Anatomical description of the skeleton of the domestic duck (Tadorna tadorna – Linnaeus, 1758) found dead at the IBIMM Research Center in São Paulo – SP - Brazil

Descripción anatómica del esqueleto del pato doméstico (Tadorna tadorna - Linnaeus, 1758) encontrado muerto en el Centro de Investigación del IBIMM en São Paulo - SP – Brasil

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ABSTRACT

The domestic duck (Tadorna tadorna) is an aquatic bird with anatomical and physiological characteristics that have contributed to its worldwide occurrence. Despite being a well-known animal globally, specific anatomical studies regarding its skeletal composition are non-existent. In this sense, the present study aimed, in addition to describing the skeletal anatomy of the duck, also to demonstrate the laboratory techniques for manipulating the carcass and bones of animals, with the aim of providing the assembly of the skeleton for academic purposes, from an animal found dead inside the Research Center of the Institute of Biology and Environment, located in Santa Cruz das Palmeiras - São Paulo, Brazil. Therefore, it is concluded that the study of veterinary anatomy based on osteology and anatomy techniques contributes greatly to professional veterinary medical training.

Keywords: duck, Tadorna tadorna, skeleton, osteology, veterinary anatomy.

RESUMEN
El pato doméstico (Tadorna tadorna) es un ave acuática con características anatómicas y fisiológicas que han contribuido a su presencia en todo el mundo. A pesar de ser un animal muy conocido a nivel mundial, no existen estudios anatómicos específicos sobre su composición esquelética. En este sentido, el presente estudio tuvo como objetivo, además de describir la anatomía esquelética del pato, también demostrar las técnicas de laboratorio para la manipulación de la carcasa y los huesos de los animales, con el fin de proporcionar el montaje del esqueleto para fines académicos, a partir de un animal encontrado muerto dentro del Centro de Investigación del Instituto de Biología y Medio Ambiente, ubicado en Santa Cruz das Palmeiras - São Paulo, Brasil. Por lo tanto, se concluye que el estudio de la anatomía veterinaria basado en técnicas de osteología y anatomía contribuye en gran medida a la formación médica veterinaria profesional.

Palabras clave: pato, Tadorna tadorna, esqueleto, osteología, anatomía veterinaria.

1 INTRODUCTION

The anatomical evolution of birds, which is completely different from that of other species, has made it easier for them to adapt to different habitats, which makes the osteology of these animals complex and necessary in order to understand each skeletal modification that allows them to be inserted into aerial, terrestrial or aquatic environments.

In this sense, one of the main characteristics that allows both flight and swimming is the lightness of the skeletal structure due to factors such as: reduction in the number of bones; fusion of bones forming plates that provide resistant and simplified movements; modification of the thoracic limb into a wing; reduction in bone density; absence of internal bone matrix (pneumatic bones) and air sacs extending into the medullary cavity in the largest bones (King, 1986; O'malley, 2005; Tully, 2009; Arent, 2010 apud Silva, 2013).

According to the Brazilian Committee of Ornithological Records, there are more than 12,000 species of birds on the planet and approximately 2,000 are found in Brazil. Among them is the duck, which is well known around the world for inhabiting places such as ponds and rivers and having a very distinctive beak and feet. The duck belongs to the Anseriformes order, which is made up of surface-swimming birds such as teals and geese, which have much more caudal pelvic limbs compared to other species as a way of improving propulsion in water. In addition, animals of this order have dense plumage, a uropygial gland, which produces waterproofing oil for the feathers, and feet with interdigital membranes that help with swimming (Benedito, 2015).

With regard to systematics and phylogeny, researchers say that the classification of these animals can be started from records dating back up to 99 million years, during the late Cretaceous period. The fossils are classified as Neornithes, a superorder that can be divided into Neoaves and Galloanserae, the latter being understood as the current orders of Anseriformes and Galliformes. The Anseriformes can also be divided into Anhimidae, Anseranatidae and Anatidae (Benedito, 2015). This study will deepen our knowledge of the osteology of animals in the latter suborder (Anatidae), which includes ducks such as the Tadorna tadorna, teal, geese and swans.

According to Silveira and Oliveira (2008), the maintenance of zoological collections is neglected in most teaching and research institutions, and many collections can be considered incomplete. The authors point out that around a third of bird species are not included in any collection in the world and state that animal skeletons help with teaching activities, as they provide more precise information on the adaptations of vertebrate beings, such as posture and locomotion, as well as phylogenetic analysis of different species.

Expanding the collection of osteological descriptions of animals not only allows for the continuous updating of anatomy studies, but also guarantees the possibility of improving other areas of Veterinary Medicine:

> Most anatomical features are described in a generalized way or remain unknown. In this sense, the data obtained through anatomical approaches, whether macro or microscopic, can help in the knowledge and determination of species-specific characteristics, or even subgroups, of the great diversity that is the Brazilian fauna. In addition, they can serve as a reference for the areas of: surgery, clinic and animal rehabilitation, preventing common mistakes from occurring due to frequent homologies with domestic animals. (Aversi-Ferreira apud Ferreira, 2008, p. 2).

The field of osteology is very vast and can be divided into several main areas, including descriptive, functional and comparative osteology. Descriptive osteology involves the structural bone part of a skeleton, while functional osteology relates the function of each bone to the physiology of the organism, and comparative osteology makes it possible to point out similarities or individualities in the skeletons of different species (Cesar, 2015). In addition, the in-depth study of osteology also guarantees the explanation of other physiological characteristics of animals, such as diet, lifestyle and can reveal characteristics that determine the evolution of each species (Lopes et al., 2019).

In Veterinary Medicine, the study of animal skeletons guarantees the diagnosis of bone diseases, improves comparative analysis and enables new studies and treatments to be created in the field of orthopaedics (Torrezin et al., 2021). Osteomontage allows for the complete analysis of bone structure in a practical context, which is essential for learning by professionals in this field (Silva et al., 2023).

In addition, it should be emphasized that when working with wild animals there is a great difficulty in osteological representation due to the way the animals arrive at anatomy laboratories, requiring a constant search for new methods and techniques for handling skeletons, which further enriches science. According to Ferreira, Ebone, Brito, et al., (2015) there is a dilemma in obtaining fresh cadavers in good condition, as most animals are run over or are in a state of advanced cadaveric decomposition.

Consequently, this study aims to improve the scientific literature related to the domestic duck, which is lacking, as well as demonstrating the importance of arousing the interest of the community of students and professionals in Veterinary Medicine and Biology in subjects related to the anatomy of wild animals.

No osteological descriptions of Tadorna tadorna have been found in the literature, so the main aim of this study is to characterize the skeletal system of this species in order to complement osteological studies of birds and expand knowledge of the anatomy of wild animal veterinary medicine

2 MATERIAL AND METHODS

This study used a specimen of the duck species Tadorna tadorna found dead at the Research Center of the Institute of Marine Biology and the Environment - IBIMM located at Fazenda Palmares in Santa Cruz das Palmeiras - SP. Due to the animal's state of decomposition, it was impossible to detect the cause of death.

The animal was taken by workers from the institute, stored and frozen in the freezer of the Veterinary Anatomy Laboratory. The steps for preparing the osteology began, which was approved and authorized under protocol number 026/2023, in accordance with the rules of the Institution's Ethics Committee on the Use of Animals. After being thawed using boiling water, the dissection of the animal began.

The materials used for dissection were: gloves, scalpel handles with blades (various), dissecting forceps (rat tooth, straight, cotton) and scissors (blunt and fine).

The organs and muscles were discarded and mechanical maceration was carried out as a form of manual stripping to remove all the soft tissue structures that were close to the bones. This stripping was made easier by heating the animal's body in boiling water and detergent, leaving the carcass in this solution for around 24 hours to soften all the soft tissues. After this cleaning, the animal's skeleton was revealed with greater precision, and it was possible to disarticulate it in order to separate the bones and then group each bone into anatomical groups such as “right pelvic limb”, “left pelvic limb”, “vertebral column”, “skull”, “ribs” and so on.

To whiten the bones, they were immersed in a mixture of water with sodium hypochlorite and 10% hydrogen peroxide for a period of 24 hours. The structures were then placed in an oven at a temperature of 100°C for around 20 hours to dry (Lopes, et al., 2019).

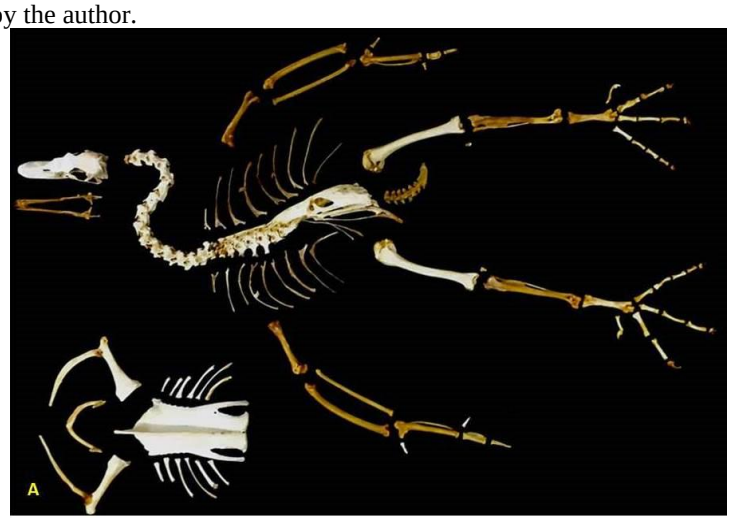
Finally, the bone structures were analyzed and identified, which helped in the osteomontage without fixing the bones, followed by the preassembly of the animal for photographic recording, which was done on a black background with cardboard paper for better visualization.

3 RESULTS

COMPLETE SKELETON

Figure 1 shows the osteomontage of the complete skeleton of a domestic duck (Tadorna tadorna), with all the structures ringed for anatomical comparison.

Figure 1 - A, complete skeleton of the domestic duck (Tadorna tadorna) to visualize the bone structures. Source: prepared by the author.



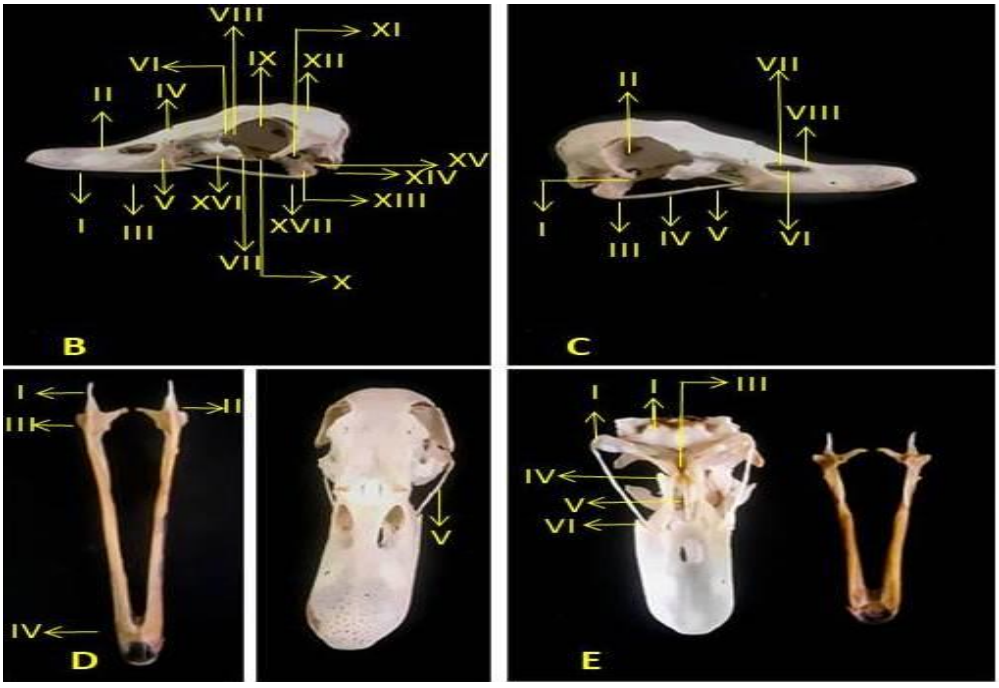
SKULL

In birds, the skull is made up of relatively thin bones and the mandible protrudes into the beak, a keratinized structure without the presence of teeth as in mammals (O'malley; Arent apud Silva, 2013). There are particularities that can be mentioned according to figure 2B, 2C, 2D, 2E:

The frontal bones are well developed, as are the tympanic cavity and the orbits, which are separated by the interorbital septum. Rostral to the frontal bones, the nasal bones (IV) make up practically the entire nasal cavity. Figure 2B

The zygomatic is divided into the jugal bone (IV) in the rostral portion and the quadratus jugal bone (III) in the dorsal portion (Figure 2C). The square bone (XIII) is exclusive to birds and is located between the mandible and the skull. Its main characteristic is high mobility and rotation, helping to open and close the beak efficiently (Romão, 2011). Figure 2B

Figure 2 - In B: Skull in left lateral view, where I - incisor bone, II - temporal process, III - ranfoteca, IV - nasal bone, V - maxillary process of the nasal bone, VI - lacrimal bone, VII - palatine bone, VIII - ethmoid bone, IX - Olfactory nerve foramen, X - Frontal process, XI - Alispenoid, XII - Frontal bone, XIII - Square bone, XIV - Temporal process, XV - External acoustic pores, XVI - Maxillary process of the maxillary bone, XVII - Jugal bone.
In C: Skull in right lateral view, with I - Orbital arboral process, II - Optic foramen, III - Quadratus jugal bone, IV - Jugal bone, V - Maxillary zygomatic process, VI - Nostrils, VII - Ethmoid bone, VIII - Temporal process.
In D: Mandible and skull dorsal view, where I - posterior angular process, II, angular bone, III articular bone, IV dental bone, V jugal bone;
In E: Skull and mandible in ventral view, I - medial condyle of the quadrate bone, II - lamina parasphenoidalls, III - tuba auditiva communis, IV - pterygoid bone, V - fossa choanalis, VI - maxillary bone.



The caudal part of the skull (figure 3) can be seen:

The occipital bone (IV) has only one condyle ventral to the foramen magnum (VII), which articulates with the first vertebra of the spine, the atlas, and with the odontoid process of the axis. This allows the head to move to a greater extent than in mammals (Silva, 2013). Figure 3D

Figure 3: in D - Skull in caudal view, with I - Parietal bone, II - Transverse nuchal crest, III - External occipital crest, IV - Occipital bone, V - Square bone, VI - Foramen magnum, VII - Temporal process. Source: prepared by the author.

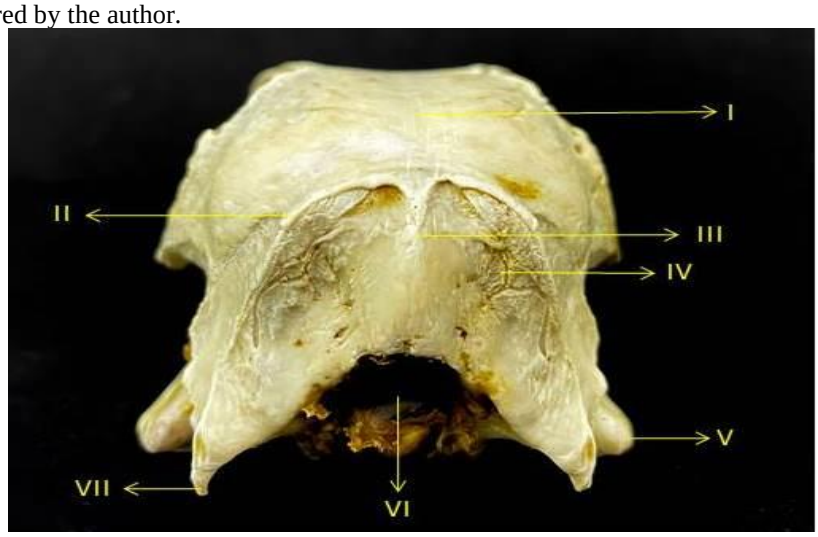


Figure 4 also shows the entire structure of the duck's vertebral column, as will be demonstrated below:

CERVICAL VERTEBRAE

There are 14 cervical vertebrae, which together form an S-shaped structure, controlling impact during flight. Figure 4F (I)

THORACIC VERTEBRAE

There are 7 thoracic vertebrae in total which articulate via the costal fovea with each rib. However, the last vertebra is fused together to form the lumbar and sacral vertebrae, which will be described below (Romão, 2011). Figure 4F (II)

LUMBAR AND SACRAL VERTEBRAE

All the lumbar and sacral vertebrae (around 11 to 14), together with the last thoracic and first coccygeal vertebrae, are fused together in the bone structure of the ilium. This occurs in all birds shortly after birth and the fusion forms the so-called sinsacral or

lumbosacral bone, which protects the animal's entire abdominal cavity (Romão, 2011). Figure 4F

CAUDAL VERTEBRAE

There are around 8 caudal vertebrae, also called coccygeal vertebrae, the first of which forms the sinsacral bone; 6 of them are free, allowing the tail to move; and further caudally there is a final segment that also originated from the functioning of the coccygeal vertebrae called the pygostyle (Silva, 2013). Figure 4F (V)

COXAL AND PIGOSTYLE

The union of the ilium, ischium and pubis forms the coxal bone, which communicates with the femur and shows an opening in the ventral part that is essential for egg laying in females. Figure 4F (IV).

The pygostyle is exclusive to birds and provides support for the uropygial gland, the insertion of the feathers that form the animal's tail and the muscles that control the feathers, providing stability in flight (Romão, 2011). Figure 4F (VI).

BACK

The duck has 7 pairs of ribs that are connected to the thoracic vertebrae, the first two of which are floating, while the rest are divided into 2 segments. One segment is connected to the vertebral column, giving rise to the vertebral ribs, and the other segment is connected to the sternum, called the sternal ribs. Also, with the exception of the first and last, the ribs of the vertebral region have an elongated and flattened process in a shape that fits perfectly with the vertebrae, the uncinate process, responsible for creating a kind of overlap with each vertebra following that of the rib, giving greater rigidity and protection to the thoracic cavity (Romão, 2011). Figure 4 (III)

Figure 4F - In F: bones of the cervical vertebrae, lumbar vertebrae, sacral bones, rib bones and pygostyle bones; in I - cervical vertebrae; II - thoracic vertebrae; III - ribs; IV - sacral bone (coxal); V - caudal vertebrae; VI - pygostyle bone. Source: prepared by the author.

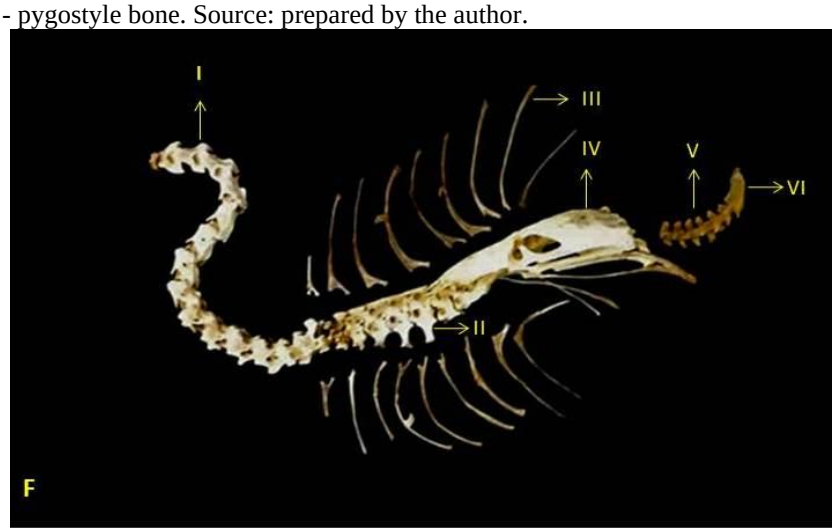


Figure 5 shows the bone structures that make up the animal's rib cage:

STERNUM

The sternum is a non-segmented bone with a convex shape on the ventral side and a ridge called a carina, popularly known as a keel, which can be more developed depending on the bird's degree of flight ability; in the case of the duck, it is not as developed (Silva, 2013). Figure 5 (V)

SCAPULA

The upper left image (I, II and III) shows the bones of the scapula, which are connected to the coracoid and clavicle bones, both of which are essential for the muscular support of the wings during flight. Figure 5G

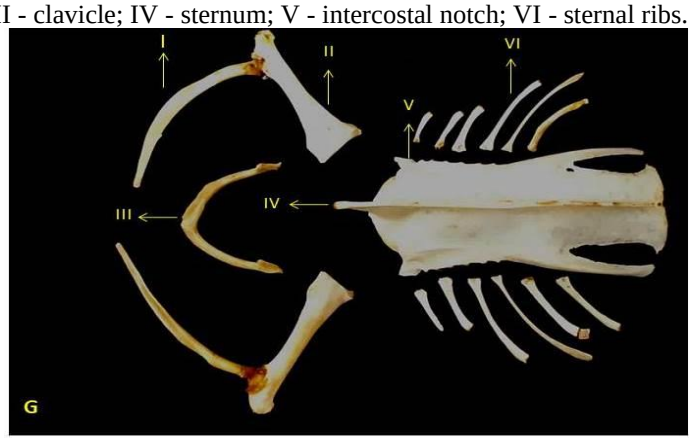
CORACOID

The coracoid bone is completely porous, i.e. an important pneumatic bone that helps the animal breathe (Romão, 2011). The ventral portion is articulated to the sternum, while the dorsal portion communicates with the scapula and humerus. Figure 5G (II)

CLAVICLES

The right and left clavicles are bones that extend medially and ensure correct shoulder movement during flight (Romão, 2011). Figure 5G (III).

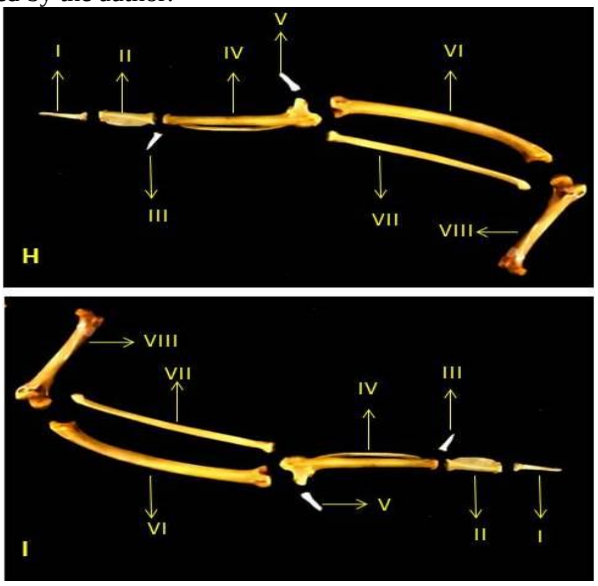
Figure 5 - In G: Ventral view of the Sternum and Scapula Bones of the domestic duck; where I - scapula; II - coracoid bone; III - clavicle; IV - sternum; V - intercostal notch; VI - sternal ribs.



THORACIC LIMB

The duck has an arm anatomy similar to many birds. The humerus (VIII), a long, pneumatic bone, communicates with the scapula and coracoid at the cranial end and with the radius (VII) and ulna (VII) at the caudal end. In this order, we can see the presence of the carpus made up of two bony structures, one connected to the radius and the other to the ulna. The metacarpal bone is made up of three metacarpals fused into a single bone structure, which serves to communicate with the phalanges of the bird's digits (Romão, 2011). In this case, the duck has three digits, the first containing one phalanx and connected to the carpus, the second with two phalanges and the third with only one phalanx. The last two digits are articulated on the distal portion of the metacarpal, also called the carpometacarpal. Figure 6 (H, I).

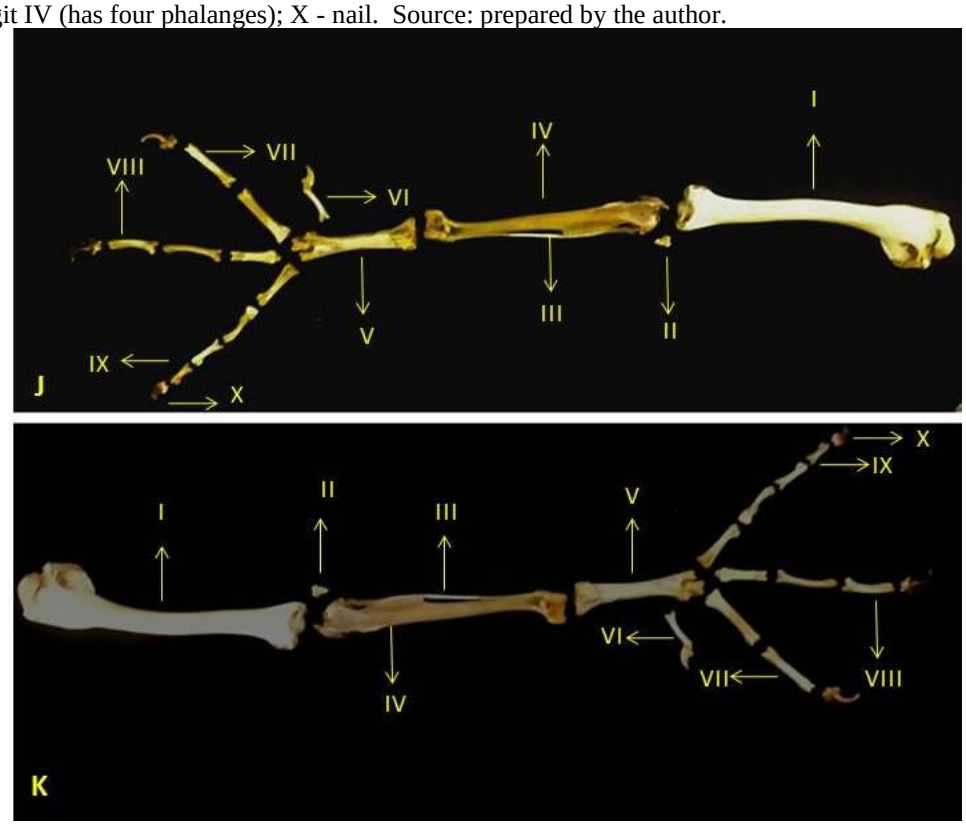
Figure 6 - In H-I: right and left thoracic limb of the domestic duck, with I - second phalanx of digit III; II - first phalanx of digit III; III - digit II; IV - carpometacarpal; V - digit I; VI - radius; VII - ulna; VIII - humerus. Source: Prepared by the author.



PELVIC LIMB

In proximal to distal order, there is the femur (II), tibia (IV) and fibula (III), metatarsus (V) and phalanges. Unlike other animals, birds do not have a tarsal structure, as this is fused to the tibia and metatarsal bones (Romão, 2011). The duck has four digits, the first with just one phalanx, the second with two phalanges, the third with three and the fourth with four phalanges. Figure 7J and 7K

Figure 7 - In J-K, right and left pelvic limb of the domestic duck; I - femur; II - patella; III - fibula; IV - tibia; V - metatarsus; VI - digit I; VII - digit II (has two phalanges); VIII - digit III (has three phalanges); IX - digit IV (has four phalanges); X - nail. Source: prepared by the author.



4 CONCLUSION

The anatomy of wild animals can be considered the most diverse and complex for osteological studies, due to the lower incidence of academic work on the subject. When it comes to birds, osteological projects are insufficient in relation to the number of species that exist around the world, which can be extremely common, such as the duck, but are still not properly studied.

The methods of macerating and cleaning the animal's carcass and bleaching the bones were satisfactory, as it was possible to identify all the structures and they were complete and whitish, demonstrating that they were in excellent condition for the possible assembly of a fixed skeleton, for example. Not only that, but it should also be noted that

this preparation for osteomontage was very cost-effective, using products that are easy to acquire and commonly used in anatomy laboratories, as well as not requiring a long period of time to complete the process.

On the other hand, the advanced state of degradation in which the duck was found meant that it was not possible to carry out a complete and sufficient pathological analysis of the cause of the animal's death. Another limiting factor for the conclusion of this study was the lack of diversity and clarity in anatomical descriptions of birds, especially aquatic birds, since most studies focus on domestic animals such as chickens. This leads to limitations in comparing and naming bone structures.

It is essential that future work on this subject further explores these relationships between bird species in order to expand the catalog of osteological descriptions of these animals.

Anatomical description is a technique that guarantees a more realistic presentation of animals and allows the author to delve into a window of scientific and biological knowledge. Bones are the basis for anatomy studies in all textbooks and even at university in Veterinary Medicine, Medicine, Physiotherapy and Biology courses, among many others. Therefore, studying these organs in depth literally means understanding the essential basis that allows animals to develop, sustain themselves and move. In this sense, studies like this not only expand the veterinary literature, but also ensure a complete education on each type of animal organism, taking into account their anatomical individualities.

In conclusion, practical activities such as the one described in this article are essential for veterinary students to learn that anatomy goes far beyond what is taught about domestic animals. It makes it possible to develop an understanding of the skeletal and, consequently, physiological differences between species and subspecies; to support the search for and creation of works and research in the area for comparative anatomy studies (intra-species); and to move between areas of Veterinary Medicine such as Anatomy, Physiology and Wild Animal Medicine, which is essential for creating an academic interdisciplinary awareness.

It is recommended that more studies be carried out on this group of animals, and that we have more scientific publications that will help students, veterinarians and people from other areas to have a better understanding of this type of animal and thus develop better conservation and preservation work.

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