Skeletal Morphology and Methodology for the Osteological Preparation of the Southern Tamandua, Tamandua Tetradactyla (Linnaeus, 1758)

Morfologia esquelética e metodologia para a preparação osteológica da tamanduá-do-sul, Tamandua tetradactyla (Linnaeus, 1758)

Morfología esquelética y metodología para la preparación osteológica del tamandúa del sur, Tamandua tetradactyla (Linnaeus, 1758)

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ABSTRACT
The southern tamandua (*Tamandua tetradactyla*) is a semiarboreal xenarthran widely distributed in South America. Detailed osteological information is relevant to comparative anatomy, teaching, and veterinary practice. This study aimed to describe the main skeletal structures and the osteological preparation method applied to an adult male specimen measuring 1.15 m in total length and weighing approximately 5 kg, found dead near Itinguçu State Park, in Peruíbe, São Paulo, Brazil. Preparation included inspection, biometry, dissection, removal of soft tissues, controlled boiling, manual cleaning, whitening,

drying, and non-articulated skeletal arrangement. The material allowed for the documentation of the elongated, edentulous skull; the axial skeleton with xenarthrous articulations and synsacral complex; and the specializations of the thoracic and pelvic limbs. Five metacarpals and a rudimentary fifth digit, represented by a single proximal phalanx, were identified in the hand. The preparation preserved the bone structures and produced material of educational and scientific value for the collection of the Instituto de Biologia Marinha e Meio Ambiente (IBIMM).

Keywords: *Tamandua tetradactyla*, Xenarthra, Comparative Anatomy, Osteology, Skeletal Assembly.

RESUMO

A tamanduá-do-sul (Tamandua tetradactyla) é um xenartrano semiarbóreo amplamente distribuído na América do Sul. Informações osteológicas detalhadas são relevantes para a anatomia comparativa, o ensino e a prática veterinária. Este estudo teve como objetivo descrever as principais estruturas esqueléticas e o método de preparação osteológica aplicado a um espécime macho adulto, medindo 1,15 m de comprimento total e pesando aproximadamente 5 kg, encontrado morto próximo ao Parque Estadual de Itinguçu, em Peruíbe, São Paulo, Brasil. A preparação incluiu inspeção, biometria, dissecção, remoção de tecidos moles, fervura controlada, limpeza manual, branqueamento, secagem e montagem esquelética não articulada. O material permitiu a documentação do crânio alongado e edêntulo; do esqueleto axial com articulações xenartrosas e complexo sinsacral; e das especializações dos membros torácicos e pélvicos. Na mão, foram identificados cinco metacarpos e um quinto dedo rudimentar, representado por uma única falange proximal. A preparação preservou as estruturas ósseas e produziu material de valor educacional e científico para o acervo do Instituto de Biologia Marinha e Meio Ambiente (IBIMM).

Palavras-chave: Tamandua tetradactyla, Xenarthra, Anatomia Comparativa, Osteologia, Montagem Esquelética.

RESUMEN

El tamandúa del sur (Tamandua tetradactyla) es un xenártrofio semiarbóreo ampliamente distribuido en Sudamérica. La información osteológica detallada es relevante para la anatomía comparada, la docencia y la práctica veterinaria. El objetivo de este estudio fue describir las principales estructuras esqueléticas y el método de preparación osteológica aplicado a un ejemplar macho adulto de 1,15 m de longitud total y un peso aproximado de 5 kg, hallado muerto cerca del Parque Estatal de Itinguçu, en Peruíbe, São Paulo (Brasil). La preparación incluyó la inspección, la biometría, la disección, la extirpación de los tejidos blandos, la ebullición controlada, la limpieza manual, el blanqueo, el secado y la disposición del esqueleto sin articulaciones. El material permitió documentar el cráneo alargado y edéntulo; el esqueleto axial con articulaciones xenartras y el complejo sin-sacro; y las especializaciones de las extremidades torácicas y pélvicas. En la mano se identificaron cinco metacarpianos y un quinto dedo rudimentario, representado por una única falange proximal. La preparación conservó las estructuras óseas y proporcionó material de valor educativo y científico para la colección del Instituto de Biología Marina y Medio Ambiente (IBIMM).

Palabras clave: Tamandua tetradactyla, Xenarthra, Anatomía Comparada, Osteología, Montaje Esquelético.

1 INTRODUCTION

The southern tamandua, *Tamandua tetradactyla* (Linnaeus, 1758), belongs to the class Mammalia, superorder Xenarthra, order Pilosa, suborder Vermilingua, and family Myrmecophagidae (Mammal Diversity Database, 2026). The species occurs east of the Andes in South America, from Venezuela and the Guianas to northern Argentina and Uruguay, inhabiting forest, savanna, and grassland environments as well as transitional areas (Hayssen, 2011).

It is a semi-arboreal mammal, capable of moving, foraging, and resting both in trees and on the ground. The tail is prehensile, the snout is elongated, the animal lacks teeth, and the forelimbs have well-developed musculature and claws, used to break into ant and termite mounds, climb, and defend itself. Activity may vary from nocturnal to diurnal or crepuscular, depending on the environment and local conditions (Hayssen, 2011).

The name Xenarthra derives from the accessory, or xenarthric, intervertebral joints, found primarily in the caudal thoracic and lumbar vertebrae. These joints contribute to the mechanical stability of the trunk without compromising its mobility (Gaudin, 1999; Oliver *et al*., 2016). Another relevant characteristic is the synsacrum, a fused vertebral complex strongly associated with the pelvis, whose composition may include sacral elements and, depending on the taxon, adjacent lumbar or caudal vertebrae (Galliari and Carlini, 2015).

The integration of osteology and osteomounting techniques is essential for the preservation and detailed study of skeletal structures, serving as the basis for the production of specimens intended for research and teaching**.** The study by Sarott, Lima, and Lopes (2024) on the species *Tadorna tadorna* reinforces this premise by demonstrating that proper laboratory handling of carcasses enables the construction of functional educational skeletal models. This practical approach enhances the quality of available academic material, making a direct and significant contribution to the consolidation of morphological knowledge in veterinary medicine undergraduate programs.

Osteological preparation and skeletal assembly make it possible to document structures, organize anatomical collections, and produce material for teaching and research. Within the scope of IBIMM, similar techniques have been applied to different

taxa, including the green-billed toucan, the hairy dwarf porcupine, and the domestic turkey (Della Torre *et al*., 2021; Farias *et al*., 2021; Queiroz *et al*., 2026). Given the anatomical variation already described for the vertebral column and hand of *T. tetradactyla*, this study aimed to describe the skeleton of an adult specimen and document the preparation methodology employed.

2 MATERIALS AND METHODS

2.1 SPECIMEN AND ORIGIN

This study used the carcass of an adult male *Tamandua tetradactyla*, with a total length of 1.15 m, measured from the rostral tip to the tip of the tail, and an approximate mass of 5 kg. The sex (male) and estimated age (5 years) were recorded. The animal was found dead by the IBIMM team in the vicinity of Itinguçu State Park (headquarters of IBIMM – Instituto de Biologia Marinha e Meio Ambiente), located at Guaraú neighborhood, in Peruíbe, São Paulo, and was subsequently frozen for inclusion in the institution's biological collection.

The procedures were performed at the IBIMM Veterinary Anatomy Laboratory, Palmares Center, in Santa Cruz das Palmeiras, São Paulo, and approved by the Ethics Committee on the Use of Animals on February 25, 2022, under protocol No. 035/22.

Initially, an external examination was performed to check for the absence of apparent skin lesions, the presence of ectoparasites, and abnormalities of the skeletal system. A lesion in the left scapulohumeral region was subsequently confirmed during dissection.

2.2 OSTEOLOGICAL PREPARATION

The dissection was performed using scalpel blades and handles, scissors, thumb forceps, toothed forceps, gloves and a lab coat. The skin incision extended from the cervical region to the abdominal region, near the pelvis. The skin was separated and kept frozen for subsequent taxidermy preparation; the organs were removed and preserved in 70% alcohol in the IBIMM collection.

After removing most of the soft tissues, the bones were separated by anatomical region and stored in labeled containers. They were then boiled in water with detergent to soften residual muscles, tendons, and fasciae. The cleaning process was supplemented by careful manual scraping.

For bleaching, the cleaned bones were left for 24 hours in a mixture of water and 5% sodium hypochlorite, rinsed under running water and subsequently placed in a bath of 10% hydrogen peroxide to further bleach the bones. They were then dried in the shade during the day, with a 15-watt 3U fluorescent lamp used to aid in bleaching, and kept in an incubator with a 100-watt clear incandescent lamp at night for three consecutive days.

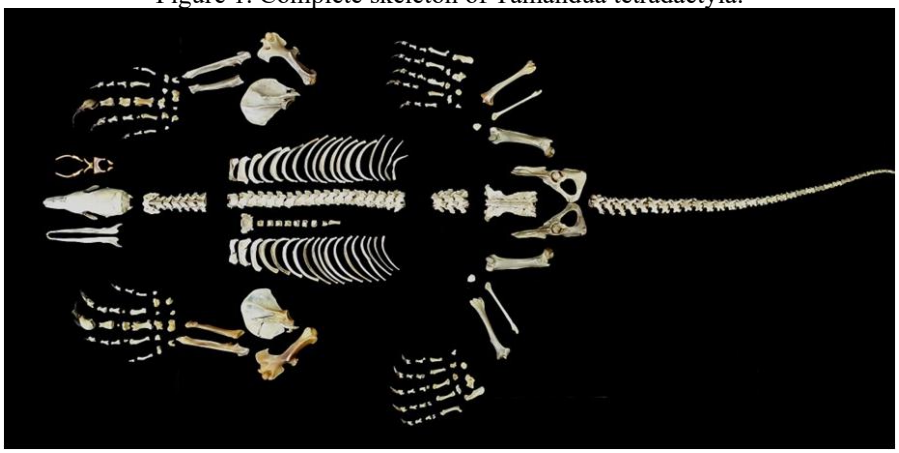
2.3 SKELETON ASSEMBLY, DOCUMENTATION, AND NOMENCLATURE

The skeleton assembly was performed without permanent fixation. The bones were positioned according to their anatomical positions and organized into three sets: axial skeleton, appendicular skeleton, and complete skeleton. The structures were photographed against a black background. Nomenclature was standardized according to the *Nomina Anatomica Veterinaria* (ICVGAN, 2017) and specific descriptions for *T. tetradactyla* (Machado Cruvinel *et al*., 2019; Lins and Lins *et al*., 2019).

3 RESULTS AND DISCUSSION

The entire process, from dissection to the final assembly of the skeleton, was completed in ten days, with each session lasting approximately six hours. The preliminary separation of the bones by anatomical region facilitated the verification of the parts and reduced the risk of mix-ups during assembly. The complete skeleton of the specimen is shown in (Figure 1).

Figure 1. Complete skeleton of Tamandua tetradactyla.

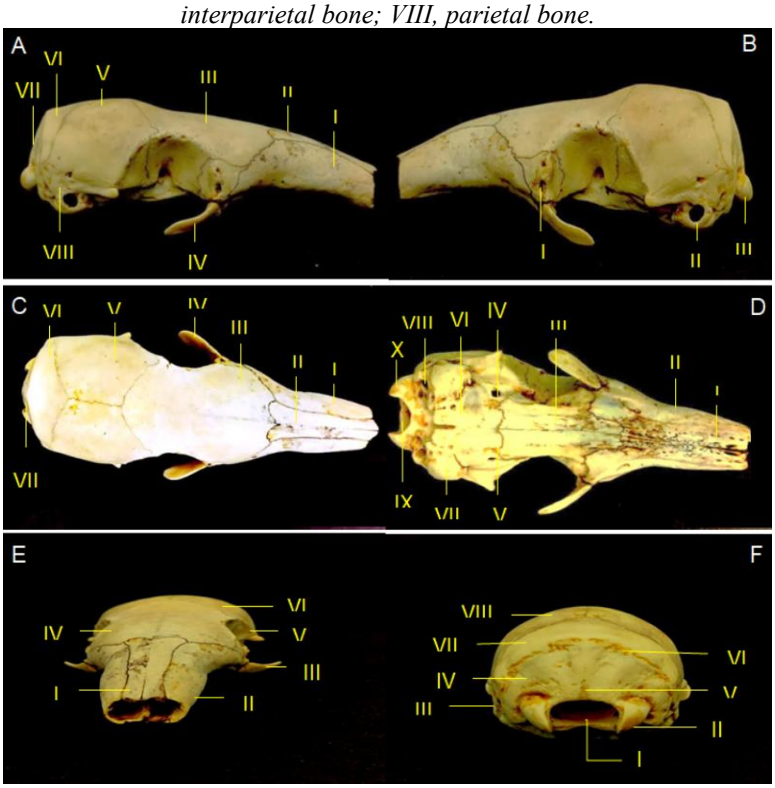


Source: Prepared by the authors (2026).

3.1 CRANIAL SKELETON

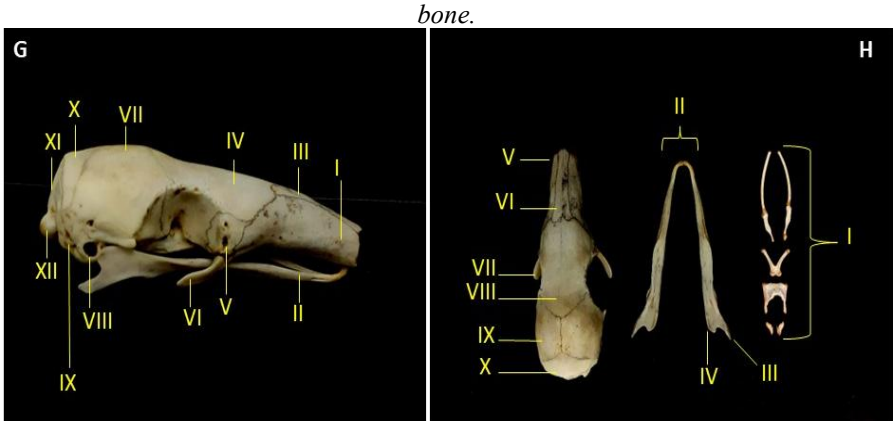
The skull has a narrow and elongated rostrum, a small oral opening and an absence of dental sockets, characteristics associated with myrmecophagy. In the facial region, the following bones were identified: nasal, lacrimal, zygomatic, maxilla, incisive, palatine, vomer, and pterygoid, as well as the mandible and the hyoid apparatus. The lateral, dorsal, ventral, rostral, and caudal views are shown in (Figures 2 and 3). The observed conformation is consistent with the cranial description of the species presented by Hayssen (2011).

Figure 2. Skull of Tamandua tetradactyla. (A) Right lateral view: I, maxilla; II, nasal bone; III, frontal bone; IV, zygomatic bone; V, parietal bone; VI, interparietal bone; VII, occipital bone; VIII, temporal bone. (B) Left lateral view: I, infraorbital foramen; II, tympanic bulla; III, occipital condyle. (C) Dorsal view: I, maxilla; II, nasal bone; III, frontal bone; IV, zygomatic bone; V, parietal bone; VI, interparietal bone; VII, occipital bone. (D) Ventral view: I, palatine bone; II, maxilla; III, presphenoid bone; IV, foramen ovale; V, mandibular fossa; VI, sphenoid bone; VII, tympanic bulla; VIII, jugular foramen; IX, foramen magnum; X, occipital condyle. (E) Rostral view: I, nasal bone; II, maxilla; III, zygomatic bone; IV, frontal bone; V, temporal bone; VI, parietal bone. (F) Caudal view: I, foramen magnum; II, occipital condyle; III, temporal bone; IV, occipital bone; V, external sagittal crest; VI, nuchal crest; VII, interparietal bone; VIII, parietal bone.



Source: Prepared by the authors (2026).

Figure 3. Skull, mandible, and hyoid apparatus of Tamandua tetradactyla. (G) Lateral view: I, maxilla; II, mandible; III, nasal bone; IV, frontal bone; V, infraorbital foramen; VI, zygomatic bone; VII, parietal bone; VIII, tympanic bulla; IX, temporal bone; X, interparietal bone; XI, occipital bone; XII, occipital condyle. (H) Dorsal view: I, hyoid apparatus; II, mandible; III, coronoid process; IV, condylar process; V, maxilla; VI, nasal bone; VII, zygomatic bone; VIII, frontal bone; IX, parietal bone; X, interparietal bone.



Source: Prepared by the authors (2026).

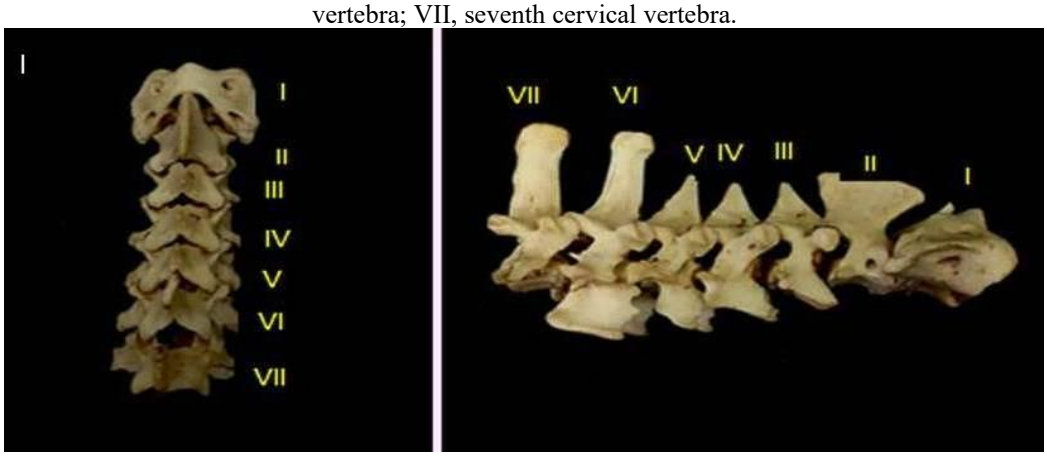
3.2 AXIAL SKELETON

The axial skeleton comprises the skull, the vertebral column, the ribs, and the sternum. In this specimen, seven cervical vertebrae, 18 thoracic vertebrae, three lumbar vertebrae, five sacral vertebrae integrated into the synsacral complex, and 42 caudal vertebrae were identified. Eighteen pairs of ribs and eight sternal segments were also identified, in addition to the manubrium and the xiphoid process. The cervical series, ribs, sternum, tail, and synsacrum are documented in (Figures 4-7).

The vertebral count should be interpreted as referring to the individual studied. There are records of 16 to 18 thoracic vertebrae and two to three lumbar vertebrae in *T. tetradactyla*, which demonstrates intraspecific anatomical variation (Hayssen, 2011; Sesoko *et al*., 2011).

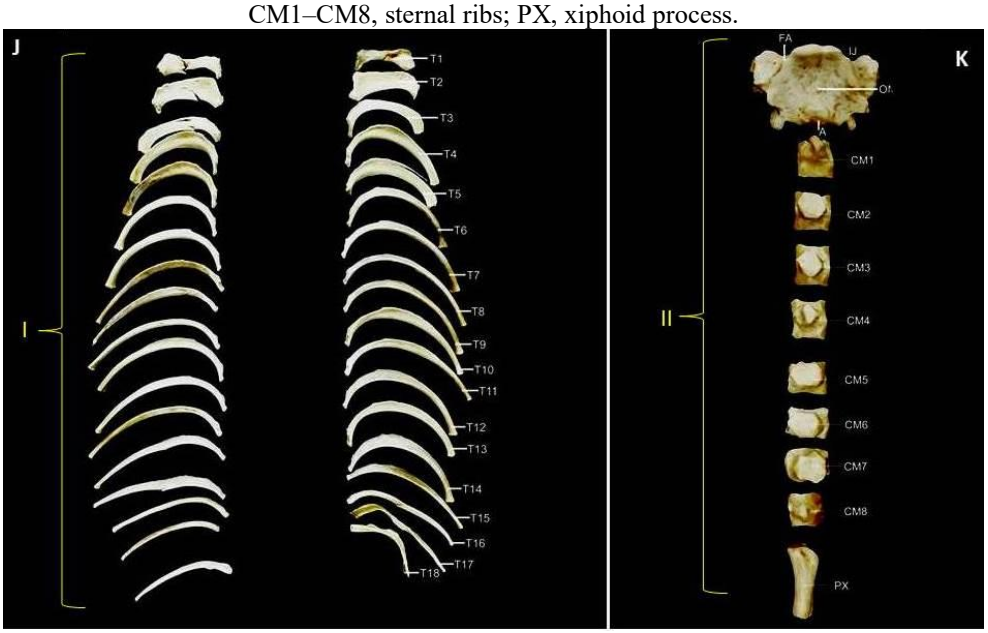
In the caudal thoracic and lumbar vertebrae, accessory joints related to xenarthrosis are observed. These joints increase the contact surfaces between successive vertebrae and contribute to trunk stability during activities that require strength from the forelimbs, such as digging and breaking open nests (Gaudin, 1999; Oliver *et al*., 2016). The synsacrum, in turn, forms a bony block firmly associated with the ilium and ischium; its vertebral delimitation requires caution due to the fusion of sacral and adjacent elements (Galliari and Carlini, 2015).

Figure 4. Cervical vertebrae of *Tamandua tetradactyla* in dorsal and right lateral views: I, atlas; II, axis; III, third cervical vertebra; IV, fourth cervical vertebra; V, fifth cervical vertebra; VI, sixth cervical vertebra; VII, seventh cervical vertebra.



Source: Prepared by the authors (2026).

Figure 5. Components of the thorax of Tamandua tetradactyla. (J) Eighteen pairs of ribs, associated with vertebrae T1–T18. (K) Sternum: FA, articular surface; IJ, jugular notch; OM, manubrium; A, articulation; CM1–CM8, sternal ribs; PX, xiphoid process.



Source: Prepared by the authors (2026).

Figure 6. *Caudal series of Tamandua tetradactyla, consisting of 42 caudal vertebrae (Cc1–Cc42).*

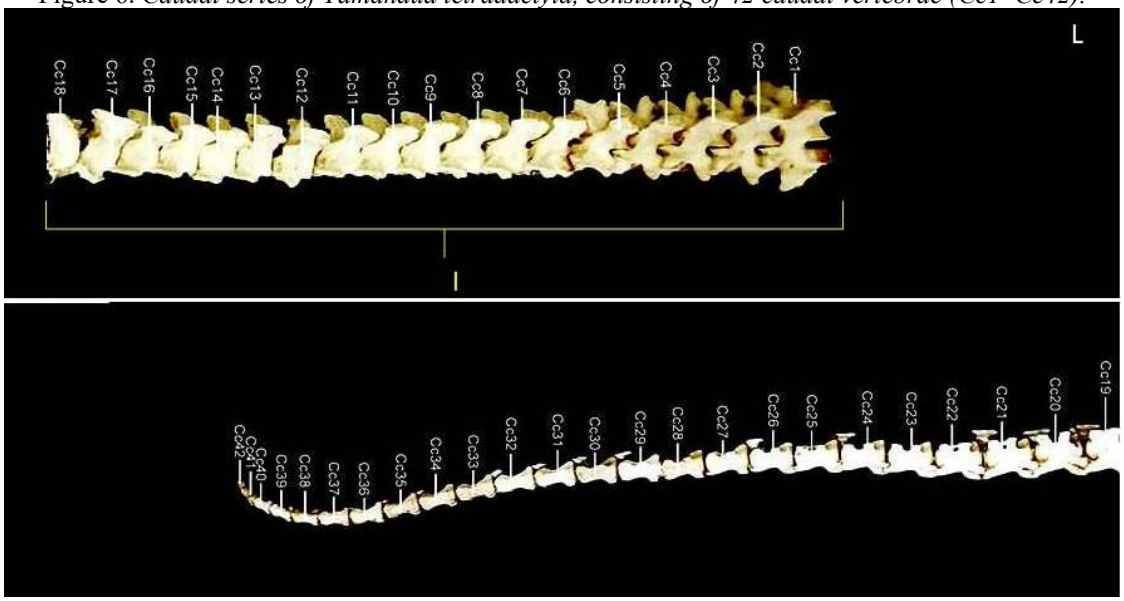


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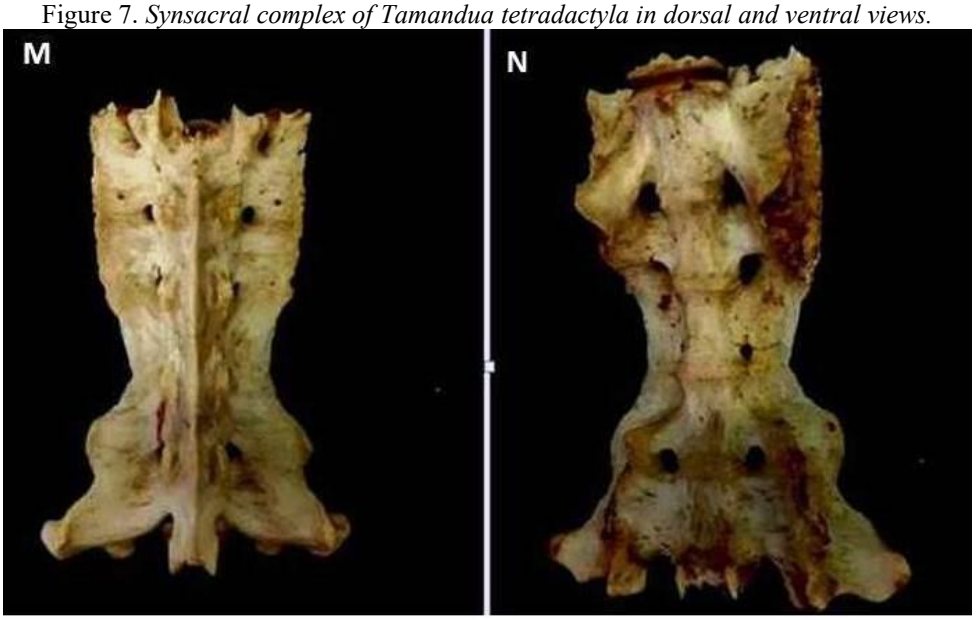
Figure 7. *Synsacral complex of Tamandua tetradactyla in dorsal and ventral views.*



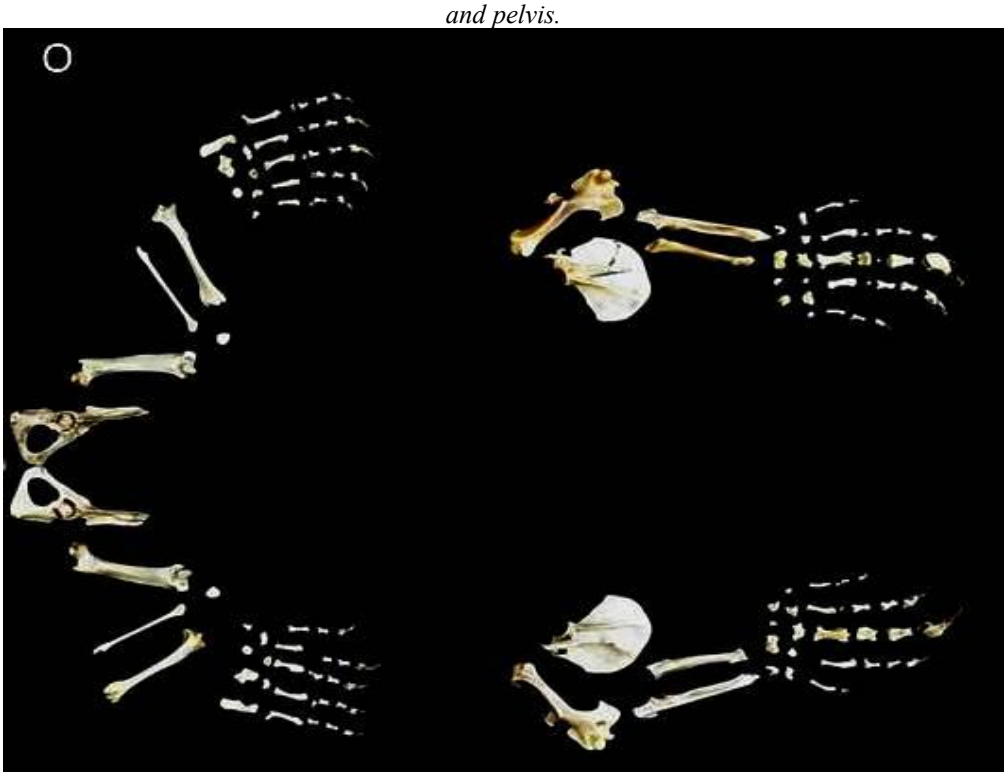
Source: Prepared by the authors (2026).

3.3 APPENDICULAR SKELETON

The appendicular skeleton consists of the cingula and the bones of the thoracic and pelvic limbs. In the thoracic limb, notable features include the broad scapula with a secondary spine, the well-developed deltoid tuberosity, the prominent medial epicondyle of the humerus, and the robustness of the hand bones. These characteristics increase the areas of muscle attachment and are related to digging, climbing, and defense functions

(Lins and Lins *et al*., 2019). The general organization of the appendicular elements is shown in (Figure 8).

Figure 8. *Dorsal view of the appendicular skeleton of Tamandua tetradactyla: thoracic limbs, hindlimbs, and pelvis.*



Source: Prepared by the authors (2026).

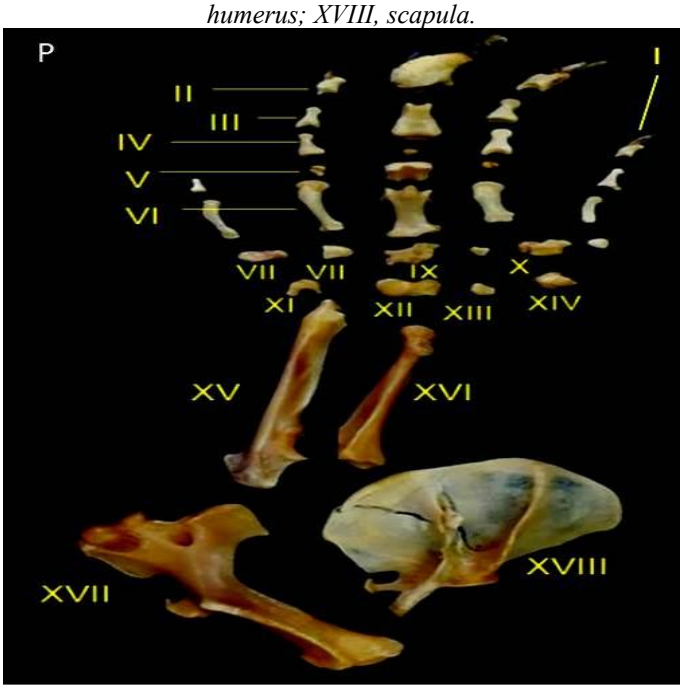
3.3.1 Thoracic Limb and Skeleton of the Hand

The hand consists of eight carpal bones arranged in two rows, five metacarpals, and five digits. The proximal row of the carpus contains the radial, intermediate, ulnar and accessory bones; the distal row contains carpal bones I through IV. Metacarpal III and the phalanges of digit III are particularly robust, reflecting the greater functional development of this digit.

Digit I has a proximal and a distal phalanx; digits II, III, and IV have proximal, medial, and distal phalanges. Digit V is not absent: it is rudimentary and represented by a single proximal phalanx, with no evident external expression. This finding corrects the traditional interpretation of a strictly tetradactyl hand and is consistent with the description by Machado Cruvinel *et al*. (2019). The distal phalanges associated with the claws are robust, especially in digit III (Figure 9).

Sesamoid bones were also observed in the metacarpophalangeal region. These structures, together with the conformation of the carpus and the support provided by the lateral surface of the hand, contribute to stability during terrestrial locomotion and help to keep the claws away from the substrate (Hayssen, 2011).

Figure 9. *Thoracic limb of Tamandua tetradactyla in dorsal view. I, claw; II, distal phalanx IV; III, middle phalanx IV; IV, proximal phalanx IV; V, sesamoid bones; VI, metacarpal IV; VII, carpal bone II (trapezoid); VIII, carpal bone I (trapezium); IX, carpal bone III (capitate or magnum); X, carpal bone IV (hamate or unciform); XI, radial carpal bone (scaphoid); XII, intermediate carpal bone (lunate); XIII, accessory carpal bone (pisiform); XIV, ulnar carpal bone (cuneiform); XV, radius; XVI, ulna; XVII, humerus; XVIII, scapula.*



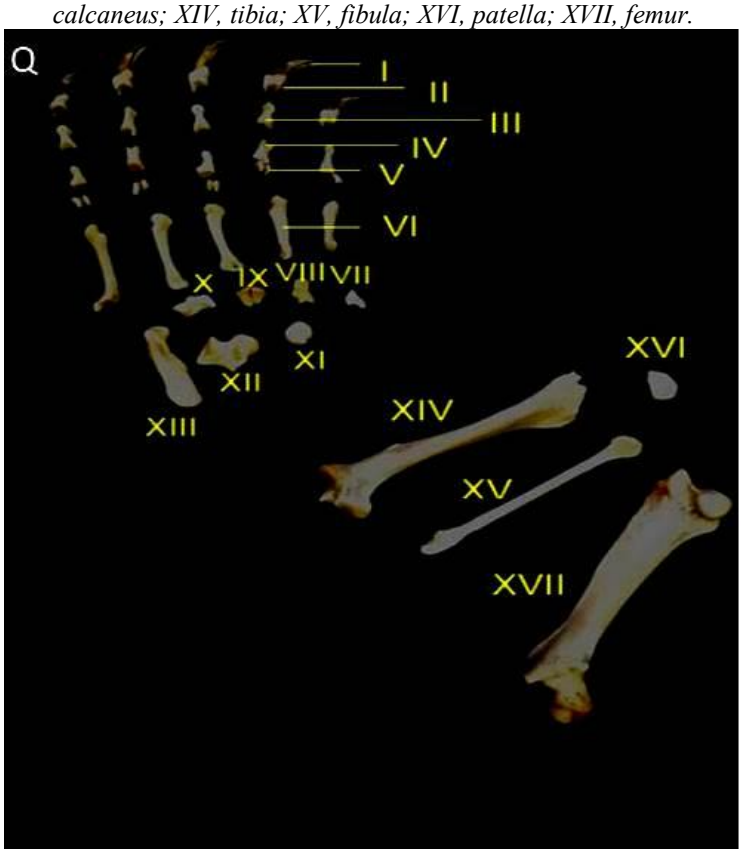
Source: prepared by the authors (2026).

3.3.2 Pelvic Limb and Skeleton of the Foot

The foot has five digits that are longer and slimmer than those of the hand and is composed of tarsal, metatarsal, and phalangeal bones. In the tarsus, the following bones were identified: the talus (astragalus); the calcaneus; the navicular bone; tarsal bones I, II, and III (medial, intermediate, and lateral cuneiforms); and tarsal bone IV (cuboid).

The five metatarsals gradually increase in length from medial to lateral and have expanded tips and approximately cylindrical bodies. Digit I has two phalanges, proximal and distal; digits II through V have three phalanges: proximal, medial, and distal. The distal phalanges are more robust than the others and support the claws, although they are smaller than the distal phalanges of the more highly developed digits of the hand (Figure 10).

Figure 10. *Dorsal view of the hindlimb of Tamandua tetradactyla. I, claw; II, distal phalanx of digit II; III, middle phalanx of digit II; IV, proximal phalanx of digit II; V, sesamoid bones; VI, metatarsal II; VII, tarsal bone III (lateral cuneiform); VIII, tarsal bone II (intermediate cuneiform); IX, tarsal bone I (medial cuneiform); X, tarsal bone IV (cuboid); XI, central tarsal bone (navicular); XII, talus (astragalus); XIII, calcaneus; XIV, tibia; XV, fibula; XVI, patella; XVII, femur.*



Source: prepared by the authors (2026).

4 CONCLUSION

The methodology employed allowed for the cleaning, bleaching, organization, and documentation of the skeleton without any evident macroscopic loss of structures. The separation of the bones by anatomical region was essential for verification and skeletal assembly, although a preexisting fracture in the left scapula was noted.

The specimen exhibited characteristics consistent with the morphofunctional specialization of anteaters, including an elongated and toothless skull, xenarthral joints, the synsacral complex, robust forelimbs, and the presence of a rudimentary fifth digit on the hand. This description contributes to the IBIMM's anatomical collection and may aid in teaching, comparative anatomy, and clinical-surgical interpretation.

Since the study was based on a single individual, vertebral counts and other morphological variations should not be generalized to the entire species. The absence of complete quantitative parameters from the bleaching stage also limits the exact

reproduction of the protocol. Studies with a larger number of specimens, comprehensive documentation of preparation conditions, and integration with radiographic or tomographic examinations are recommended.

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