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MACERATION, ANATOMICAL REVIEW, AND NON-FIXED OSTEOMOUNTING *OF EIRA BARBARA* (TAYRA)

Maceração, revisão anatômica e osteomontagem sem fixação de Eira Barbara (irara)

Caroline Lemke dos Santos*[1], Samuel Carlos Brasil Petri[2]

***Corresponding author:** Caroline Lemke dos Santos. Ruas das Graviolas, 135, Bairro Madri, Palhoça, SC, Brazil. CEP: 88136-322.
E-mail: lemkecaroline22@gmail.com

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Abstract

Eira barbara, known as the tayra or honey badger, is a Neotropical mustelid distributed from Mexico to northern Argentina. This study describes the osteological preparation of a specimen of the species, emphasizing the maceration and osteomounting stages for didactic purposes. The animal was collected by the Environmental Military Police and transferred to the Wildlife Screening Center of Santa Catarina, where it died during transportation and was subsequently destined for Anhanguera College of São José. The skeleton preparation process included skinning, maceration, bone cleaning, and anatomical assembly. Mechanical and chemical methods were used, including use of 35% hydrogen peroxide for bone whitening and disinfection. The entire process lasted 28 days. The results demonstrated the effectiveness of the protocol in obtaining clean osteological specimens suitable for anatomical studies and educational and cientific purposes.

Keywords: *Eira barbara*; osteology; chemical maceration; osteotechnique; mustelidae.

Resumo

Eira barbara, popularmente conhecida como irara ou papa-mel, é um mustelídeo neotropical distribuído do México ao norte da Argentina. Este estudo descreve o preparo osteológico de um exemplar da espécie, com ênfase nas etapas de maceração e osteomontagem para fins didáticos. O animal foi recolhido pela Polícia Militar Ambiental e encaminhado ao Centro de Triagem de Animais Silvestres

1 Veterinarian, Anhanguera College of São José (FASJ), São José, SC, Brazil.
2 Veterinarian, Anhanguera College of São José (FASJ), São José, SC, Brazil.

de Santa Catarina, vindo a óbito durante o transporte e, posteriormente, destinado à Faculdade Anhanguera São José. O preparo do esqueleto incluiu descarne, maceração, limpeza óssea e montagem anatômica. Foram utilizados métodos mecânicos e químicos, incluindo peróxido de hidrogênio a 35% para clareamento e desinfecção dos ossos. O processo teve duração total de 28 dias. Os resultados demonstraram a eficácia do protocolo na obtenção de peças osteológicas adequadas para estudo anatômico e uso didático-científico.

Introduction

Eira barbara (tayra), belonging to the mustelid family, is the only representative species of the genus Eira. It is a forest-dwelling mammal distributed from Mexico to northern Argentina. The species exhibits remarkable locomotor ability, being capable of swimming, running, and climbing with ease, in addition to building nests in tree stumps or cavities. It is also commonly known as the honey bear or tayra, a term derived from the Tupi-Guarani language meaning "owner of honey," due to its habit of invading apiaries in search of food, often causing considerable economic losses (Cubas; Silva; Catão-Dias, 2006).

The tayra (*Eira barbara*) is currently classified as "Least Concern" by the International Union for Conservation of Nature (UICN). Although it is not considered threatened with extinction, a reduction in its geographic distribution has been observed, mainly as a consequence of forest habitat destruction and the expansion of agricultural activities (Cuarón *et al*., 2016; Cubas; Silva; Catão-Dias, 2006).

From a morphological perspective, the species presents a long tail and dense, coarse fur with a rough texture. It also has a flattened head, short rounded ears, and an elongated neck. Its diet consists predominantly of rodents, other small mammals, birds, honey, and fruits (Cubas; Silva; Catão-Dias, 2006).

Anatomy plays a fundamental role in Veterinary Medicine, as the identification of structures and osteological studies, frequently conducted through dissection techniques, contribute significantly to the advancement of morphological sciences. In this context, osteology remains an essential tool for expanding knowledge about different species (Lopes *et al*., 2019).

The demand for anatomical specimens from wild animals is considerable and is relevant for both professionals and students in the fields of Veterinary Medicine and Biology. Therefore, investment in knowledge related to anatomy, osteology, osteotechnics, and skeletal assembly is necessary, particularly regarding the preparation of anatomical materials, considering the still limited availability of information in the scientific literature (Santos *et al*., 2022).

Osteological collections also constitute important didactic resources, enabling comparative studies among vertebrates and contributing to the understanding of evolutionary processes, adaptive radiations, and homologous relationships among different taxa (O que são coleções [...], s.d.). Furthermore, skeletons play a significant role in scientific research, being employed both in the identification of characteristics in anatomical and phylogenetic studies and in the teaching of body organization. Such collections also contribute to the advancement of fields such as Paleontology and Veterinary Medicine (Auricchio; Salomão, 2002).

In the preparation of bone specimens and skeletons, several factors must be considered, including the need for complete disarticulation or the preservation of cartilage and joints. Therefore, the intended use of the material should be defined beforehand, guiding the selection of the most appropriate technique (Silveira; Teixeira; Oliveira, 2008). Among the stages involved in skeleton preparation are evisceration and skin removal; defleshing, which consists of removing tissues using instruments such as scalpels, knives, and scissors until the bones are exposed; and the separation of skeletal elements into anatomical regions, including forelimbs and hindlimbs, skull, vertebrae, ribs, sternum, and pelvic bones (Faruk; Das, 2023).

The boiling method in water must be applied with caution. Although it contributes to the elimination of potential pathogens, excessive heating may cause structural damage and shrinkage, particularly in smaller bones. Subsequent cleaning and whitening procedures may be performed using degreasing detergent and hydrogen peroxide (H_2O_2), respectively (Faruk; Das, 2023).

Considering this, the present study primarily aims to provide an anatomical and osteological review of *Eira barbara*, as well as to describe the maceration process applied to the species.

Materials and Methods

The tayra (*Eira barbara*) used in the present study was found deceased on a public road and collected by the 1st Environmental Military Police Company (CPMA). Subsequently, it was sent to the Veterinary Morphology Laboratory of Faculdade Anhanguera São José (FASJ), in Santa Catarina, for *post mortem* analyses and skeletal assembly for didactic purposes. The animal was the victim of a possible roadkill incident on a public road in Antônio Carlos and was collected by the 1st CPMA while being transported to the Wildlife Screening Center of Santa Catarina (Cetas-SC). It was subsequently designated to Faculdade Anhanguera São José (FASJ) as the primary didactic material. During biometric evaluation, the animal was found to measure 93 cm in total length and weigh 3.5 kg. It was an adult female approximately five years of age. In addition, no visible external lesions were observed. The animal underwent necropsy, which revealed muscular injuries with the presence of hematomas. However, no other significant alterations were identified that would allow determination of the cause of death.

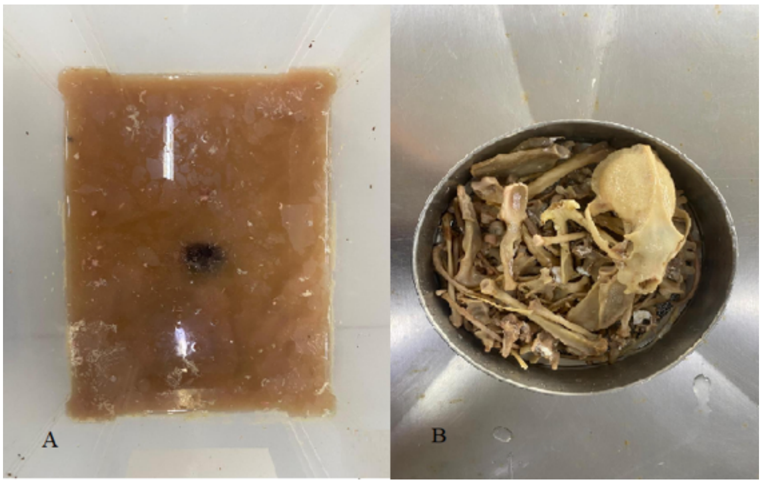
Osteotechnics consists of the preparation and assembly of skeletons and osseous structures, allowing bones to be visualized and manipulated for didactic purposes. This procedure is fundamental for the teaching of anatomy and zoology, as it provides students with the opportunity to understand the actual structural organization of animals, reinforcing theoretical concepts in a practical manner. Furthermore, by using animals that have died naturally or accidentally, the technique promotes an ethical and sustainable approach to species study, emphasizing conservation and the responsible use of wild specimens (Hilton; Watkins-Colwell; Huber, 2021).

The mechanical maceration method is especially recommended for skeleton assembly using cadavers already available in anatomy laboratories. For this purpose, it is essential to manually remove all soft tissues present in these bodies before proceeding with the process (Rocha, n.d.).

After external and internal evaluation, the mechanical maceration procedure was initiated, consisting of manual defleshing with the aid of surgical instruments, including anatomical forceps, scalpel handle and blade, and scissors, in order to remove as much tissue, muscle, tendons, and joint material as possible.

After manual tissue removal, the cadaver was subjected to chemical maceration, as shown in Figure 1 (A) and (B). This process is extremely important for bone preparation, ensuring complete cleaning without residual dirt or soft tissue remnants.

Figure 1 – Chemical maceration process



Source: Produced by authors Santos and Petri (2024).

Note: In (A): chemical maceration. Products used: 8 liters of water and 300 mL of 35% hydrogen peroxide. Performed on 12/15/2023. In (B): completed chemical maceration. Performed on 01/09/2024.

Chemical maceration consists of the complete cleaning and whitening of bones, as shown in Figure 2 (C) and (D). The procedure was performed by immersing the bones in a tank sized according to the dimensions of the tayra (*Eira barbara*), using more aggressive products such as 35% hydrogen peroxide combined with water, with the specimens remaining submerged for three days.

However, the use of low-concentration hydrogen peroxide solutions (0.5% to 1.5%), combined with the final removal of excess adhered tissue, as proposed in the alternative protocol, replaced the need for high concentrations, providing complete cleaning and whitening of the bones while reducing costs and preventing corrosion of the specimens (Netta; Macedo; Costa, 2024).

Figure 2 – Bone whitening

Source: Produced by authors Santos and Petri (2024).

Note: In (C): bone whitening. Products used: 5 liters of water and 500 mL of 35% hydrogen peroxide. Performed on 01/09/2024. In (D): completion of the whitening process. Performed on 01/12/2024.

In the preparation of bone specimens for osteological collections, different osteotechnical techniques may be applied; however, not all provide a satisfactory cost-benefit relationship. Furthermore, the limited availability of detailed literature regarding these procedures requires that methods be adapted according to the available material resources and physical space (König; Liebich, 2016).

Once prepared, the bones were organized separately, and skeletal assembly without fixation was performed following the correct anatomical arrangement of each structure in order to facilitate visualization of every part of the skeleton, which can be divided into the axial skeleton, appendicular skeleton, and complete skeleton.

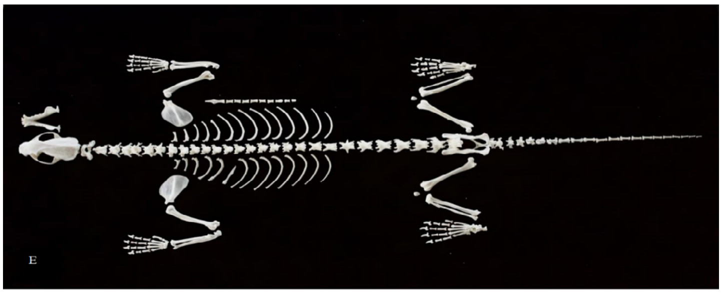
Results

This study was conducted for educational purposes as an anatomical and osteotechnical description of the tayra (*Eira barbara*), covering the process from dissection to its anatomical positioning.

Mechanical maceration was used to remove the greatest possible amount of soft tissue, thereby accelerating the decomposition process. The entire procedure lasted 28 days, during which the progression of soft tissue decomposition was assessed every seven days. It was concluded that the time required for chemical maceration and bleaching may vary, as a shorter period can result in residual fat remaining on the bones.

The planning of this project was divided into several stages, one of which was skeletal assembly, in order to achieve the anatomical positioning of *Eira barbara*. Figure 3 shows the complete disarticulated skeleton, consisting of the skull, axial skeleton, and appendicular skeleton.

Figure 3 – Complete non-fixed skeleton of the animal (*Eira barbara*)



Source: Produced by authors Santos and Petri (2024.

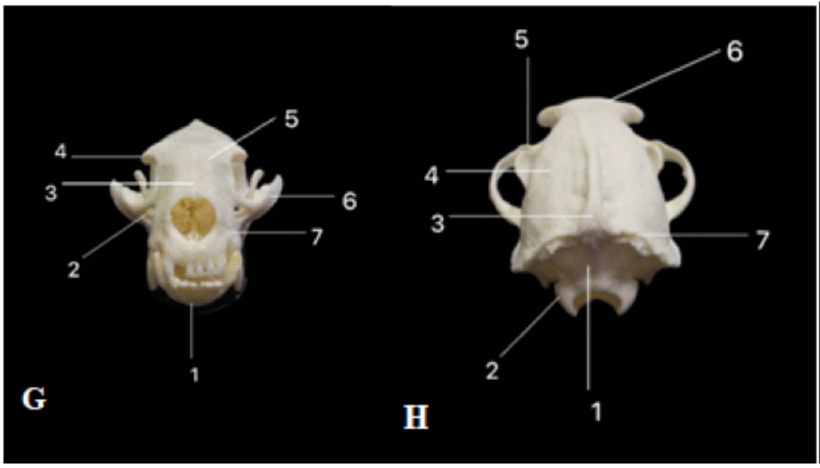
Axial Skeleton

The axial skeleton corresponds to the central axis of the body and is composed of the bony structures of the head, vertebral column, and thoracic skeleton. It includes the skull—formed by the neurocranium and viscerocranium—the mandible, the hyoid apparatus, the auditory ossicles of the middle ear, as well as the vertebrae, ribs, and sternum. Its primary function is to protect vital organs, such as the brain, spinal cord, and thoracic structures, in addition to providing body support and stability. The vertebral column, in particular, plays a fundamental role by connecting the skull to the caudal region, allowing mobility and shock absorption through the intervertebral discs and its physiological curvatures. Thus, the axial skeleton not only ensures protection but also contributes to the stability and functionality of the locomotor system (König; Liebich, 2016).

Skull

The skull is formed by a set of bones that are mostly joined by sutures, constituting a rigid and resistant structure. These bones are organized into two main portions: the neurocranium, responsible for forming the cranial cavity, and the viscerocranium, which forms the face. Among the principal bones composing the skull are the frontal, parietal, temporal, occipital, sphenoid, and ethmoid bones, in addition to facial bones such as the maxilla, nasal, zygomatic, and lacrimal bones. The development of these bones occurs through intramembranous and endochondral ossification from ossification centers, with the bones initially separated and later fused throughout growth. This osseous organization ensures structural resistance and appropriate skull conformation among different species (König; Liebich, 2016). Figures 4, 5, and 6 show the skull of *Eira barbara* (tayra).

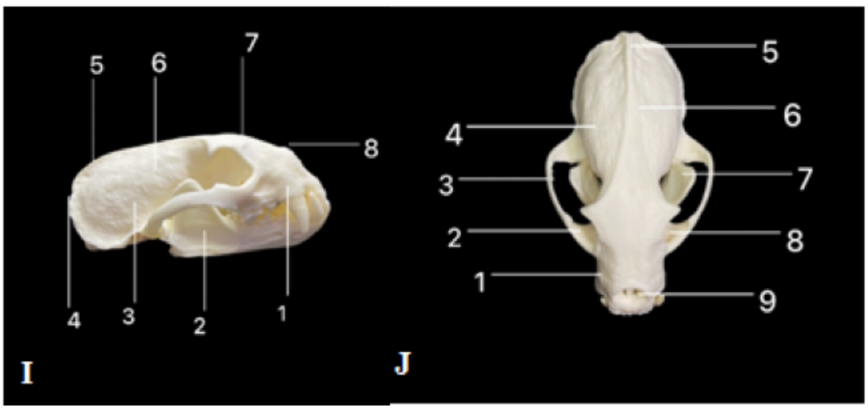
Figure 4 – Skull in anterior and nuchal views



Source: Produced by authors Santos and Petri (2024).

Note: In (G), viewed from the anterior aspect: 1) mandible; 2) infraorbital foramen; 3) nasal bone; 4) zygomatic process of the frontal bone; 5) frontal bone; 6) frontal process of the zygomatic bone; 7) maxilla. In (H), viewed from the nuchal aspect: 1) occipital bone; 2) occipital condyle; 3) external sagittal crest; 4) parietal bone; 5) zygomatic arch; 6) frontal bone; 7) nuchal crest.

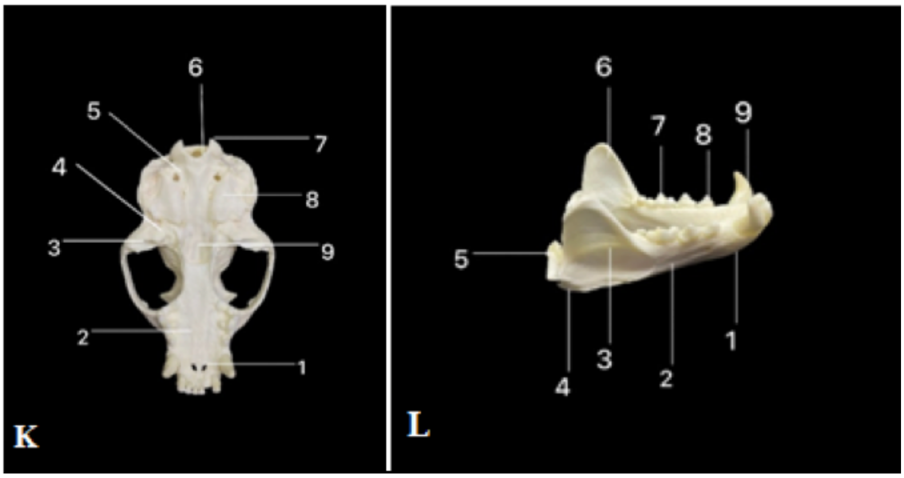
Figure 5 – Skull in right lateral and dorsal views



Source: Produced by authors Santos and Petri (2024).

Note: In (I), viewed from the right lateral aspect: 1) maxilla; 2) ramus of the mandible; 3) temporal bone; 4) occipital bone; 5) interparietal bone; 6) parietal bone; 7) nasal bone. In (J), viewed from the dorsal aspect: 1) facial surface of the maxilla; 2) lacrimal foramen; 3) zygomatic arch; 4) parietal bone; 5) external sagittal crest; 6) temporal line; 7) coronoid process of the mandible; 8) infraorbital foramen; 9) body of the incisive bone.

Figure 6 – Skull in ventral and right lateral views



Source: Produced by authors Santos and Petri (2024).

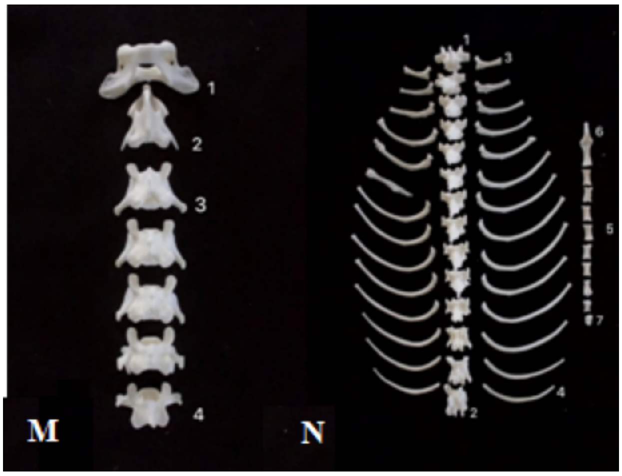
Note: In (K), viewed from the ventral aspect: 1) palatine fissure; 2) palatine bone; 3) mandibular fossa of the articular surface; 4) retroarticular process; 5) hypoglossal canal; 6) foramen magnum; 7) occipital condyle; 8) tympanic bulla. In (L): 1) mental foramen; 2) body of the mandible; 3) masseteric fossa; 4) angular process; 5) condylar process; 6) coronoid process; 7) molar; 8) premolar; 9) canine.

Vertebrae, Ribs, and Sternum

The vertebrae, ribs, and sternum constitute the thoracic skeleton and play a fundamental role in protecting vital organs and supporting respiratory dynamics. The thoracic vertebrae form the dorsal axis and articulate with the ribs, which are arranged laterally in pairs and delimit the thoracic cavity. Each rib consists of a dorsal osseous portion and, in many cases, a ventral cartilaginous portion, which may connect directly to the sternum (sternal ribs), indirectly through cartilage (asternal ribs), or remain free (floating ribs). The sternum, located ventrally, completes the thoracic wall by serving as the insertion point for the costal cartilages. This structural organization protects the heart and lungs while allowing thoracic expansion and retraction during respiration (König; Liebich, 2016).

Tayras, *Eira barbara*, like other mammals, possess seven cervical vertebrae, including the atlas and axis, shown in Figure 7 (M), and fourteen thoracic vertebrae, with fourteen pairs of ribs present in this specimen, shown in Figure 7 (N).

Figure 7 – Vertebrae, ribs, and sternum



Source: Produced by authors Santos and Petri (2024).

Note: In (M): cervical column: 1) atlas; 2) axis; 3 and 4) cervical vertebrae. In (N): 1 and 2) thoracic vertebrae; 3 and 4) ribs; 5) sternum; 6) manubrium of the sternum; 7) xiphoid process.

Figure 8 – Vertebrae, ribs, and sternum

Source: Produced by authors Santos and Petri (2024).

Note: In (O): 1 and 2) vertebral column; 3) sacrum. In (P): 1) caudal vertebrae.

Appendicular Skeleton

The appendicular skeleton is divided into the thoracic limb and pelvic limb. It is responsible for the movement and support of the animal's body. Figure 9 (Q) and (R) shows the appendicular skeleton in dorsal position.

Figure 9 – Appendicular skeleton

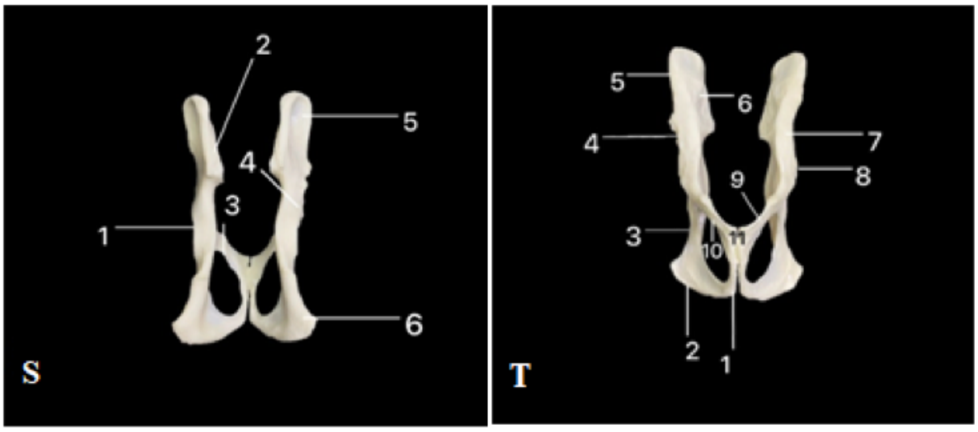
Source: Produced by authors Santos and Petri (2024).

Note: In (Q): 1) scapula; 2) humerus; 3) radius; 4) ulna; 5) bones of the manus. In (R): 6) pelvic bones; 7) femur; 8) patella; 9) tibia; 10) fibula; 11) bones of the pes.

Pelvis

The pelvis constitutes the osseous base of the pelvic limb and is formed by the coxal bones (ilium, ischium, and pubis), which unite to form the pelvic girdle. These bones articulate with each other at the pelvic symphysis and dorsally with the sacrum, forming a rigid ring that delimits the pelvic cavity. The ilium is the most cranial and broadest portion, contributing to articulation with the sacrum; the ischium forms the caudal portion and supports the animal when seated; and the pubis composes the ventral portion, participating in the formation of the pelvic floor. This osseous structure performs essential functions, including supporting body weight, protecting internal organs (bladder, rectum, and reproductive organs), and transmitting forces from the hind limbs to the trunk (König; Liebich, 2016). Figures 10 and 11 show the pelvis.

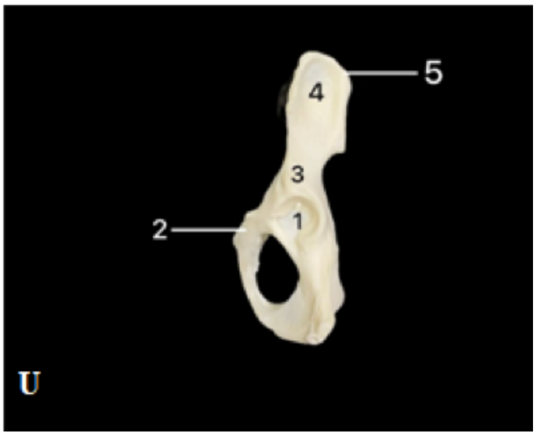
Figure 10 – Pelvis



Source: Produced by authors Santos and Petri (2024).

Note: In (S), viewed from the dorsal aspect: 1) acetabulum; 2) iliac crest; 3) body of the pubis; 4) body of the ilium; 5) wing of the ilium; 6) ischium (ischial tuberosity). In (T), viewed from the ventral aspect: 1) ischial arch; 2) ischial tuberosity; 3) body of the ischium; 4) coxal tuberosity; 5) wing of the ilium; 6) auricular surface; 7) body of the ilium; 8) acetabulum; 9) cranial ramus of the pubis; 10) caudal ramus of the pubis; 11) pubic symphysis.

Figure 11 – Pelvis viewed from the right lateral aspect



Source: Produced by authors Santos and Petri (2024).

Note: 1) acetabulum; 2) pubis; 3) body of the ilium; 4) wing of the ilium; 5) iliac crest.

Bones of the Manus and Foot

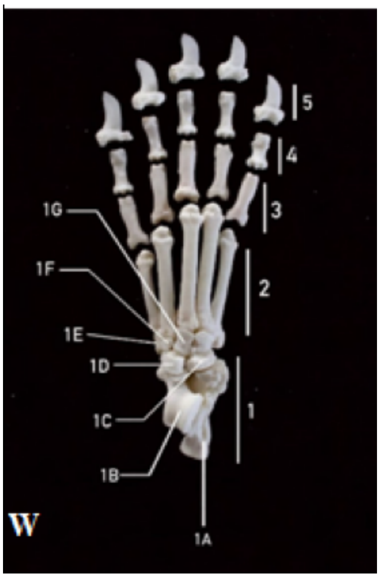
The bones of the manus and pes constitute the autopodium of the thoracic and pelvic limbs, respectively, and are organized into the basipodium, metapodium, and acropodium. In the thoracic limb, they include the carpal bones, metacarpal bones, and phalanges; the carpal bones are arranged in proximal and distal rows, articulating with the radius and ulna as well as with the metacarpals. In the pelvic limb, the pes is formed by the tarsal bones, metatarsal bones, and phalanges, with the tarsus divided into three rows that articulate with the tibia and metatarsals. Figures 12 and 13 identify the structures of the manus and pes bones of *Eira barbara* (tayra).

Figure 12 – Bones of the hand

Source: Produced by authors Santos and Petri (2024).

Note: 1) carpal bones; 1A) radial/intermediate carpal bone; 1B) carpal bone III; 1C) carpal bone IV; 1D) ulnar carpal bone; 2) metacarpal bones; 3) proximal phalanx; 4) middle phalanx; 5) distal phalanx.

Figure 13 – Bones of the foot



Source: Produced by authors Santos and Petri (2024).

Note: 1) carpal bones; 1A) radial/intermediate carpal bone; 1B) carpal bone III; 1C) carpal bone IV; 1D) ulnar carpal bone; 2) metacarpal bones; 3) proximal phalanx; 4) middle phalanx; 5) distal phalanx.

The pelvic limbs are responsible for locomotion and propulsion and are divided into the stylopodium, zeugopodium, and autopodium. Their joints and associated structures ensure mobility, stability, and weight support.

Final Considerations

The present study demonstrated that the maceration technique associated with skeletal assembly without prior fixation is effective for obtaining osteological material of *Eira barbara* intended for didactic purposes. The protocol employed, with a total duration of 28 days, allowed adequate removal of soft tissues and preservation of the osseous structures.

The use of 35% hydrogen peroxide proved effective in the bone whitening process, resulting in specimens of good quality for anatomical study and satisfactory whitening outcomes.

Thus, the method described represents a viable and easily applicable alternative for the preparation of skeletons of wild mammals, contributing to the teaching and practice of veterinary anatomy.

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CRediT Author Statementr

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- **Conflicts of interest**: The authors declare that there are no conflicts of interest related to the conduct and publication of this study.
- **Ethical approval**: The study was conducted using a specimen originating from natural death and forwarded by the competent environmental agencies, without the performance of experimental procedures on live animals. Therefore, submission to the Animal Ethics Committee (Ceua) was not required.
- **Data and materials availability**: The data and materials supporting this study are available from the authors upon reasonable request.
- **Author contributions**: SANTOS, C. L. dos participated in the execution of the maceration stages, osteological cleaning, anatomical review, literature survey, data interpretation, and manuscript writing. PETRI, S. C. B. participated in the skeletal assembly without fixation and photographic planning, as well as in the study conception, supervision of activities, methodological guidance, and critical review of the scientific content.

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