

Skeletal anatomical, osteotechnical and osteoassembly description of the seagull *Larus domimicanus* (Lichtenstein – 1823) found dead, in the conservation units of the Jureia-Itatins mosaic, South coast of SP

Descripción anatómica esquelética, osteotécnica y osteomontaje de la gaviota *Larus domimicanus* (Lichtenstein - 1823) encontrada muerta en las unidades de conservación del mosaico Jureia-Itatins, litoral sur del Estado de São Paulo

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ABSTRACT

The southern gull or gull (*Larus dominicanus*) belongs to the Laridae family. It stands out for being the largest species among the seagulls frequently found in Brazil, reaching approximately 58 cm in length. Identification of these birds can be done through their plumage, which is divided into four distinct age categories. Typically, the female lays two to three eggs, and the responsibility for feeding the young is shared by both parents. The objective is to describe the morphology and skeletal anatomy in order to disseminate knowledge, highlighting the importance of such research for the literature in the area and as a specific objective the assembly of a structure that can help in the identification of the anatomical parts of the species, since it is There are few research specimens for this species. The study took place on the corpse of the animal found dead in the conservation units of the Jureia-Itatins mosaic, on the south coast of São Paulo. Using maceration and bleaching techniques to prepare the skeleton, it was possible to detail the bone structure, providing an understanding of the functionalities related to flight, nutrition and reproduction of this species, in addition to demonstrating the effectiveness and cost-

benefit of anatomical preparation methods. adopted. This approach aimed to evaluate the osteomounting procedure, which enabled an improved understanding of the seagull's skeletal structure. Thus, the final assembly of the skeleton became a tool to assist both veterinary medicine and biology students, emphasizing the relevance of the osteology and osteoassembly techniques presented in this work.

Keywords: seagull, *Larus dominicanus*, veterinary anatomy.

RESUMEN

La gaviota o gaviota del sur (*Larus dominicanus*) pertenece a la familia Laridae. Se destaca por ser la especie de mayor tamaño entre las gaviotas frecuentes en Brasil, alcanzando aproximadamente 58 cm de longitud. La identificación de estas aves se puede hacer a través de su plumaje, que se divide en cuatro categorías de edad distintas. Típicamente, la hembra pone de dos a tres huevos, y la responsabilidad de la alimentación de las crías es compartida por ambos padres. El objetivo es describir la morfología y la anatomía esquelética con el fin de difundir el conocimiento, destacando la importancia de este tipo de investigación para la literatura en el área y como objetivo específico el montaje de una estructura que puede ayudar en la identificación de las partes anatómicas de la especie, ya que es Hay pocos especímenes de investigación para esta especie. El estudio se realizó sobre el cadáver del animal encontrado muerto en las unidades de conservación del mosaico Jureia-Itatins, en el litoral sur de São Paulo. Utilizando técnicas de maceración y blanqueamiento para preparar el esqueleto, fue posible detallar la estructura ósea, proporcionando una comprensión de las funcionalidades relacionadas con el vuelo, la nutrición y la reproducción de esta especie, además de demostrar la eficacia y el coste-beneficio de los métodos de preparación anatómica adoptados. Este enfoque tenía como objetivo evaluar el procedimiento de osteomontaje, que permitía una mejor comprensión de la estructura esquelética de la gaviota. Así, el montaje final del esqueleto se convirtió en una herramienta de ayuda tanto para estudiantes de medicina veterinaria como de biología, poniendo de relieve la relevancia de las técnicas de osteología y osteomontaje presentadas en este trabajo.

Palabras clave: gaviota, *Larus dominicanus*, anatomía veterinaria

1 INTRODUCTION

The common tern (*Larus dominicanus*) is a species of seabird belonging to the Laridae family, found in various coastal and oceanic regions of the world (Branco; Ebert, 2002). This bird has an average length of 58 cm and an approximate weight of 940 grams (Junior, 2002). Adults display a color pattern where the back and upper part of the wings are dark, contrasting with the white head and belly. Its beak stands out for being yellow with a striking red spot at the end of the upper mandible, while its legs have a greenish-yellow hue (Branco, 2001).

Young individuals have darker plumage on the upperparts, marked by white spots, and a white belly with dark spots. Its beak is black and its feet have a pinkish-gray hue

(Barbieri, 2008). It is common for the female to lay two to three eggs, with both parents taking an active part in raising the young (Silva et al., 2000). There are five recognized subspecies of this bird: *Larus dominicanus dominicanus* (Lichtenstein, 1823), *Larus dominicanus austrinus* (J. H. Fleming, 1924), *Larus dominicanus judithae* (Jiguet, 2002), *Larus dominicanus melisandae* (Jiguet, 2002) and *Larus dominicanus vetula* (Bruch, 1853) as cited by Kaczmarek (2018).

Larus dominicanus can be seen in both small and large groups in the rocky coastal areas of Rio de Janeiro, as described by Sick (1997), and resting on the beaches of Ilha Comprida, located in the southeastern region of São Paulo, according to studies by Barbieri (2008). In the states of Santa Catarina and Rio Grande do Sul, this bird is seen throughout the year, occupying the beaches to rest and feed, as documented by Vooren and Brusque (1999). The region of the Cananéia-Iguape-Ilha Comprida estuary is particularly notable for its high primary productivity, which attracts a large number of invertebrates, fish and other coastal and marine birds, making it an area of high concentration for this species (Barbieri; Pinna, 2005).

According to the International Union for Conservation of Nature (IUCN), this species is classified as “Least Concern” in terms of conservation (Almeida, 2017). This classification reflects the relative stability of the global population and its wide geographical distribution. Gulls are known for their ability to adapt to different marine and coastal environments, and are often spotted on beaches, harbors, estuaries and urban areas close to the sea (Ebert et al., 2014). As Ebert (2015) points out, despite the favorable situation of the global population, some local populations may face challenges, such as habitat loss due to coastal development, marine pollution and predation by invasive species. It is therefore crucial to closely monitor these populations and implement appropriate conservation measures to ensure the long-term preservation of the gull and its marine ecosystem.

Osteology is the branch of anatomy that studies bones and their organization in the skeleton of living beings, mainly humans and animals. This discipline is fundamental not only for understanding the structure and function of the skeletal system, but also for studying bone diseases, evolution, paleontology and archeology (Cesar, 2015). Bone is a living, dynamic tissue that has several functions. It provides support and shape to the body, protects vital organs, facilitates movement by acting as attachment points for muscles, stores minerals such as calcium and phosphorus, and hosts the bone marrow,

where blood cells are produced. The complexity and diversity of bones reflect the wide range of functions they perform (Belloti; Tamaoki, 2013).

Osteology is divided into several subdisciplines. Descriptive osteology focuses on describing the shapes, structures and relationships of bones to each other. Functional osteology analyzes the functions of bones and the skeleton as a whole, such as support and leverage for movement. Comparative osteology studies the differences and similarities between the skeletons of different species, contributing to an understanding of evolution and phylogeny (Cesar, 2015). In the archaeological and paleontological context, osteology provides bases on the life of ancient societies and extinct species (Torrezin et al., 2021). The analysis of human and animal skeletons can reveal information about diet, health, lifestyle, species evolution and cultural practices (Lopes et al., 2019).

Within the fields of Veterinary Science and Biology, osteology has emerged as a key element in understanding the skeletal structure and function of animals, allowing for the diagnosis of bone pathologies, the development of orthopedic treatments and comparative research (Torrezin et al., 2021). By applying osteomontage techniques, professionals and scholars are able not only to visualize anatomical complexities in a practical context, but also to promote learning about the interrelationships between form, function and evolution, which is essential for education in these areas (Silva et al., 2023). This process, which ranges from the detailed study of bones to the reconstruction of skeletons, highlights the interdisciplinary role of osteology, culminating in osteomontage as an indispensable educational and research tool in these fields.

2 MATERIALS AND METHODS

This study used a specimen of a meridional gull (*Larus dominicanus*) found lifeless near the Institute of Marine Biology and the Environment - IBIMM, located in the region of Peruíbe (Jureia-Itatins Mosaic Units), on the south coast of São Paulo. Preliminary analysis of the specimen included assessing its weight, coloration and the presence of possible bruises or other marks indicating the cause of death.

After being collected, the specimen was transported to IBIMM's Veterinary Anatomy Laboratory, where it was stored under freezing conditions for preservation until the osteological study procedures began, in accordance with the guidelines of the institution's Animal Use Ethics Committee, approved at a meeting on 15/03/2024, under

number 008/2024. The next stage involved thawing the animal's body using hot water, preparing it for dissection.

Specific equipment was used for the dissection, including gloves, scalpels with different types of blades, tweezers of various models for delicate handling and scissors. The process focused on the careful removal of the surrounding soft tissues, facilitated by mechanical maceration. This technique involved submerging the carcass in hot water with detergent for approximately 24 hours, softening the tissues to facilitate their removal and reveal the skeleton more clearly.

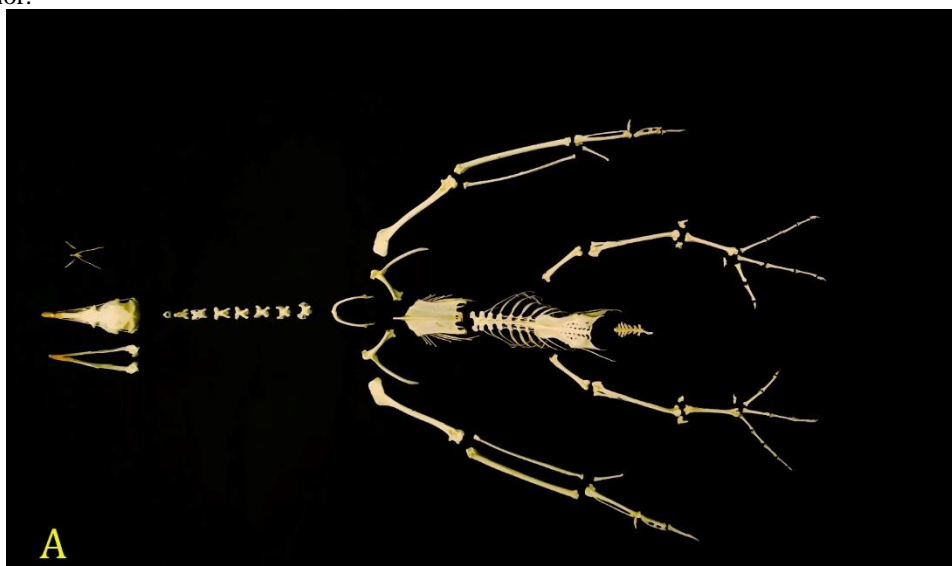
With the skeleton exposed, the bone structures were carefully disarticulated, followed by the organization and classification of the bones into specific anatomical groups, such as pelvic limbs, spine, skull and ribs, for a more detailed analysis. The bone bleaching stage involved immersing the pieces in a solution of water, sodium hypochlorite and 10% hydrogen peroxide for 24 hours. The structures were then dried in an oven at a temperature of 100°C for around 20 hours.

Finally, a thorough analysis and identification of the bone structures was carried out, culminating in osteomontage. This phase allowed the skeleton to be reconstructed without fixing the bones, preserving the animal's original anatomy. To document and better visualize the work carried out, the assembled structures were photographed against a black cardboard background.

3 RESULTS

The practical work, from dissection to the assembly of the complete skeleton of the gull (*Larus dominicanus*) culminated in a process that took approximately 5 days, with a daily working day of 5 hours. Figure 1 illustrates the specimen of the Mediterranean Gull (*Larus dominicanus*) found in the Perúibe region, after dissection. The specimen is shown in a laboratory environment, standing out on a flat surface for initial inspection. The image offers an organized view of the bones arranged on a work surface, each anatomical set has been identified and numbered for reference, including pelvic limbs, vertebral column, skull and ribs.

Figure 1: Complete skeleton with all the structures of the gull (*Larus dominicanus*). Source: Prepared by the author.



SKULL

The skull of the Gull (*Larus dominicanus*) has remarkable morphological characteristics. Its robust and aerodynamic structure provides support during flight and support for the sensory organs essential for feeding and orientation during foraging activities (Kaczmarek et al., 2018). The mandible, distinguished by its strength and serrated edges, is a fundamental adaptation for the efficient capture and manipulation of prey, while the tapered beak is adapted for piercing and grasping food in different marine environments (Barbieri, 2008).

Figure 2 shows two different angles of a meridional gull's skull. The image on the left (B) shows the anterior view of the skull, focusing on the beak (I) and frontal bone (II), showing details of the bone structure that contribute to the aerodynamic shape and to the bird's grasping and feeding functions. On the right (C), we can see the posterior view of the skull, highlighting the occipital bone (III), a crucial part for connecting the skull to the vertebral column. The photograph details the complex and specialized morphology of the gull's skull, essential for understanding the biomechanics of flight and the evolutionary adaptations related to its diet and behaviour.

Figure 2: Anterior view: I. Beak, II. Frontal bone. C posterior view: III. Occipital bone. Source: Prepared by the author.

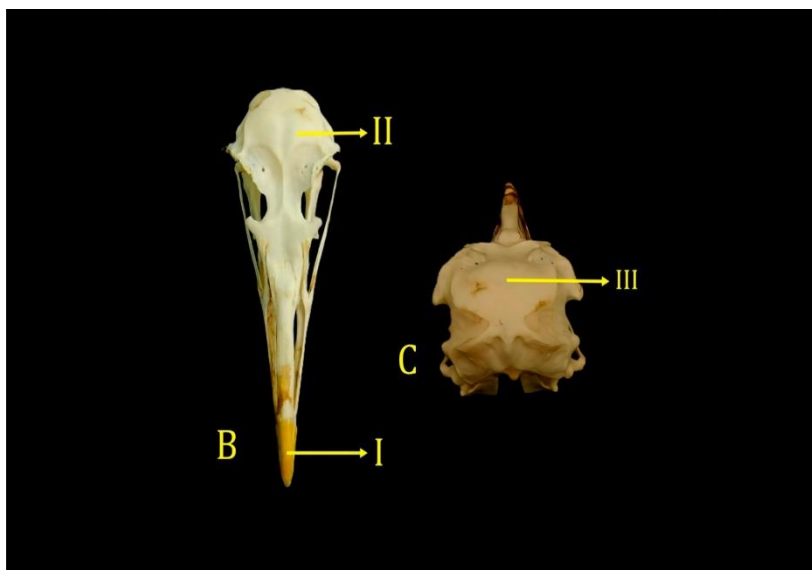


Figure 3 shows the two lateral views of the skull of a meridional gull, detailing important components of the cranial anatomy. On the left (D), we have the right lateral view of the skull, where we can see the orbit (IV), the lacrimal bone (V) and the nasal bone (VI), highlighting the parts that form the ocular cavity and the base of the bird's olfactory system. On the right side (E), the left lateral view is shown, focusing on the premaxilla (VII), which is essential for the formation of the beak, together with the zygomatic bone (VIII) and the quadrate bone (IX), which are crucial for mandibular articulation and the lateral structuring of the skull. These views provide a deeper understanding of the lateral anatomy of the skull, allowing insights into the functionality and evolutionary adaptations of the gull.

Figure 3: D - Right lateral view: IV. Orbit, V. Lacrimal bone, VI. Nasal bone. E - Left lateral view: VII. Premaxilla, VIII. Zygomatic bone, IX. Square bone. Source: Prepared by the author.

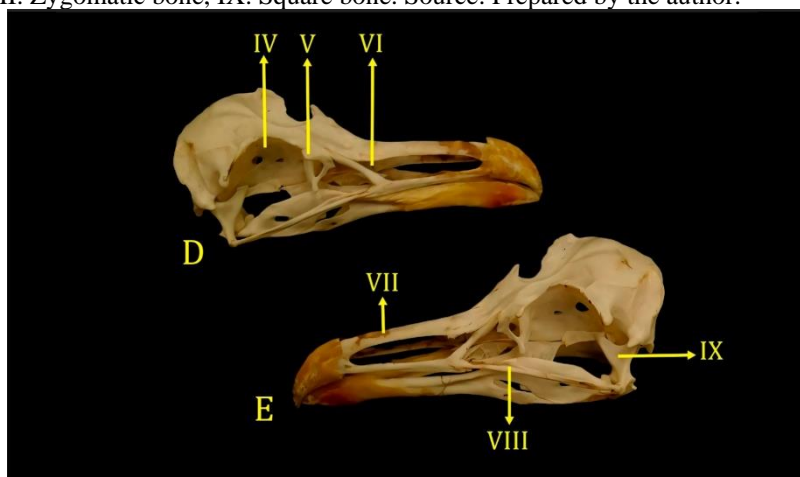


Figure 4 shows the fundamental elements of the cranial anatomy of the meridional gull. On the left (F), we can see the dorsal view of the mandible (X), highlighting the shape and structure adapted for feeding and handling prey. On the right (G), the image shows the anterior view of the skull, with emphasis on the external acoustic meatus (XI), indicative of the bird's ear canals. This combination of views offers a detailed perspective of the highly developed grasping abilities and senses that are vital for the survival of this marine species.

Figure 4: F - Dorsal view: X. Mandible. G - Anterior view: XI. External acoustic meatus. Source: Prepared by the author.

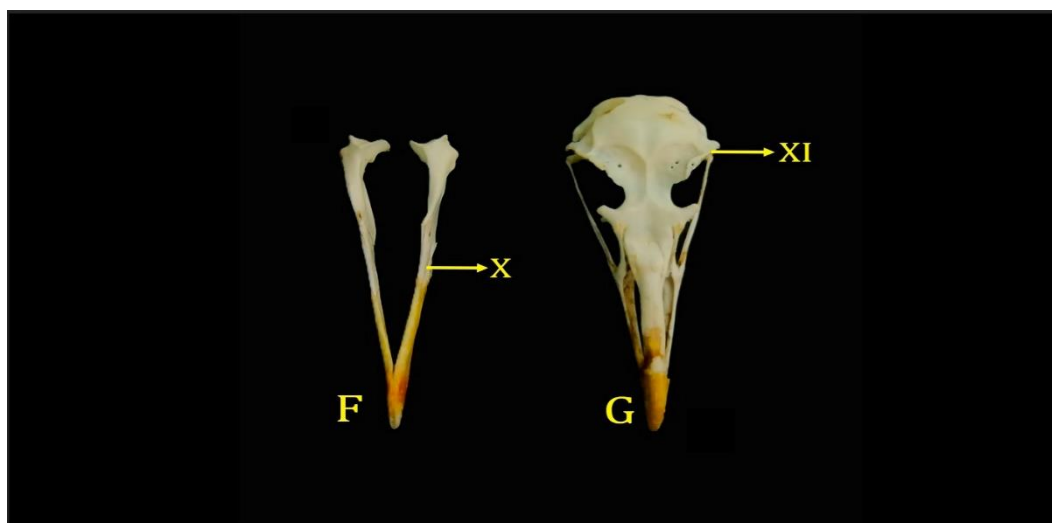
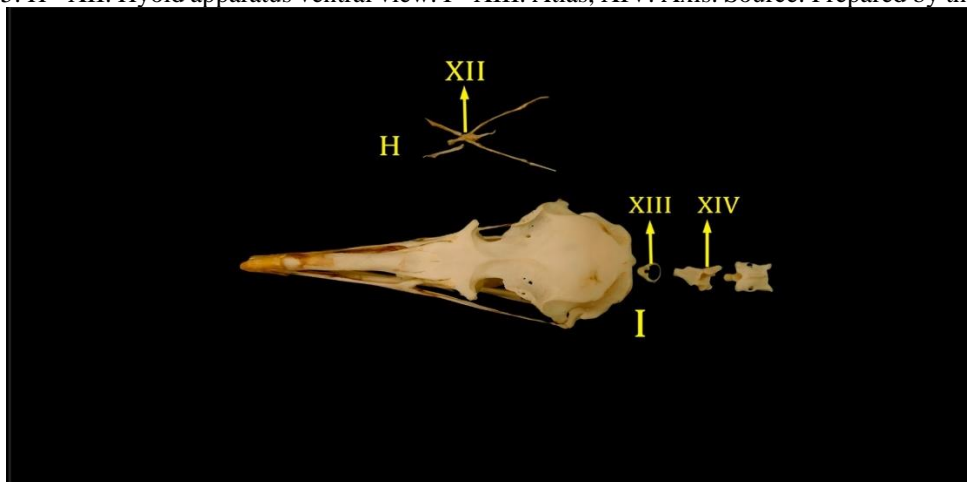


Figure 5 shows the different bone structures of the upper part of the gull's skeleton. In the upper part of the image (H), we see the hyoid apparatus in ventral view (XII), a structure that supports the tongue and is involved in swallowing. Below, in the same image (i), is the lateral view of the skull with the focus on the atlas (XIII) and axis (XIV), the first two cervical vertebrae that allow the head to move. The precision of this image offers a detailed visualization of the complexity and specialization of the bone structures that are crucial to the feeding behaviour and cervical mobility of this species.

Figure 5: H - XII. Hyoid apparatus ventral view. I - XIII. Atlas, XIV. Axis. Source: Prepared by the author.

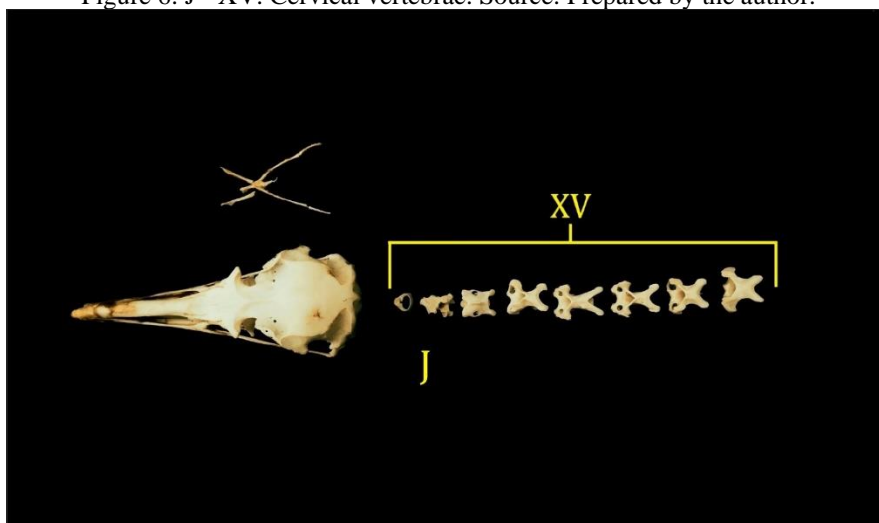


CERVICAL SPINE

Analysis of the vertebral column reveals a highly flexible structure segmented into different regions. The elongated cervical vertebrae allow for a wide range of movement, facilitating the rapid identification and pursuit of prey during flight. The robust and segmented thoracic and lumbar vertebrae provide structural support for the body, ensuring stability and resistance during aerial and aquatic activities.

Figure 6 shows a set of cervical vertebrae (XV) lined up side by side, highlighting the variation and specific articulation of this region of the meridional gull's skeleton. Above the vertebrae, the hyoid apparatus (J) is shown, responsible for supporting the tongue and larynx. This image provides a clear view of the bird's skeletal adaptations for neck movement and swallowing, vital components for its ability to forage and consume food.

Figure 6: J - XV. Cervical vertebrae. Source: Prepared by the author.

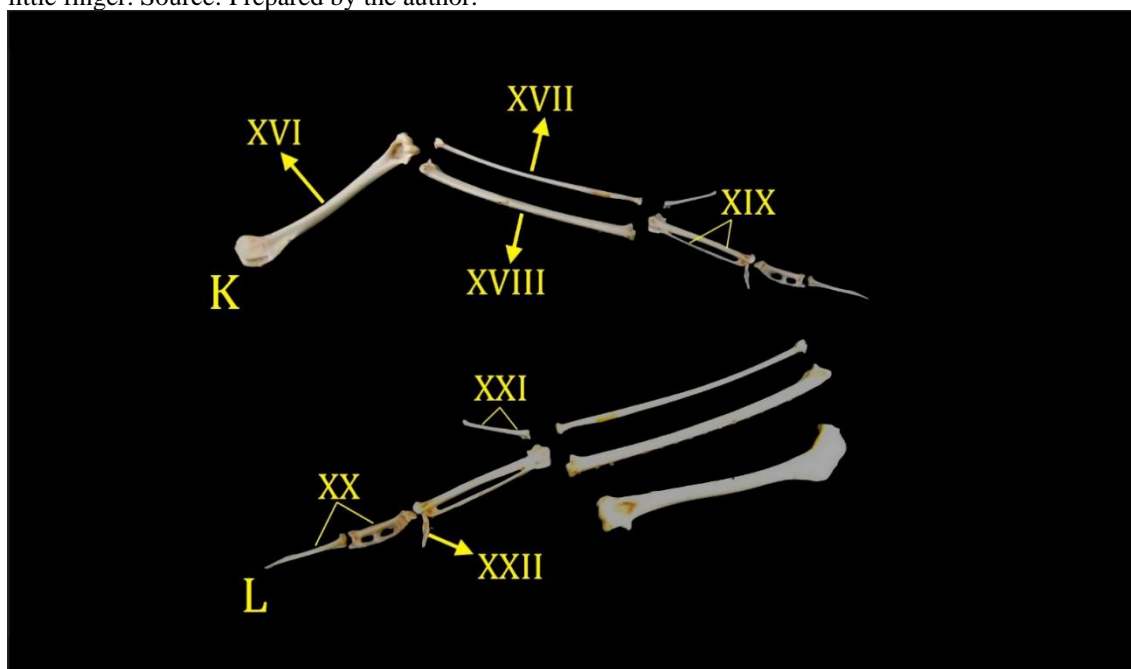


THORACIC LIMBS (WING)

The wings are made up of a variety of bones, each playing a crucial role in their aerodynamic performance. The ulna and radius, long and slender, provide the necessary support for sustained flight, while the metacarpals contribute to structuring the wing. This combination of bones allows the gull to glide and maneuver with agility, optimizing its ability to forage and evade predators.

Figure 7 illustrates the bony components of the meridional gull's wings, detailing the anatomy of the wing limbs that are essential for flight. On the left (K), we see the humerus (XVI), radius (XVII) and ulna (XVIII), together with the carpometacarpal bone (XIX), structures that make up the main support of the wing. In the image on the right (L), the phalanges of the fingers are shown, with emphasis on the two phalanges of the greater finger (XX), the phalanges of the alunar finger (XXI) and the single phalanx of the lesser finger (XXII), all of which are crucial for the extension and mobility of the wings during flight. This set of bones shows the evolutionary adaptations that allow the gull to glide and maneuver efficiently in the air.

Figure 7: K - Right: XVI. Humerus XVII. Radius, XVIII. Ulna, XIX. Carpometacarpal bone. L - Left: XX. Two phalanges of the (greater) finger, XXI. Phalanges of the alunar finger, XXII. Single phalanx of the little finger. Source: Prepared by the author.



CHEST (THORACIC REGION)

The thoracic region, located between the neck and abdomen, houses essential organs, including the heart and lungs. The sternum is a flat bone located in the chest.

RIBS

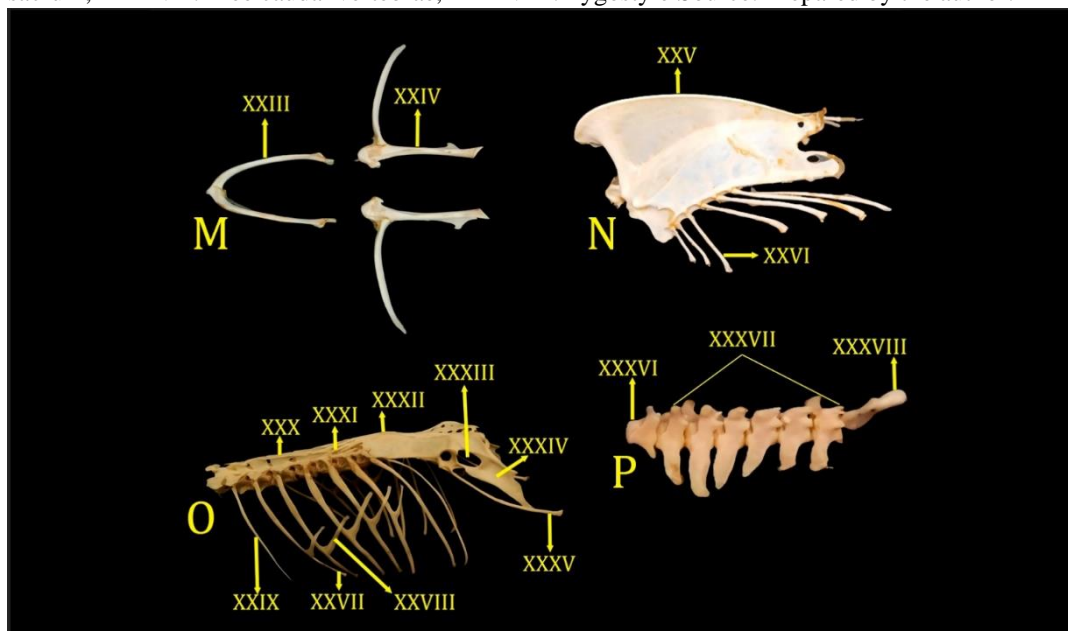
The ribs are long, curved bony structures that make up the chest wall of animals, providing protection for vital organs. They originate from the vertebral column and extend towards the sternum or the adjacent costal cartilages.

CAUDAL END

The caudal end of the sacrum, the free caudal vertebrae and the pygostyle are essential structures in the anatomy of gulls and other birds. They provide support, mobility and control during flight and other activities, such as movement on the ground. The pygostyle, in particular, serves as an anchor point for the muscles that control the tail feathers, contributing to stability and control during flight.

Figure 8 is a composite of images highlighting various bone structures of the meridional gull. The upper left image (M) shows the furcula (XXIII) and the coracoid (XXIV), both of which are essential for muscular support of the wings during flight. On the right (N), the keel of the sternum (XXV) and the sternal rib (XXVI) are shown, indicative of the robustness of the thorax and its ability to protect the internal organs. The lower left image (O) shows a series of vertebral ribs (XXVII - XXX), some with an uncinate process (XXVIII), highlighting the flexibility and protection offered to the thoracic region. Finally, on the right (P), you can see a series of caudal vertebrae (XXXI - XXXVI), culminating in the pygostyle (XXXVII), which are essential for the mobility and support of the tail. Together, these structures make up the complex skeleton that allows the bird its various abilities, from flight to precise movements on land.

Figure 8: M - XXIII. Furcula, XXIV. Coracoid. N - XXV. Sternal keel, XXVI. Sternal rib. O - XXVII. Vertebral rib, XXVIII. Uncinate process, XXIX. Floating rib, XXX. Notary, XXXI. Thoracic vertebra, XXXII. Ilium, XXXIII. Closed foramen, XXXIV. Ischium, XXXV. Pubis. P- XXXVI. Caudal end of sinsacrum, XXXVII. Free caudal vertebrae, XXXVIII. Pygostyle Source: Prepared by the author.



PELVIC LIMBS

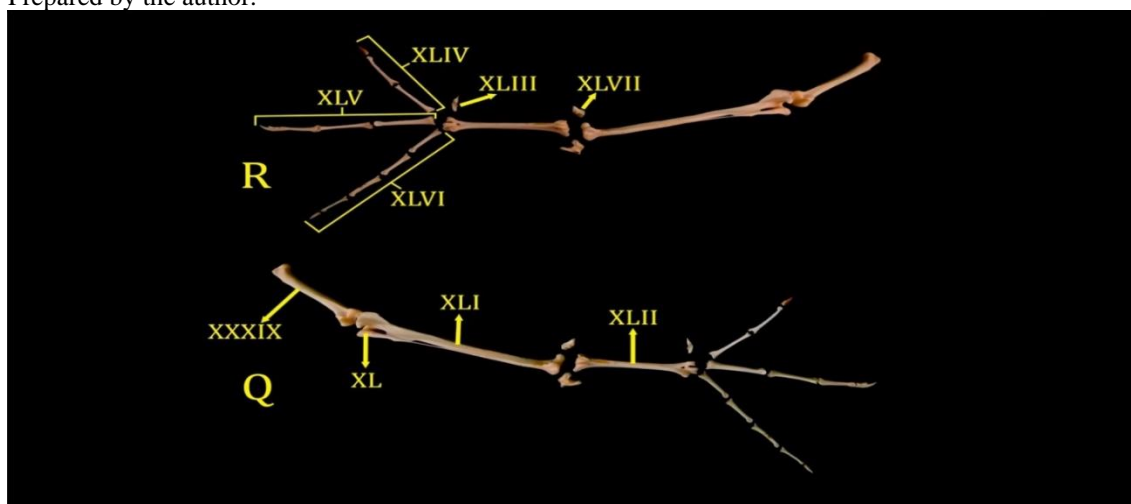
The pelvis is a robust and flexible structure, essential for supporting body weight during landing and terrestrial locomotion. Made up of the iliac, ischium and pubis bones, the pelvis provides stability and support for incubating eggs during the reproductive period. It also plays a fundamental role in the efficient transmission of muscular forces during flight and other physical activities.

Analysis of the anatomy of the legs and feet reveals specific adaptations for different environments and activities. The robust legs, made up of the femur, tibia and fibula, provide support and propulsion during terrestrial locomotion and running to launch into flight. The feet, equipped with long, articulated toes and sharp claws, are ideal for grasping and manipulating prey, as well as traversing uneven surfaces with ease.

Figure 9 shows details of the meridional gull's lower limbs. The image on the left (Q) shows the femur (XXXIX), fibula (XL) and tibiotarsus (XLI), highlighting the robustness and complexity of the bones that make up the bird's legs. We can also see the metatarsal bone (XLII), which is essential for support and locomotion. On the right (R), the image shows the bones of the toes, starting with Finger 1 (XLIV), which has a single phalanx, followed by Finger 2 (XLV), with two phalanges, Finger 3 (XLVI), with three phalanges, and Finger 4 (XLVII), the most complex, with five phalanges, which demonstrate the specialization of the limbs for different functions. The image also

highlights the hypotenar sesamoid bones (XLIII and XLVIII), small bones that help with the mechanics of the foot during locomotion. This bone configuration allows the gull to adapt to both walking on land and swimming.

Figure 9: Q - XXXIX. Femur, XL. Fibula, XLI. Tibiotarsal bone, XLII. Metatarsal tarsal bone. R - XLIII. Hypotarsal sesamoid bone, XLIV. Finger 1 (two phalanges), XLV. Finger 2 (three phalanges), XLVI. Finger 3 (four phalanges), XLVII. Finger 4 (five phalanges) XLVIII. Hypotarsal sesamoid bone. Source: Prepared by the author.



4 CONCLUSION

The research dedicated to the bone anatomy of the Mediterranean Gull (*Larus dominicanus*) has provided a detailed understanding of the anatomy, morphology and biology of this species, while underlining the media role of such studies in the conservation of marine biodiversity. Detailed analysis of cranial, mandibular, wing, leg and pelvic bones revealed the evolutionary strategies that enable this bird to adapt and thrive in globally diverse coastal habitats.

The maceration and bleaching techniques used to prepare the gull skeleton proved to be efficient, preserving the integrity of the bones and resulting in a whitish color that was desirable for anatomical study. The organization of the bones into anatomical groups and the subsequent osteomontage not only made it easier to visualize the structural complexities, but also emphasized the importance of consulting specialized literature, which increased the precision of our work.

The careful choice of techniques for preparing the anatomical pieces not only guaranteed the quality of the work, but also provided advantages in terms of efficiency and cost. This practical activity not only enriched the learning of the students directly

involved, but also served as a valuable resource for the professional training of future veterinarians and biologists.

This study offers not only an enrichment to the body of academic knowledge about *Larus dominicanus*, but also serves as a didactic resource for teaching veterinary anatomy, promoting understanding of anatomical nuances in a practical and applicable context. In turn, this benefits educators, conservationists and researchers by providing tools for a more informed approach to the protection and management of marine species.

However, research is not without its limitations. Reliance on a single specimen may restrict the generalizability of findings to the species as a whole, and the techniques used, while effective, could be improved to further reduce damage to delicate bones during preparation. For future studies, the inclusion of a greater number of specimens is recommended, allowing for a more comprehensive comparative analysis that could reveal intraspecific variations. In addition, the development of less invasive techniques for the preservation and preparation of bones could offer an even clearer view of the morphological adaptations of the species. Continuing to expand knowledge in this area will not only advance academia, but also contribute to more effective conservation strategies and public awareness of the ecological importance of gulls and other seabirds.

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