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Anatomofunctional comparison between the ribs of man and domestic animals

Comparação anatomofuncional entre as costelas do homem e dos animais domésticos

Comparación anatomofuncional entre las costillas del hombre y los animales domésticos

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Abstract
The objective was to compare the ribs in men, canines, horses and cattle, highlighting structural similarities in terms of functions, types, quantities and formats, using parts from the Human and Veterinary Anatomy Laboratory of the University of Franca, articles and books in this area of expertise. Among the similar functions of the ribs, the support of the skeleton by participating in the formation of the rib cage, aid in respiratory movements and protection of organs stood out. As for the types, all species presented sternal ribs (articulating directly with the sternum) and sternal ribs (indirect contact with the sternum) in different amounts; on the other hand, only the canine and human, the floating ones (without connection with adjacent cartilage). The number of ribs corresponded to that of thoracic vertebrae, varying between species (13 pairs in the canine, 18 in the equine, 13 in the bovine and 12 in the human). Regarding the shape, there was variation according to each species, being longer, wider and flatter in cattle compared to horses; in canines more narrow and curved and in humans in semi-arches. It is possible to infer that, regardless of the species, the ribs perform the same functions, however, there are alternations in terms of types, quantities and formats, which may be involved with evolutionary and postural characteristics.
Keywords: Comparative anatomy; Asternal; Sternal; Floating; Anatomical homology.

Resumo
O objetivo foi comparar as costelas nos homens, caninos, equinos e bovinos, destacando similaridades estruturais quanto às funções, tipos, quantidades e formatos, utilizando peças do Laboratório de Anatomia Humana e Veterinária da Universidade de Franca, artigos e livros desta área de especialidade. Dentre as funções similares das costelas, destacaram-se a sustentação do esqueleto ao participarem da formação da caixa torácica, auxílio nos movimentos respiratórios e proteção de órgãos. Quanto aos tipos, todas as espécies apresentaram costelas esternais (articulando-se diretamente com o esterno) e asternais (contato indireto com o esterno) em quantidades distintas; em contrapartida, somente a canina e humana, as flutuantes (sem conexão com cartilagem adjacente). A quantidade de costelas correspondeu à de vértebras torácicas, variando entre as espécies (13 pares na canina, 18 na equina, 13 na bovina e 12 na humana). Em relação ao formato, notou-se variação de acordo com cada espécie, sendo mais compridas, largas e

achatadas nos bovinos em comparação aos equinos; nos caninos mais estreito e curvo e nos humanos em semi-arcos. É possível inferir que, independente da espécie, as costelas exercem as mesmas funções, no entanto, alternâncias quanto aos tipos, quantidades e formatos, os quais podem estar envolvidos com características evolutivas e posturais.
Palavras-chave: Anatomia comparada; Asternal; Esternal; Flutuante; Homologia anatômica.

Resumen
El objetivo fue comparar las costillas en hombres, caninos, equinos y bovinos, destacando similitudes estructurales en términos de funciones, tipos, cantidades y formatos, utilizando piezas del Laboratorio de Anatomía Humana y Veterinaria de la Universidad de Franca, artículos y libros en este área de especialización. Entre las funciones similares de las costillas destacaba el sostén del esqueleto al participar en la formación de la caja torácica, auxiliar en los movimientos respiratorios y protección de los órganos. En cuanto a los tipos, todas las especies presentaron costillas esternales (articuladas directamente con el esternón) y costillas esternales (contacto indirecto con el esternón) en diferente cantidad; en cambio, sólo los caninos y humanos, los flotantes (sin conexión con cartílagos adyacentes). El número de costillas correspondió al de las vértebras torácicas, variando entre especies (13 pares en el canino, 18 en el equino, 13 en el bovino y 12 en el humano). En cuanto a la forma, hubo variación según cada especie, siendo más largas, anchas y planas en los bovinos en comparación con los equinos; en caninos más angostos y curvos y en humanos en semiarcos. Es posible inferir que, independientemente de la especie, las costillas cumplen las mismas funciones, sin embargo, existen alternancias en cuanto a tipos, cantidades y formatos, lo que puede estar relacionado con características evolutivas y posturales.
Palabras clave: Anatomía comparada; Asternal; Esternal; Flotante; Homología anatómica.

1. Introduction

Anatomy is the science that studies the form, architecture and structure of living beings (Didio, 2002; Done, et al., 2010). In this context, the part of anatomy that emphasizes the morphological differences between species is called comparative anatomy (Dyce, et al., 2010; Konig & Liebich, 2011).

The comparison between similar and different anatomical structures refers to aspects related to the function and evolution of individuals; thus, evolutionary processes are believed to explain the format and functionality of each one of them (Getty, 1986; Kardog, 2011). Thus, the similarity of anatomical structures that share a common ancestry is known as homology (Gray and Goss, 1988; Kardog, 2011).

Among the anatomical structures that make up the body of individuals, include the ribs, characterized as elongated, light and mobile bone structures that extend from the thoracic vertebrae to the chest wall (Konig & Liebich, 2011). They are serially arranged in pairs and are interspersed by the intercostal spaces, which are covered by the external and internal intercostal muscles (Kardog, 2011).

Each rib consists of a dorsal bony part (bony part) and a ventral cartilaginous part (costal cartilage), which unite at the costochondral junction (Getty, 1986; Konig & Liebich, 2011).

The ribs share basic anatomical architecture, including the head, neck, body, costal tubercle, facet joint, costal groove, nutrient foramina, and costal extremity. The dorsal walls of all the ribs articulate with the thoracic vertebrae, while the costal cartilages differentiate in terms of articulation with the sternum (formed by the manubrium, sternebrae, and xiphoid process) (Getty, 1986; Gray & Goss, 1988; Putz & Pabst, 1995).

The shape and size of the rib bodies vary widely among different species (Putz & Pabst, 1995; Kardog, 2011).

The number of pairs of ribs corresponds to the number of thoracic vertebrae, and may vary between species (Getty, 1986; Konig & Liebich, 2011).

Thus, given the importance of pairs of ribs, the present study aimed to compare such bone elements in humans and domestic animals (dogs, horses and cattle) in terms of functions, types, quantities and shapes, and nevertheless, to highlight the structural similarities in these different species.

2. Methodology

Skeletons and individual anatomical pieces from the collection of the Human and Veterinary Anatomy Laboratory of the University of Franca (UNIFRAN - Franca, SP) were used, as well as scientific articles and books on anatomy established in this area of expertise to compare the pairs of ribs in dogs, equine, bovine and human in relation to functions, types, quantities and formats. Then, these bones were compared to show the homologous and distinct structures.

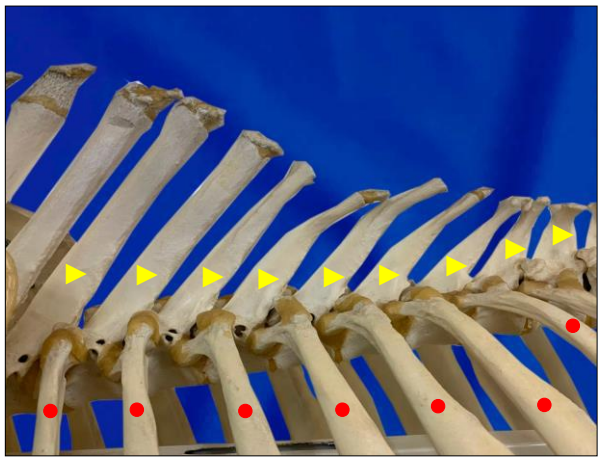
The anatomical terms were based on the Nomina Anatomica Veterinaria (2017) and the results expressed in a descriptive way.

3. Results and Discussion

Regardless of the species, it was observed in this study that the ribs are rigid and light bone structures and, according to Reece (2017), made up of inorganic salts deposited in an organic matrix composed of collagen fibrils and glycoproteins, calcium, phosphorus, magnesium, sodium, potassium, chloride and fluoride. As for the functions, the ribs actively participate in the formation and shape of the skeleton, which serves as a support and framework for the body, in addition to actively participating in the process of inspiration and expiration respiratory movements by composing the rib cage laterally, together with the intercostal muscles external and internal. Furthermore, due to their curvilinear shapes, the ribs protect the viscera of the thoracic region and some of the abdominal region (Konig & Liebich, 2011).

All animal skeletons analyzed indicated rib joints with two thoracic vertebrae (Figure 1), which coincided with the statements by Getty (1986) and Konig and Liebich (2011). In contrast, in humans, only the pairs of ribs that have two articulating faces on the head articulate with two thoracic vertebrae (Gray & Goss, 1988).

Figure 1. Photographic image of equine skeleton, demonstrating the articulations of the ribs (•) with the thoracic vertebrae (►).



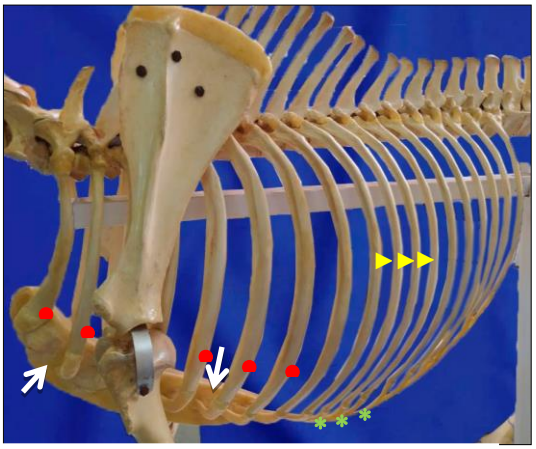
Source: Personal Archive (2022).

Regarding the costal cartilages, it was noted that they were distinguished as to the type of joint with the sternum, which is formed by the manubrium, sternebrae and xiphoid process (Getty, 1986; Gray & Goss, 1988). In this theme, the ribs are characterized as sternal or true (they articulate directly with the sternum, being short and thick), sternal or false (remaining delicate caudal ribs that articulate indirectly with the sternum when joining with the cartilage of the rib in front to form the costal arch) and floating (caudal ribs that end free in the musculature, without direct connection with an adjacent cartilage)

(Getty, 1986; Dyce, 2010). Thus, all species studied had sternal and sternal ribs (Figure 2); however, only in humans and canines were the floating ones found (Figure 3). According to Konig and Liebich (2011), floating ribs participate in the origin and insertion of muscle structures, in addition to protecting organs such as the kidneys and part of the liver.

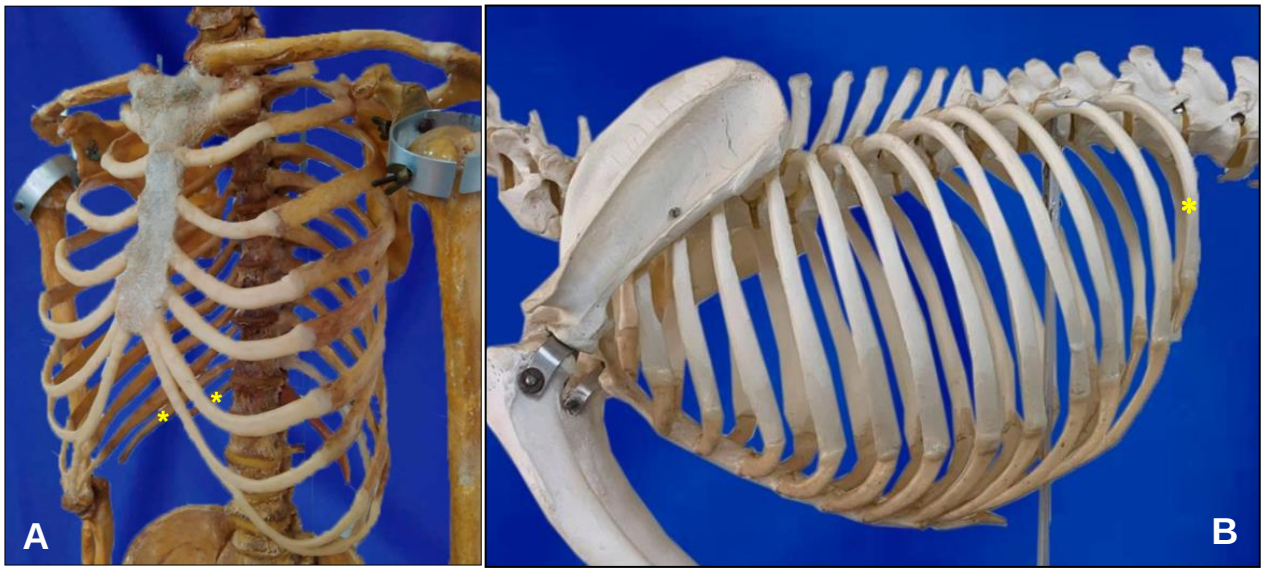
As for the number of ribs, it was found that it corresponds to the number of thoracic vertebrae. The canine species normally has 13 pairs, eight sternal, four sternal and one floating. The human species also has floating ribs (two pairs), in addition to seven sternal pairs and three sternal pairs. In most cases, horses have 18 pairs of ribs, eight sternal and 10 sternal, without flotation, and cattle 13 pairs, nine sternal and four sternal. However, according to Carvalho and Lopes (2012) and Milagres et al. (2021), the number of rib pairs can also vary between individuals of the same species.

Figure 2. Photographic image of equine skeleton, showing some sternal-type ribs (•) articulating directly with the sternum (arrows) and some asternal-type ribs (►) articulating indirectly with the sternum through the rib cartilages (*).



Source: Personal Archive (2022).

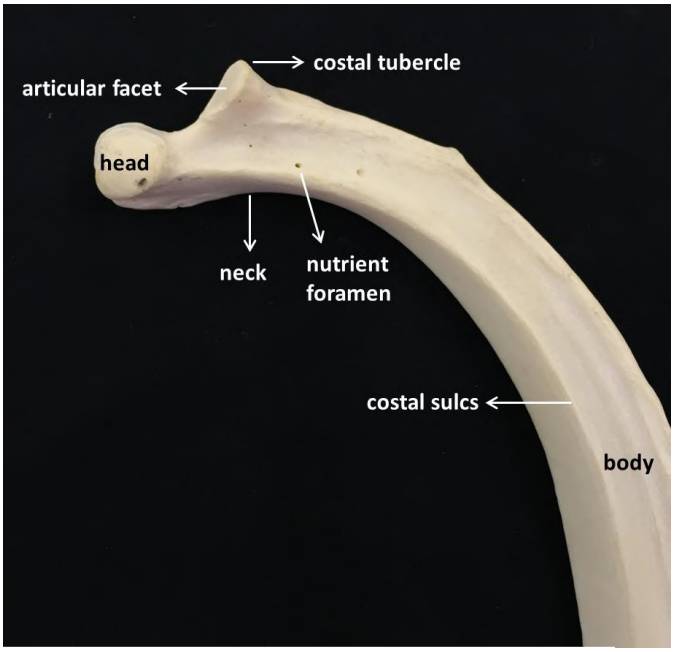
Figure 3. Photographic images of skeletons, demonstrating the presence of two pairs of floating-type ribs (*) in the human species (A) and one pair (*) in the canine species (B).



Source: Personal Archive (2022).

Regarding the anatomical architecture, it was noted that canine, equine and bovine ribs are basically constituted by the same bone characteristics, including head, neck, body, costal tubercle, articular facet, costal groove and nutrient foramina (Figure 4) and, moreover, they do not have a spinal canal, confirming the scientific reports by Getty (1986). In humans, some pairs of ribs are considered atypical in relation to the others in terms of shape; in this sense, the 1st pair is flattened and the costal tubercle is fused at the angle; the 2nd pair has a tuberosity in the body for fixation of the serratus anterior muscle; the 11th and 12th pairs lack neck and tubercle, and the 12th is shorter than most ribs (Gray & Goss, 1988).

Figure 4. Photographic image of the bone accidents (head, neck, body, costal tubercle, articular facet, costal sulcus and nutrient foramen) present in the ribs of canine, equine, bovine



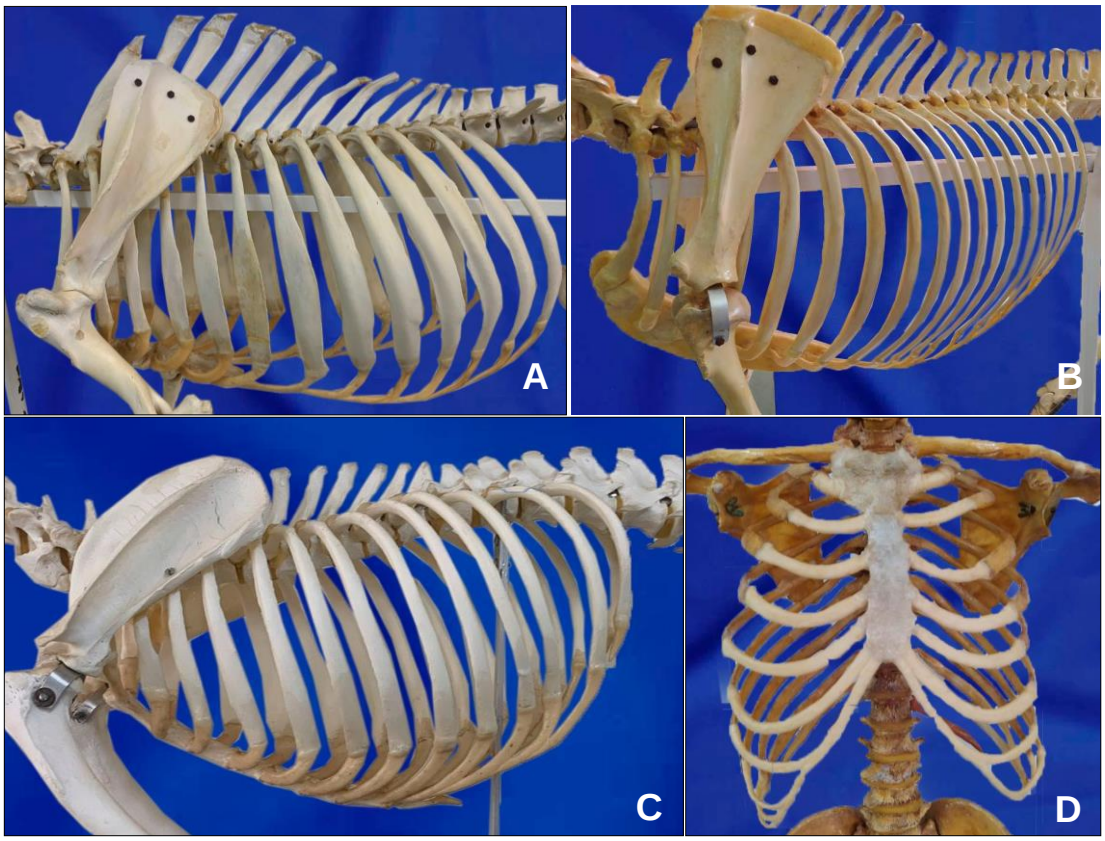
Source: Personal Archive (2022).

In this context, the shape and size of the rib bodies showed variations between the different species studied, as already reported by Putz and Pabst (1995), Kardog (2011) and Farias et al. (2020). Thus, in cattle, the ribs were wider and flatter and the tuberosities were more prominent compared to horses, while in canines they were narrower and curved and in humans in the form of semi-arches (Figure 5). Another characteristic observed in all species was that the length of the ribs gradually increased in the first ten pairs, shortening caudally as the thickness increased.

In all species studied, including humans, the first pair of ribs proved to be relatively short and strong, associated with small and thick costal cartilage, with contact and attachment to the sternum through a firm joint, corroborating the descriptions by Dyce, Sack and Wensing (2010). In humans, this same pair of ribs is more curved compared to the others (Didio, 2002; Kardog, 2011).

In the investigated species, reports of deformities were observed, some due to congenital anomalies (Farias et al., 2020), closed and exposed fractures in traumatized patients or those with mineral deficiencies (Pereira & Cardoso, 2011; Feng et al., 2019; Choi et al., 2021), in addition to benign and malignant neoplasms (Brondino et al., 2017; Aires et al., 2020; Goldback et al., 2020; Santos et al., 2021) in the ribs.

Figure 5. Photographic images of skeletons, demonstrating the different shapes of the ribs, being wider and flatter in the bovine species (A), compared to the equine (B) and narrower and curved in the canine (C), while in the human (D) in semi-arc shape.



Source: Personal Archive (2022).

4. Conclusion

According to the methodology applied and the results obtained, it is assumed that, regardless of the species, the ribs perform the same functions, however, there are distinctions in terms of types, quantities and formats. Furthermore, the anatomical morphological differences and similarities between the ribs may be related to the functional, evolutionary and postural aspects of the different species studied.

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Declaration of competing interest

The authors declare that there are no conflicts of interest.

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