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THE CHIMPANZEE SKULL (*PAN TROGLODYTES*, BLUMENBACH, 1775): CASE STUDY

CRANIUL DE CIMPANZEU (*PAN TROGLODYTES*, BLUMENBACH, 1775): STUDIU DE CAZ

B. GEORGESCU[1],
Petronela Mihaela ROȘU[1)*)], C.R. BELU[1],
C. VISOIU[2], Adela Ioana MUSTĂȚEA[1]

ABSTRACT | REZUMAT

The study aims to describe the morphological characteristics of the chimpanzee skull (*Pan troglodytes*, Blumenbach, 1775). The genus *Pan*, like the genus *Homo*, is part of the order *Primates* (Linnaeus, 1758) and presents similar characteristics. The particularities of the skull are valuable elements necessary for species identification. Data in the specialized literature on chimpanzee cranial morphology are sparse and lacking in detail. For the study, a skull from an adult male chimpanzee, deceased of natural causes, a specimen found in the collection of the Anatomy discipline, was used. The following conclusions were drawn: the foramen magnum and the occipital condyles moved slightly ventro-rostral due to the tendency of bipedal movement; the external sagittal crest is absent; the two orbits are complete and arranged in the frontal plane; the presence of two ethmoidal holes (anterior and posterior); the mastoid and styloid processes, are reduced; an anterior and an accessory palatine foramen are present, both located in the aboral extremity of the palatine process.

Keywords: chimpanzee, skull, ethmoidal foramen, anterior palatine foramen

Studiul își propune să descrie caracteristicile morfologice ale craniului de cimpanzeu (*Pan troglodytes,* Blumenbach, 1775). Genul *Pan*, ca și genul *Homo*, fac parte din ordinul *Primates* (Linnaeus, 1758) și prezintă caracteristici asemănătoare. Particularitățile craniului sunt elemente valoroase necesare pentru stabilirea speciei. Datele din literatura de specialitate cu privire la morfologia craniului la cimpanzeu sunt puține și fără aspecte detaliate. Pentru studiu s-a utilizat un craniu de la un cimpanzeu adult, decedat din cauze naturale, exemplar aflat în colecția disciplinei de Anatomie. In urma studierii acestui craniu s-au putut desprinde următoarele concluzii: gaura occipitală și condilii occipitalului s-au deplasat foarte puțin în jos și spre înainte, datorită unei ușoare verticalizări a corpului animal,creasta sagitală externă absentă, cele doua orbite, complete, sunt dispuse in plan frontal, prezența a două găuri etmoidale (anterioară și posterioară), procesele mastoidian și stiloid ale stâncii temporalului sunt foarte reduse, sunt prezente o gaura palatină anterioară si una accesorie, ambele situate în extremitatea aborală a procesului palatin.

Cuvinte cheie: cimpanzeu, craniu, gaura etmoidală, gaură palatină anterioară

The name *Primate* was given by Carl Linnaeus in 1758 in the 10th edition of *Systema Naturae.* Old World monkeys and New World monkeys descend from the old Omomyids' group. The chimpanzees, the gorillas, and the orangutans belong to the African great apes. Together with the humans belonging to the family *Hominidae*, which is classified as the Old-World monkeys.

At the time of their appearance, the primates were very different in aspect, being generally small and often nocturnal animals. Some primates have survived today, such as lorises in Africa and Asia, but many aspects of their anatomy differ from those of ancient primates. They cannot be considered representative, although general characteristics are preserved (7).

In the Eocene, between 55 and 35 million years ago, primates appeared in a form similar to the present ones. It was a period of global warming, with tropical conditions extending to northern Europe and southern England (2, 7).

Due to taxonomic links, all primates are generally studied by a part of physical anthropology called primatology.

The genus *Pan*, like the genus *Homo*, is part of the order of *Primates* and shares similar characteristics.

All primates have a significant tendency to bipedalism. Regardless of the degree of evolution, from *Lemurians* to chimpanzees, they rise on the hind limbs at least for a short period (3, 4, 5, 7).

Initially, primates had a plant-based diet, but with the advent of the first *Hominins*, they began to adopt an omnivorous diet, especially meat-eating, which led

1) University of Agronomic Sciences and Veterinary Medicine, Faculty of Veterinary Medicine, Bucharest, Romania
2) Zoological Garden, Bucharest, Romania
*) *Corresponding author: rosupetronelamihaela@yahoo.com*

to success in the evolution of this species. *Hominins* began to make and use tools, mainly to procure food.

A special feature of *Primates* is their sociability. All primates, including the genus *Pan*, are characterized by sociability, use of body language, and vocalizations. *Primates*, except for humans, have their bodies entirely covered with hair.

The progressive evolution of mammals and then primates, from the *Lemurians* to the *Hominids*, shows how interesting nature can be and how effective adaptations change the world. One effective adaptation happens when cognitive abilities and decision-making efficiency evolve instead of physical means of locomotion, attack, and defence (7, 9).

The primates' general characteristics are represented by: opposable thumbs, nails presence, heel elongation, accentuated use of the pelvic limbs during locomotion, front eyes for stereoscopic vision, enlarged brain size, slow development of the foetus during the gestation period, and a longer lifespan (5, 9, 11).

In the specialized literature, there is a small amount of data about the anatomy of the species *Pan troglodytes*, especially the study of bones. It does not include detailed aspects of the skull bones, which can provide clues for species recognition. Numerous data are present in the literature on the dynamics of facial bone growth, limb development, growth, tooth morphology, as well as skeletal bone comparisons between species of the genus *Pan* and *Gorilla*(1,5,6, 8, 10). No data regarding the morphological features of the skull in the genus *Pan* was published in Romania. The morphological study of the skull bones provides valuable data to determine primate origins, making the identification of the species much more accessible.

MATERIAL AND METHOD

For the morphology description of the skull bones, one cranium of an adult male chimpanzee (*Pan troglodytes*, Blumenbach, 1775) belonging to the Anatomy discipline collection was used. The skull bones' morphological characteristics were described and photographed. Description and identification have been made according to Nomina Anatomica Veterinaria (NA V) 2017 and Anatomical Terminology 2019 (12, 13).

RESULTS AND DISCUSSIONS

The neurocranium consists of two regions: the skull's base and the cranial vault. These two parts are delimited by a plane that passes through the glabella and the external occipital protuberance of the occipital bone. Everything above this plane forms the skull's vault, and all below it is called the base of the skull.

The cranial vault includes the squamous part of the frontal bone, two parietal bones, the squamous part of the occipital bone, the wings of the sphenoid bone, and the squamous part of the temporal bone. On the dorsal face of the neurocranium, the sagittal suture and the external occipital protuberance are observed.

The exocranial face of the parietal bones is slightly convex, the superior temporal lines are very prominent, located in the dorsal plane, and the inferior ones are poorly outlined and arranged in a ventral position (Fig. 1).

Fig. 1. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) neurocranium: dorsal face. 1. Parietal bone; 2. External occipital protuberance; 3. The upper timeline; 4. Sagittal suture; 5. Temporal bone; 6. The zygomatic process of the temporal bone; 7. Frontal bone 8. Lower temporal line; 9. Supraorbital crest; 10. Supraorbital fossa

Fig. 2. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) frontal bone: exocranial face. 1. Supraciliary or supraorbital arch; 2. Frontozygomatic arcade; 3. Supraorbital fossa; 4. Supraorbital crest; 5. The nasal portion of the frontal

Below the lower temporal line is a temporal fossa delimited by the zygomatic bone and the zygomatic process of the temporal bone.

In the rostral extremity, towards the median plane, two protrusions, called frontal tubercles or frontal eminences, are observed in the anterior part. Below the frontal tubercles, above the orbits, are two arched formations called supraciliary or supraorbital arches. The glabella is arranged between the two supraorbital arches in the middle plane. There is a supraorbital foramen in the latero-aboral plane of the supraorbital arches. Unlike humans, where the exocranial face of the frontal is convex and wide, in a chimpanzee, it is taller, slightly convex, elongated, and narrower.

Behind the supraorbital arches, a deep and narrow supraorbital fossa is present on the lateral side, delimited on the lateral side by a very high supraorbital crest (Fig. 2). There are two depressions on the orbital face of the frontal bone, lateral, the lacrimal fossa, and anteromedial, the trochlear fossa.

On the ventral face of the neurocranium, the wings of the sphenoid bone appear divided into two parts: the greater wings located aborally and the lesser wings anteriorly. The wings of the sphenoid bone participate in the rostral part in structuring the dorsal wall of the orbit. In the middle plane, at the level of the body of the sphenoid, is a reduced depression.

The base of the wings is crossed by three foramina: foramen rotundum, which allows the communication of the cranial cavity with the pterygopalatine fossa, foramen ovale, and foramen spinosum. The foramen lacerum is reduced in size (Fig. 3 and 4).

Fig. 3. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) neurocranium: ventral face. 1. Foramen magnum; 2. Occipital condyles; 3. Condylar fossa; 4. Hypoglossal foramen; 5. Jugular foramen; 6. Stylomastoid foramen; 7. External auditory canal; 8. Foramen ovale; 9. Foramen spinosum; 10. Styloid process; 11. Mastoid process; 12. Pharyngeal tubercle; 13. Body of the sphenoid bone; 14. Mandibular fossa; 15. Articular tubercle; 16. The lesser wings of the sphenoid bone; 17. The greater wings of the sphenoid bone

The pterygoid processes detached from the ventral part of the body, and the rostral portion of the wings of the sphenoid delimit the pterygoid fossa. The pterygoid canal crosses the base of these processes. At the level of the basioccipital is a prominent pharyngeal tubercle, and at the suture site with the sphenoid body are two evident muscular tubercles. In the condylar fossa are two openings: the foramen of the hypoglossal nerve, located in the medial plane, and laterally from it, there is the jugular foramen.

On the lateral face of the ethmoid labyrinth, inside the orbit, there are two ethmoidal foramina, anterior and posterior ethmoidal foramina.

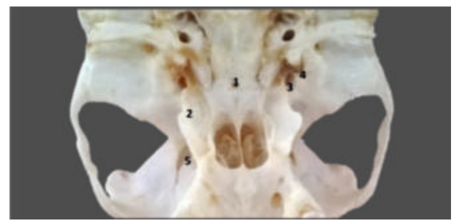

Fig. 4. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) sphenoid: exocranial face. 1. The body of the sphenoid; 2. Wings of the sphenoid; 3. Foramen ovale; 4. Foramen spinosum; 5. Orbital fissure

The lateral face of the neurocranium presents the zygomatic process of the temporal, flattened lateromedial and articulated with the rostral extremity to the zygomatic bone, where it contributes to the formation of the zygomatic arch (Fig. 5).

Fig. 5. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) neurocranium: lateral face. 1. Parietal bone; 2. Frontal bone; 3. Zygomatic process of the frontal; 4. Supraciliary or supraorbital arch; 5. Temporal; 6. Zygomatic process of the temporal; 7. External auditory canal; 8. Sphenopalatine foramen

The zygomatic process of the frontal descends from the supraciliary arches on the lateral side and articulates with the zygomatic bone.

An evident orbital fissure is observed inside the orbit on its ventral side. Above it is the optic canal, through which the optic nerve and the ophthalmic artery pass. The articular surface of the temporal for the mandible is elongated, having the appearance of a fossa laterally delimited by an evident articular tubercle. An evident stylomastoid foramen is at the base of the external auditory canal. The external auditory canal is reduced. The mastoid and styloid processes of the temporal bone have reduced dimensions. Behind the stylomastoid foramen, the groove of the occipital artery is observed.

The occipital bone forms the nuchal face of the neurocranium. On the dorsal plane presents an occipital protuberance, from which the external occipital crest descends in a dorsoventral direction. The crest is prominent in the dorsal extremity and the middle third and less visible in the ventral part.

On each side of the external occipital protuberance, two lines detach laterally: dorsally – the superior nuchal line, and ventrally, the inferior nuchal line (Fig. 6).

The occipital condyles are elongated with a convex surface, delimiting the foramen magnum, which is directed slightly oro-aboral and oval-shaped. These structures are placed slightly ventro-rostral due to the bipedal movement tendency of the animal.

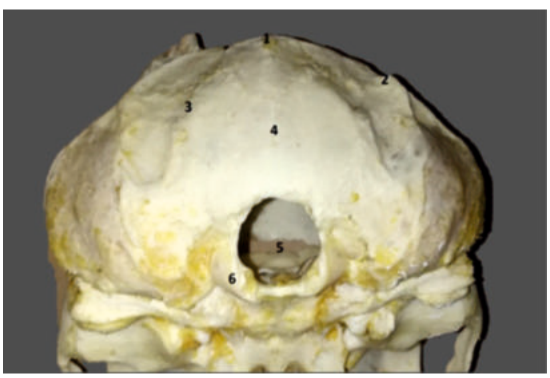

Fig. 6. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) neurocranium: nuchal face. 1. External occipital protuberance; 2. The superior nuchal line; 3. The inferior nuchal line; 4. External occipital crest; 5. Foramen magnum; 6. Occipital condyles

The viscerocranium in the chimpanzee is more massive compared to that of humans. Compared to other mammal species, the splanchnocranium is in a ventrorostral position and slightly below the neurocranium in primates. The bones that construct the dorsal face of the viscerocranium are represented by the maxilla, lacrimal, nasal,and zygomatic bones.On the dorsal face, the maximum width of the viscerocranium is the level of the canines' alveoli.

The maxilla has an infraorbital foramen and an evident canine fossa. The frontal process of the maxilla has an anterior lacrimal crest, laterally bounded by an evident lacrimal notch, which is flanked by a reduced lacrimal spine. A lacrimal foramen is at the lacrimal fossa level, which continues in a rostral direction with the nasolacrimal canal. The alveolar process of the maxilla presents on its surface, in the ventral plane, the alveolar arch, where the alveoli for canines, premolars, and molars are arranged.

The most developed teeth on the superior arch are the canines. The dental arch, as a whole, has a rectangular appearance.

At the level of the zygomatic bone, the zygomaticofacial foramen is located on the dorsolateral side. The zygomatic's upper edge participates in the orbit's delimitation, and there is a small spine in its medial part. The nasal bone is reduced and flattened (Fig.7).

Fig. 7. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) viscerocranium: dorsal face. 1. Anterior lacrimal crest; 2. Lacrimal spine; 3. Lacrimal notch 4. Zygomaticofacial foramen;5.Infraorbital foramen; 6. Canine fossa; 7. Maxillary spine (anterior nasal spine of maxilla)

The lateral face of the viscerocranium is formed by the zygomatic and maxilla bones. Dorsally, the frontal process of the zygomatic articulates the zygomatic process of the frontal, creating the frontozygomatic arch. The temporal process of the zygomatic bone is directed aboral. The zygomatic arch is formed with the participation of the zygomatic bone, the zygomatic process of the frontal, and the zygomatic process of the temporal. From the infraorbital foramen, a suborbital canal descends in a latero-ventral direction. On the aboral edge of the frontal process of the zygomatic bone, there is a prominence called the marginal tubercle. There is a pronounced spine on the ventral edge in the rostro-ventral extremity of the zygomatic bone (Fig. 8). The maxillary hiatus, located in the aboral extremity of the maxilla, has a reduced orifice, the maxillary foramen, and aborally of it, there is an evident sphenopalatine foramen and a lesser aboral palatine foramen (Fig. 9). Above the canine fossa is situated the infraorbital foramen.

Fig. 8. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) viscerocranium:lateral face.1.Zygomatic spine; 2. Zygomatic bone; 3. Temporal fossa; 4. Suborbital canal; 5. Maxillary spine; 6. Canine alveoli; 7. The alveolar process of the maxilla

Fig. 9. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) maxilla:lateral face. 1.Suborbitary canal; 2. Zygomatic spine; 3. Maxillary tuberosity; 4. Sphenopalatine foramen; 5. Aboral palatine foramen

On the ventral face of the viscerocranium are the palatine processes of the maxilla, delimited on the lateral sides by the alveolar processes of the maxilla.

The maxilla's palatine processes and the palatine bone's horizontal processes form the hard palate. An anterior palatine foramen is at the suture between these two formations, aborally flanked by an accessory palatine foramen. The aboral palatine foramen communicates through the palatine canal with the anterior palatine foramen, located in the aboral extremity of the palatine processes, at the place of their articulation with the palatine bone.

In the median-rostral plane, the opening of the incisive canal is visible, flanked on the sides by numerous accessory incisive foramina (Fig. 10).

There is a reduced prominence in the aboral extremity of the suture of the two palatine processes.

The mandible is an odd bone, presenting a body and two vertical rami. The body of the mandible has a convex and smooth anterior face. In the inferior part, on the ventro-median side, there is a reduced protuberance. The posterior face has two prominences on both sides and in the ventral plane, there is the medial mental foramen (Fig. 11).

The alveolus for the canine is located on the diastema. As the superior one, the lower canine is highly developed in the chimpanzee compared to humans. The dental arch is similar to the superior one, rectangular. On the lateral face of the mandible body, there is a mental foramen. The ventral edge of the mandibular ramus is rectilinear. At the level of the mandibular ramus on the lateral face is a reduced masseteric fossa for the insertion of the masseter muscle. The angle presents a prominent rough protuberance called the masseteric tuberosity (Fig. 12).

Fig. 10. Chimpanzee (*Pan troglodytes*, Blumenbach, 1775) viscerocranium: ventral face. 1. Horizontal portion of the palatine bone; 2. The palatine process of the maxilla; 3. Anterior palatine foramen; 4. Accessory palatine foramen; 5. Medial prominence of the hard palate; 6. Interincisive channel; 7, 8. Interincisive foramina; 9. The alveolar process of the maxilla

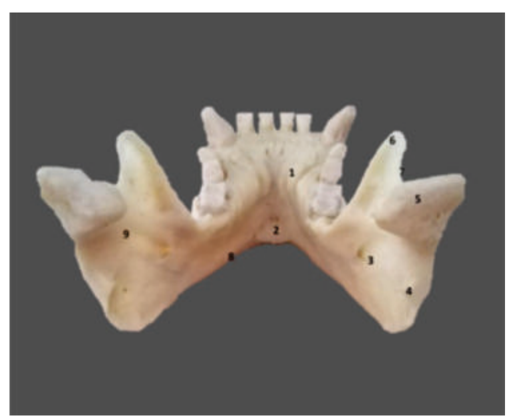

Fig. 11. Chimpanzee *(Pan troglodytes*, Blumenbach, 1775) mandible. 1.Mandibular protuberance; 2.Medial mental foramen 3. Mandibular foramen; 4. Pterygoid tuberosity; 5. Condylar process; 6. Coronoid process; 7. Mandibular notch; 8. The mylohyoid line; 9. Pterygoid fossa

The mandibular foramen, which represents the entrance to the mandibular canal, is on the mandibular ramus's medial face. In the aboral part, towards the angle of the mandible, a rough and prominent surface is present, the pterygoid tuberosity, for the insertion of the medial pterygoid muscle. The pterygoid fossa is located under the neck that supports the condylar process. The coronoid process of the mandible, situated rostrally of the mandibular notch, is short and relatively triangular, with a rounded margin. The condylar process is higher than the coronoid process and presents a convex, oro-aboral, articular surface for the temporal bone. A wide and deep mandibular notch separates the two condyles (Fig. 12).

Fig. 12. Chimpanzee *(Pan troglodytes*, Blumenbach, 1775) mandible. 1. Diastema; 2. Mental foramen; 3. Masseteric fossa; 4. Mandibular angle; 5. Coronoid process; 6. Condylar process; 7. Mandibular notch

CONCLUSIONS

The neurocranium has a lower development than humans, presenting a slightly elongated appearance and narrower and reduced convexity. The foramen magnum and the occipital condyles are placed slightly ventrorostral due to the bipedal movement tendency of the animal. This migration of the foramen magnum is much smaller than that of humans, directly influenced by exclusive bipedal locomotion. The external sagittal crest is absent, and from the level of the external occipital protuberance, two lines detach laterally: dorsally, the superior nuchal line, and ventrally, the inferior nuchal line. Orbital convergence and complete development of the orbital walls are observed. The frontal tubercles and the supraorbital arches are significantly developed compared to those of humans. The ethmoid bone presents on the lateral face of the ethmoidal labyrinth, inside the orbit, with two ethmoidal foramina: an anterior ethmoidal foramen and a posterior one. The sphenoid bone presents inside the orbit, on its ventral side, an evident orbital fissure above which the optic canal is observed. The base of the sphenoid wings is crossed by three foramina: the foramen rotundum, the foramen ovale, and the foramen spinosum. The temporal bone has a reduced, oval-shaped external auditory canal and, at its base is an evident stylomastoid foramen. The mastoid and styloid processes of the temporal bone are very small. The viscerocranium is reduced and arranged from its previous position to the skull in a subcranial position. Compared to a human, the viscerocranium is more elongated in the chimpanzee. The superior dental arch has a relatively rectangular appearance in chimpanzees, compared to humans, where the dental arcade is parabolic due to the shortening of the viscerocranium. The most developed teeth on the superior and inferior arch of the chimpanzee are the canines. The nasal region is flattened. The mandible has a medial mental foramen above the mandibular angle and a masseterine tuberosity.

REFERENCES

1. *Bolter D.B., Zihlman A.L.,* (2012), Skeletal development in *Pan paniscus* with comparisons to *Pan troglodytes*. AJPA, 147:629-636
2. *Bălăceanu-Stolnici C., Glavce C., Raicu F., Apăvăloaie L.,* (2006), Incursion in anthropogenesis (in Romanian), (Ed.) Medicala, Bucharest, Romania
3. *Gibbs S., Collard M., Wood B.*, (2002), Soft-tissue anatomy of the extant hominoids: a review and phylogenetic analysis. J Anat, 200(Pt 1):3–49
4. *Grimaud-Hervé D.,Serre F.,Bahain J.J.,Nespoulet R.,* (2015), Histoires d'ancêtres: La grande aventures de la préhistoire, 5e edition, (Ed.) Errance, Paris, France
5. *Lieberman D.E., Ross C.F., Ravosa M.J.,* (2000), The Primate cranial base: ontogeny, function, and integration. Am J Phys Anthropol,Suppl 31:117-169
6. *Martinez-Maza C., Freidline S.E., Strauss A., Nieto-Diaz M.,* (2016), Bone growth dynamics of the facial skeleton and mandible in Gorilla gorilla and Pan troglodytes. Evol Biol, 43:60-80
7. *Roberts A.,* (2011), Evolution the human story, (Ed.) Dorling Kindersley Limited, London, UK
8. *Schultz A.H.,* (1930) - The skeleton of the trunk and limbs of higher primates. Hum Biol, 2:303-438
9. *Stringer C., Andrews P.,* (2006), The Complete World of Human Evolution, (Ed.) Aquila, Oradea, Romania
10. *Zihlman A.L., Bolter D.R., Boesch C.,* (2007), Skeletal and dental growth and development in chimpanzees of the Taı National Park, Cote D'Ivoire. J Zool (Lond), 273:63-73
11. *Zollikofer C.P.E., Bienvenu T., Ponce de Leon M.S.,* (2017), Effects of cranial integration on hominid endocranial shape, J Anat, 230:85-105
12. ***, (2017), Nomina Anatomica Veterinaria, 5th ed., Editorial Committee Hannover (Germany), Ghent (Belgium), Columbia (USA), Rio de Janeiro (Brazil)
13. ***, (2019), Terminologia anatomica,3rd ed., International Anatomical Terminology (FIPAT). (ed.) Georg Thieme Verlag, Leipzig, Germany.