where the species is protected, and its range remains intact, a stable or slightly increasing number of individuals is expected. Poaching is one of the major problems leading to species' decline.

According to research conducted in areas where poaching is very intense, it has been estimated that 221-450 snow leopards have been poached annually since 2008. If these estimates are relatively accurate, they suggest that approximately 2-10% of the snow leopard population may be poached annually (Nowell et al., 2016; Chundawat & Rawat, 1994; Alexander et al., 2015; McCarthy et al., 2017).

With all the data obtained from experts, it is complicated to estimate the size of the snow leopard population, as the lack of concrete data on general population trends prevents estimating the extent of any decline based on partial evidence, being largely speculative. However, the evidence does not show that the situation has deteriorated much since 2008, so this species has not been included in the *Red List* as an endangered species but only as a vulnerable species. Recent survey information indicates that snow leopard densities in several areas are higher than previously thought, implying that the total population size is also likely larger than minimum estimates (Jackson et al., 2010; Mallon et al., 2016; Berger et al., 2013).

Several conservation measures are being taken to reduce threats or mitigate their effects, including establishing new protected areas in the snow leopard range, more effective anti-poaching measures, training the conservation

professionals in Asian states with snow leopard populations; several independent initiatives to reduce conflicts with pastoralists; community engagement programs and educational programs to raise awareness of the snow leopard and its habitat.

Although the snow leopard is undoubtedly still threatened, the above measures have improved the overall conservation situation of snow leopards since 2008.

Studies have been carried out on the functional adaptability of the forelimbs for moving on rocky terrain in alpine areas, concluding that *Panthera uncia* is intermediate between *Acinonyx jubatus* (cheetah) and *Panthera onca* (jaguar). A scapular and pectoral musculature development provides stability to the shoulder girdle when the animal brings down large prey and supports it during jumping and climbing. At the *biceps brachii* muscle level, a unique bifurcation is observed in its tendon, which may provide increased functional stability at the level of the humeroradial joint (Smith et al., 2021). There are also differences at the level of brachial plexus between domestic cats and snow leopards, which may reflect different prey capture strategies between the subfamilies (Hall et al., 2023).

Numerous studies have been conducted on the conservation of the species in different habitats (Schaller et al., 1988), including the ovarian activity of female snow leopards throughout the estrous cycle and gestation through an enzyme immunoassay that measures fecal concentrations of estrogen and progesterone metabolites (Reichert-Stewart et al., 2014).

In 2022, Dinesh Kumar Jha et al. conducted a study to develop a species identification technique based on the cranial morphometry of Asian big cats. This technique could be used in forensic analysis of poaching cases (Jha et al., 2022).

Usually, the skull is the forensic sample through which the species can be identified; for this reason, the study aims to describe the morphological particularities of the *Panthera uncia* skull.

MATERIALS AND METHODS

A skull from an adult snow leopard (neutered male) (*Panthera uncia*), which died of natural causes, was used for morphology description.

The skull from the Anatomy discipline of the Faculty of Veterinary Medicine Bucharest collection was obtained after removing the soft tissues and then subjected to controlled maceration, washing, and degreasing.

The most interesting aspects were described and photographed. The description and identification are by Nomina Anatomica Veterinaria (N.A.V.) 2017.

RESULTS AND DISCUSSIONS

The skull of the snow leopard is characterized by a viscerocranium smaller than the neurocranium. The dorsal face of the skull is elongated, presenting a maximum height before the detachment of the zygomatic processes of the frontals.

The maximum width of the dorsal face is at the level of the zygomatic processes of the frontals. In the central portion, at the level of the interfrontal suture, an interfrontal depression (fossa) can be observed, elongated oro-aborally (Figure 1).

Figure 1. Dorsal side of the snow leopard (*Panthera uncia*) skull (original)
1. Nuchal crest; 2. Parietal; 3. External sagittal crest; 4. External occipital protuberance; 5. Zygomatic process of the frontal; 6. Interfrontal fossa; 7. Zygomatic; 8. Nasal; 9. Incisive; 10. Lateral process of the nasal; 11. Nasal notch

The zygomatic processes of the frontal are short, triangular in appearance and latero-ventrally directed. Rostral to the zygomatic process of the frontal, a small supraorbital notch is observed. At the rostral extremity, the frontal ends in a pointed nasal process.
The exocranial face of the parietals is convex oro-aborally and medio-laterally, being separated at the level of the median suture by a high and sharp external sagittal crest.
The external occipital protuberance is reduced in height, slightly thickened, and drawn aborally. The external sagittal crest departs from it in a rostral direction and divides at the suture site between the frontal and parietal in two weakly highlighted temporal lines. The temporal lines end at the level of the free extremity of the zygomatic process of the frontal (Figure 2).

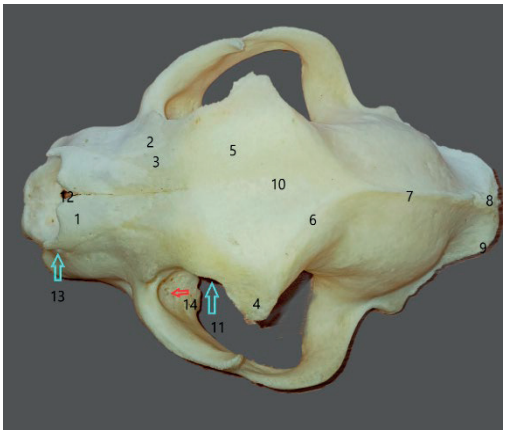

Figure 2. Dorsal side of the snow leopard (*Panthera uncia*) skull (original)
1. Nasal; 2. Frontal process of the maxilla; 3. Nasal process of the frontal; 4. Zygomatic process of the frontal; 5. Frontal; 6. Temporal line; 7. External sagittal crest; 8. External occipital protuberance; 9. Nuchal crest; 10. Interfrontal fossa; 11. Supraorbital notch; 12. Internasal notch; 13. Naso-incisive notch; 14. Maxillary foramen

The nasals are slightly concave in the aboral extremity and convex in the rostral one. Their rostral extremity is divided into two processes, one lateral elongated and pointed and a medial one short and rounded. A wide but reduced in-depth internasal notch is between the two nasal processes. The maximum width of the nasals is at their rostral extremity (Figure 3).
Between the nasal bone and the nasal process of the incisive is a reduced naso-incisive notch. The incisive body is evident, with a right angle shape; the upper part is horizontal, and the lower is vertical. The central (I1) and middle (I2) incisors are much smaller than the lateral incisors (I3). The entrance in the nasal cavity is wide, and the rostral portion of the vomer, which presents a deep septal sulcus, is easy to see (Figure 3).
The maxilla extends dorso-aborally through an obvious frontal process and shows a prominent canine alveolar relief on the lateral side.

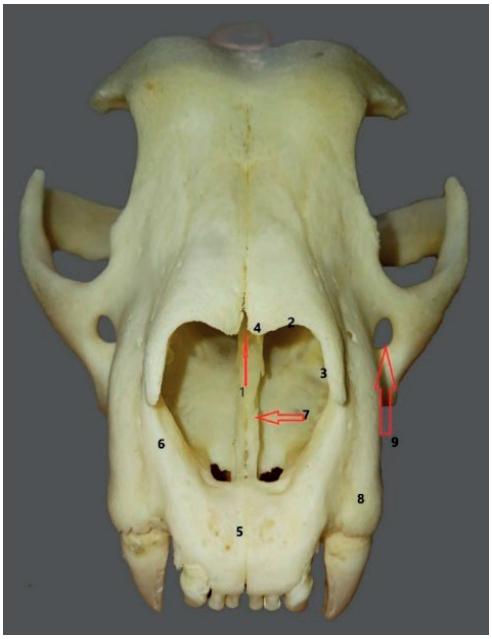

Figure 3. The rostral extremity of the snow leopard (*Panthera uncia*) skull (original)
1. Internasal notch; 2. Nasal; 3. Lateral nasal process; 4. Medial nasal process; 5. Incisive; 6. Nasal process of the incisive; 7. Vomer; 8. Canine alveolar relief; 9. Infraorbital foramen

The zygomatic process of the temporal is later-dorso-rostrally oriented and joins the zygomatic bone, forming the zygomatic arch (Figure. 4). The zygomatic arch is well-highlighted and has a lateral convexity.
The orbit is relatively circular, wide, and incomplete. The orbit communicates broadly with the pterygopalatine fossa.
The orbital hiatus is deep and presents the following openings: the ethmoidal foramen, the optic canal, the orbital fissure and the round foramen, missing the alar foramen and the alar

canal. The oval foramen can be observed ventro-aboral of the *foramen rotundum* (Figure 4 - 5).

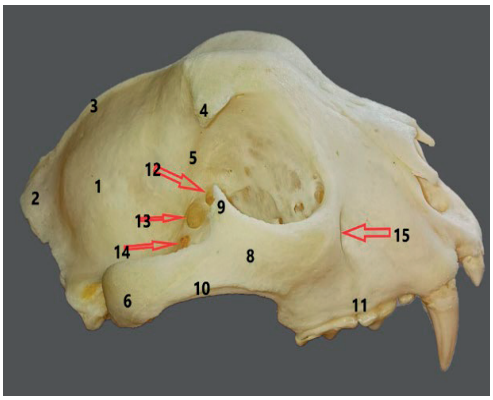

Figure 4. Lateral side of the snow leopard (*Panthera uncia*) skull – (original)
1. Parietal; 2. The external occipital protuberance; 3. External sagittal crest; 4. Zygomatic process of the frontal; 5. Orbito-temporal crest; 6. The zygomatic process of the temporal; 8. Zygomatic; 9. The temporal process of the zygomatic – the medial portion; 10. The temporal process of the zygomatic–lateral portion; 11. Alveolar process of the maxilla; 12. Optical canal; 13. Orbital fissure; 14. *Foramen rutundum*; 15. Infraorbital foramen.

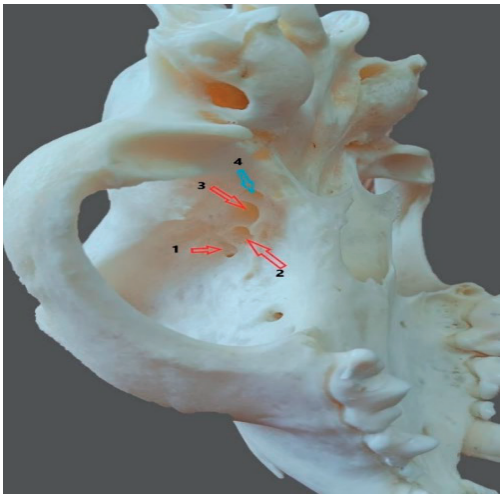

Figure 5. Lateral face of the snow leopard (*Panthera uncia*) skull – (original)
1. Ethmoidal foramen; 2. Optical canal; 3. Orbital fissure; 4. *Foramen rotundum*

A wide and shallow tympanic notch can be observed in the auricular region, and ventral to it is a wide and oval external acoustic meatus arranged slightly oblique caudo-rostral (Figure 6). The tympanic bulla is evident and oval, with convex surfaces arranged slightly oblique latero-medially.
Latero-aboral to the tympanic bulla is a reduced mastoid process, and at its base is a small stylomastoid foramen. Attached to the aboral extremity of the tympanic bulla is a short paracondylar process that is separated from the mastoid process by a small incision.

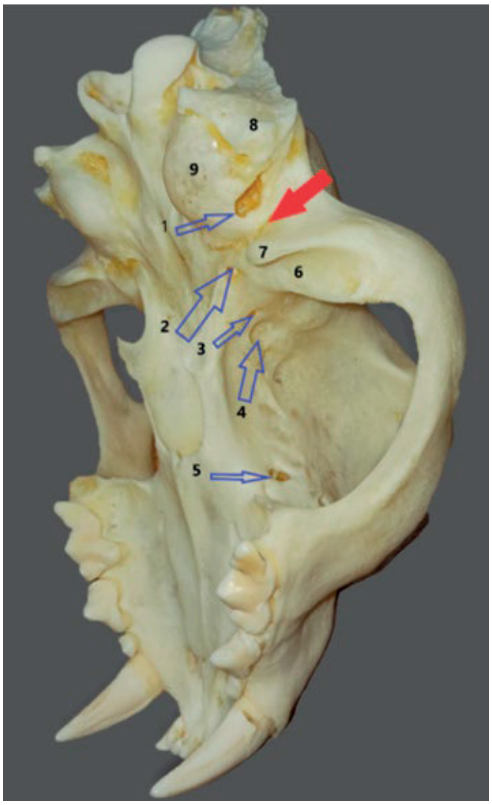

Figure 6. Lateral face of the snow leopard (*Panthera uncia*) skull (original)
1. External acoustic meatus; 2. Oval foramen 3. *Foramen rotundum*; 4. Orbital fissure; 5. Caudal palatine foramen; 6. Articular surface; 7. Retroarticular process-Retroarticular foramen (red); 8. Mastoid process; 9. Tympanic bulla

The maxillary hiatus has the following openings: the maxillary foramen, the sphenopalatine foramen, and the caudal palatine foramen (Figure 7). Between the maxillary and sphenopalatine foramina, there is an apparent vascular foramen.
The lacrimal fossa is reduced; there is an obvious lacrimal foramen at its level, and

dorsally, it is a very small accessory lacrimal foramen.

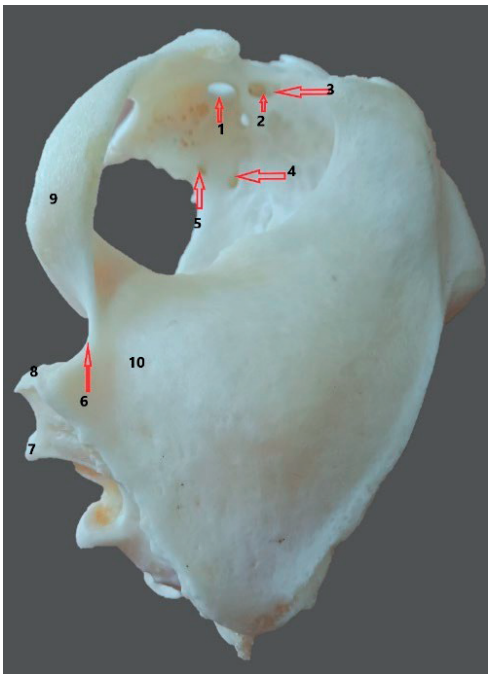

Figure 7. The laterodorsal face of the snow leopard (*Panthera uncia*) skull (original)
1. Maxillary foramen; 2. Lacrimal foramen; 3. Accessory lacrimal foramen; 4. Sphenopalatine foramen; 5. Caudal palatine foramen; 6. Tympanic notch; 7. Jugular process; 8. Mastoid process; 9. The zygomatic process of the temporal; 10. Temporal - squamos part

On the ventral face of the temporals' zygomatic process, the mandibular fossa is oro-aborally convex and elongated, and caudal to it is an obvious retroarticular process. A small retroarticular foramen is at the base of this process (Figure 6).
A defined jugular foramen can be observed laterally to the aboral extremity of the tympanic bulla, and the hypoglossal canal can be found medio-aborally on its edge (Figure 8).
On the exocranial face of the basioccipital is a reduced pharyngeal tubercle, bounded on each side by two reduced fossae (Figure 10).
An elongated and reduced fossa is in the central portion of the basisphenoid.
The pterygoid has a long, sharp, aborally oriented hamulus at the aboral extremity.
The spinous foramen can be observed on the rostral edge of the tympanic bulla and in the rostral direction, at a distance of less than 1 cm, the oval foramen. Lateral to the spinous foramen is the carotid canal (Figure 9).
The palatine processes of the maxilla are crossed at the base by the greater palatine foramina, which is continued orally with the well-marked palatine grooves up to their middle third.

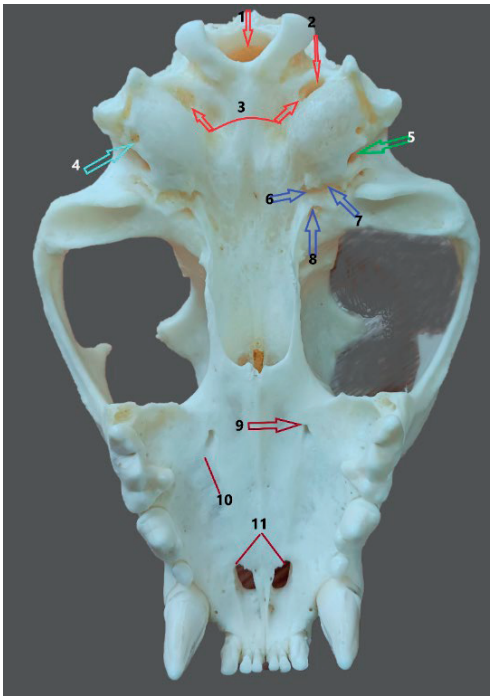

Figure 8. The ventral side of the snow leopard (*Panthera uncia*) skull (original)
1. Foramen magnum; 2. Jugular foramen; 3. Hypoglossal canal; 4. Stylomastoid foramen; 5. External acoustic meatus; 6. Spinous foramen; 7. Carotid foramen; 8. Oval foramen; 9. The greater palatine foramen; 10. Palatine groove; 11. Palatine fissures.

In the rostral extremity of the hard palate, there are two oval palatine fissures, which continue rostrally on the palatine surface of the incisive with two grooves that narrow in the rostral extremity of the incisive bone (Figure 8).
On each side of the foramen magnum is a slightly oblique dorsoventral condyle with the articular surface convex in the same direction. The spheno-basioccipital tubercles are inconspicuous. The jugular processes (paracondylar) are reduced and attached at the aboral extremity of the tympanic bulla (Figure 10).

Figure 9. The ventral side of the snow leopard (*Panthera uncia*) skull– (original)
1. Carotid foramen; 2. External acoustic meatus; 3. Stylomastoid foramen; 4. Hypoglossal canal; 5. Jugular foramen.

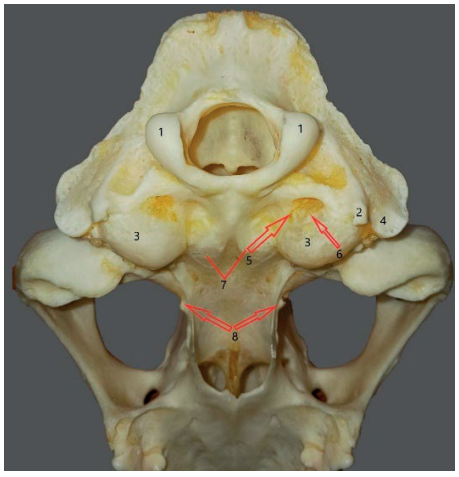

Figure 10. The nuchal face of the snow leopard (*Panthera uncia*) skull – (original)
1. Occipital condyles; 2. Jugular process; 3. Tympanic bulla; 4. Mastoid process; 5. Hypoglossal canal; 6. Jugular foramen; 7. Spheno-basioccipital tubercles; 8. Pterygoid processes

The nuchal ridges are well highlighted on the nuchal face, and the external occipital protuberance is reduced in height, slightly thickened, and drawn in the aboral direction.
From the external occipital protuberance descends a prominent external occipital crest. Rough lines of muscle insertions are present on either side of it (Figure 11).
The jugular processes are reduced and oriented ventro-aborally. The ventral condylar fossae are shallow, and the foramen magnum is wide and relatively rectangular.
Above the ventral condylar fossae are the deep and elongated dorsal condylar fossae. The two fossae, dorsal and ventral, are separated by a slightly oblique ridge.

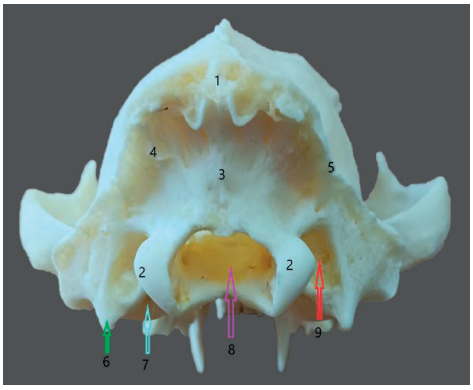

Figure 11. The nuchal face of the snow leopard (*Panthera uncia*) skull – (original)
1. External occipital protuberance; 2. Occipital condyles; 3. External occipital crest; 4. Lines of muscle insertion; 5. Nuchal crest; 6. Jugular process; 7. Ventral condylar fossa; 8. Foramen magnum; 9. Dorsal condylar fossa.

The mandible is an unpaired bone. The ventral margin of the horizontal portion is straight. The angular process is developed and slightly aboro-ventrally directed.

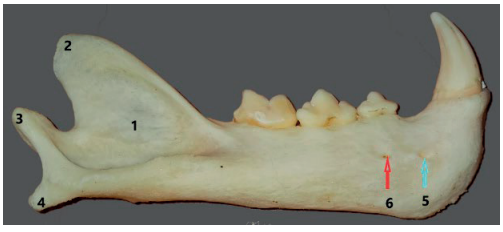

Figure 12. Snow leopard mandible (*Panthera uncia*) – lateral view (original)
1. Masseteric fossa; 2. Coronoid process; 3. Condylar process; 4. Angular process;
5. Mental foramen; 6. Accessory mental foramen

The masseteric fossa is deep and wide, exceeding half the height of the coronoid process. An accessory mental foramen accompanies the mental foramen (Figure 12).

The condylar process has a relatively cylindroid appearance with a convex articular surface. The coronoid process is curved aborally, and the free margin is relatively rounded.

Figure 13. Snow leopard mandible (*Panthera uncia*) – medial surface (original)
1. Coronoid process; 2. Condylian process; 3. Pterygoid fossa; 4. Angular process; 5. Mandibular notch; 6. Mandibular foramen; 7. Notch between the condylar and angular processes

On the mandibular medial surface is an obliterated pterygoid fossa, and dorsal to the angle is the mandibular foramen. Between the condylar and angular processes, a wide and shallow notch is observed (Figure 13).

CONCLUSIONS

At the level of the interfrontal suture, there is an interfrontal depression (fossa), elongated oro-aborally and rostral; the frontal ends with a sharp nasal process.

In the rostral extremity, the nasal bone is divided into two processes (one lateral and the other medial); between the processes, there is a wide internasal notch, reduced in depth, and between the lateral process of the nasal and the nasal process of the incisive there is a reduced naso-incisive notch.

The mastoid process, located latero-aboral to the tympanic bulla, is reduced, and at its base is a reduced stylomastoid foramen.

In the reduced lacrimal sac fossa, there is an obvious lacrimal foramen and, dorsally, a very small accessory lacrimal foramen.

In the maxillary hiatus open: the maxillary foramen, the sphenopalatine foramen, and the caudal palatine foramen; between the maxillary and sphenopalatine foramen, an obvious vascular foramen is present.

Lateral to the aboral extremity of the tympanic bulla, there is an apparent jugular foramen and medio-aboral, on its edge, the hypoglossal canal.

A reduced pharyngeal tubercle is present on the basioccipital's exocranial face, with two reduced fossae on either side.

On the nuchal face, from the level of the external occipital protuberance descends the external occipital crest, well highlighted and lateral to it are rough lines for muscle insertion.

The ventral condylar fossae are shallow, and above them are the deep and elongated dorsal condylar fossae, the ventral fossae being separated from the dorsal ones by a slightly oblique crest.

The angular process of the mandible is developed and slightly directed antero-ventrally. An accessory mental foramen accompanies the mental foramen. A wide and shallow notch is observed between the condylar and angular processes.

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