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Analysis of the structure of the fighting bull's horn through image analysis. Horn sheath effect

Análisis de la estructura del cuerno del toro de lidia mediante análisis de imagen. Efecto del enfundado

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ABSTRACT

The horns are the most important anatomical part of the animal, since it gives it its offensive character and at the same time gives it purity and integrity. Today, in many farms, the horn is protected during last year of breeding with a fiberglass cover. This paper aims to study the internal structure of the fighting bull's horn, analyzing the possible influence of the sheath on it. For this, horns have been collected from 55 bulls (4-5 years), with a group of sheathed individuals of 25 animals. Biometric information has been collected on the horn and the age of the animal. One horn from each animal has undergone an imaging study using radiography, densitometry and magnetic resonance imaging. The radiological study offered great information on the internal structure of the horn, being a good method for evaluating the integrity of the horn. The antlers of the non-sheathed animals presented higher values of bone area, mineral content and mineral density at the level of the distal bone area, which reveals a harmful effect of the sheath. This could lead to a greater predisposition to an eventual fracture, however, no differences between groups were observed in the study performed by magnetic resonance imaging.

Keywords: fighting bull, fighting bull breed, horns.

RESUMEN

La cornamenta del toro de Lidia es la parte anatómica más importante del animal, ya que le confiere su carácter ofensivo y a la vez le dota de pureza e integridad. En la actualidad, en muchas de las explotaciones se protege el cuerno durante el último año de cría del toro con una funda de fibra de vidrio. Con el presente trabajo se pretende estudiar la estructura interna del cuerno del toro de Lidia, analizando la posible influencia del enfundado en la misma. Para ello se han recogido cuernos de 55 toros (4-5 años), contando con un grupo de individuos enfundados de 25 animales. Se ha recogido información biométrica del cuerno y de la edad del animal. Un cuerno de cada animal ha sido sometido a estudio de imagen mediante radiografía, densitometría y resonancia magnética. El estudio radiológico ofreció gran información sobre la estructura interna del cuerno, siendo un buen método para la valoración de la integridad del mismo. La cornamenta de los animales no enfundados presentó mayores valores de área ósea, contenido y densidad mineral a nivel de la zona ósea distal, lo que revela un efecto nocivo del enfundado. Este podría derivar en una mayor predisposición a una eventual fractura, sin embargo, no se observaron diferencias entre grupos en el estudio realizado mediante resonancia magnética.

Palabras clave: toro de Lidia, raza de Lidia, cuernos.

INTRODUCTION

The horns of the bull are, without a doubt, a transcendental element in the bullfighting festival and in the ritual of the spectacle; they are the icon of integrity and purity of the spectacle itself; this integrity has been debated and discussed since the beginnings of bullfighting. The veterinary approach to this aspect should be carried out from a technical and professional point of view, and therefore as an anatomical structure of the animal susceptible to various injuries and pathologies (Sotillo *et al*., 1996). Therefore, knowledge of its anatomical, histological, physiological and pathological characteristics is essential to diagnose and explain the different diseases or frauds affecting it (Alonso *et al*., 2016).

The existing literature on the horns of fighting bulls is not very abundant. The classic outdoor books (Aparicio-Sánchez, 1960; Sañudo, 2009), deal with the subject of horns as just another bull, but do not refer specifically to the fighting bull. Other authors (Cossío, 1967; Barga, 1972) refer specifically to this breed, but rather make a classification according to its conformation.

Since the discovery of the "shaving" fraud, the literature on horn conformation and its relation to the fighting ability of the bulls has been more abundant (Trillo, 1961; Maubon, 1956; Llorente, 1980; Bobed, 1982; Martín, 1984; Fuente *et al*., 1999; Ezpeleta, 1999; Aparicio *et al*., 2000).

The horn is an epidermal production located on both sides of the forehead, supported by the bony projection of the frontal bone, adopting a conical and elongated shape; it is divided into 3 parts (Figure 1): proximal part or "stock" (also called cob), middle part or "shovel" and distal part or "piton" (Fernandez, 2009). As a bone product, its composition includes minerals such as calcium, iron, magnesium, sodium, potassium and phosphorus; depending on its hardness to a great extent (Cabanas *et al*., 1994).

Horns of bulls suffer a risk of deterioration, mainly in the last year of life, as a result of potential fights, rubbing, contact or blows with the ground, trees, and fences, feeding troughs or the walls of the chutes or handling pens (Aparicio *et al*., 2000). For this reason, in recent years the use of a fiberglass bandage has become popular to cover the horns so that they are protected until they are fought in the arena (Lomillos *et al.* 2013). It is an easy to handle, porous material that hardens quickly by polymerization with water, providing good consistency (Figure 2). The technique consists of immobilizing the animal in the muzzle and wrapping the horn with this bandage to protect it from any aggression or rubbing. The distal part of the horn, i.e. the tip, is reinforced in many cases with a harder material, metal tubes or similar, in order to reduce wear in the apical area (Pizarro *et al*., 2008a and b).

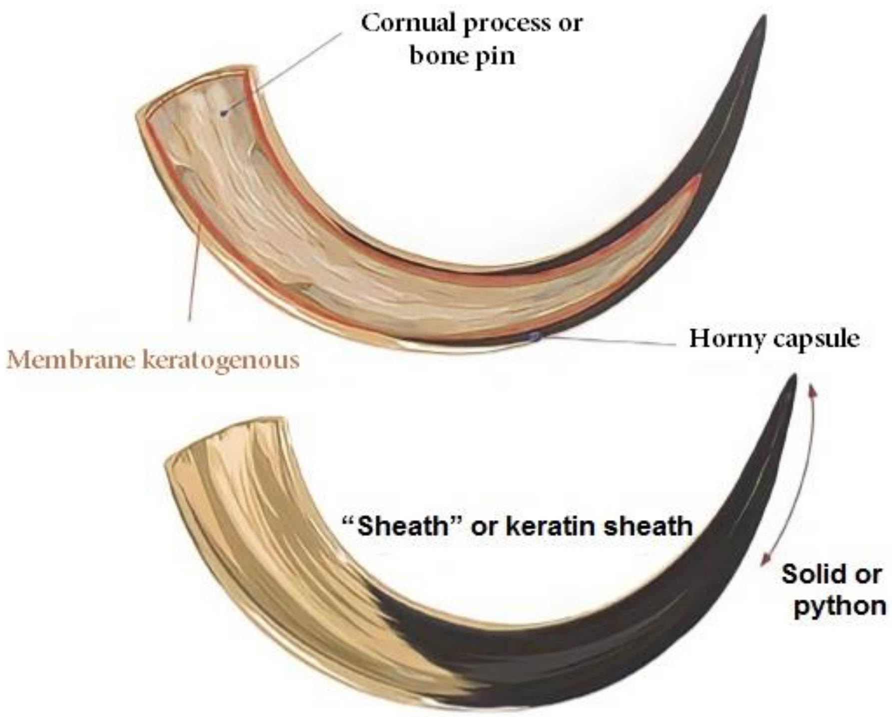

Figure 1. Anatomy of the bull horn (Calvo, 2005)

Figure 2. Sheathing management *(Photo: Julio Cesar Sanchez, 2018)*

There is a debate about the legitimate use of sheaths in the face of the obvious manipulation of horns when the bandage is applied and removed. Its defenders argue that this practice has the objective of preserving the integrity of horns; while the current legislation states that the breeder must ensure the "intangibility of the bull's defenses" (REAL DECRETO 176/1992).

It is also unknown how this type of horn manipulation could affect its structure and, therefore, predispose to the possibility of a fracture; since some authors have observed necrosis of the cornual dermis, with loss of bone structure and the appearance of hollow spaces inside the horn, which could reduce its resistance (Gómez *et al*., 2009).

Some small studies on the effect of sheathing and surface hardness have been carried out, with mixed conclusions (Pizarro *et al*., 2008 a,b and 2009; Salamanca, 2009; Horcajada *et al*., 2009), but there are no studies on the effect on the internal structure of this organ.

The aim of this work is to expand the knowledge on the internal structure of the Lidia bull's antlers and to shed light on the possible effect of sheathing on it.

MATERIAL AND METHODS

The antlers of 55 fighting bulls from 3 to 5 years of age were analyzed, 25 of which were sheathed 6 months before slaughter.

Initially, several horn measurements were carried out: antler length (average of external and internal length) and vertical and horizontal diameters in the stock, blade and tip by means of tape measure and caliper.

Radiology

An image analysis of the horn structures was performed using Sedecal radiology equipment, collecting the images in a Fujifilm digital chassis (CR). X-rays were initially taken in 12 animals in both horns, observing a manifest symmetry between the two horns in the bony part, for which it was decided to perform the following determinations, only in the right horns.

Densitometry

Since one of the determining aspects of the mechanical resistance of the horn is the degree of calcification of the bony structures that support it, it is considered necessary to evaluate the bone density of the cornual processes of the frontal bone, in order to verify the existence or not of influence of the sheathing at this level. A Hologic QDR-1000/W densitometry equipment was used; measurements were taken of both the proximal half of the horn (base) and the distal half (tip). To determine the two study regions, the midpoint of the horn located by laser was used as a reference (Figure 3).

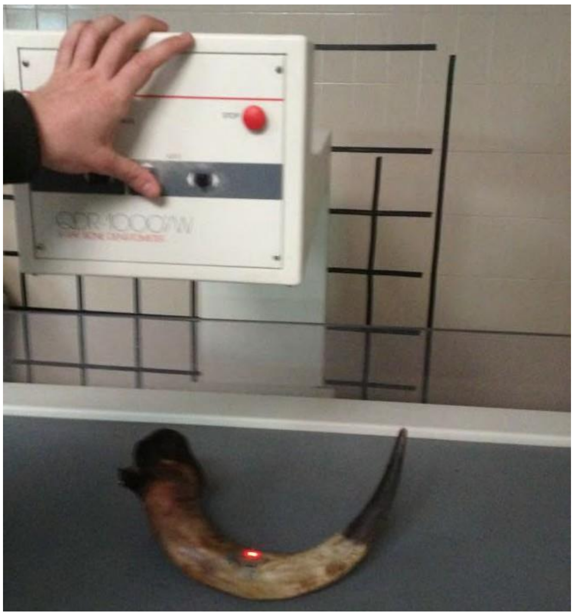

Figure 3. Laser localization of the midpoint of the horn

From that moment on, a series of radiological beams are performed to obtain values of Bone Mineral Content (BMC gr), and bone area studied (cm^2), from which the densitometer software calculates the Bone Mineral Density (BMD gr/cm^2).

Magnetic Resonance Imaging

For this study a 3 Tesla closed magnetic resonance equipment was used, with superconductive magnet, General Electric Medical System brand; after two preliminary tests with a wrist antenna and a head antenna, it was decided to carry out the studies with a Cardio-array antenna (Figure 4), of the same brand. The images were processed using the OsiriX program, which allows precise measurements to be made on the images.

Figure 4. Covered horn with Cardio-array antenna

The horns were placed on two pads to center them in the magnet, in a position that would correspond to the supine decubitus position of the animal; but slightly more rotated to take advantage of the area of greater magnetic intensity.
The study technique consisted of a locator in 3 planes, with a second locator also in three complementary planes; oblique coronal slices were made on these, looking for the plane that covered the greatest length of the horn and covering the rest of the anatomy with the rest of the slices (Figure 5). These slices were 5 mm thick and 0.5 mm apart, which translates into a distance of 5.5 mm between slices. These images were acquired in T2 FRFSE and in T1SE.

Figure 5. Image of 5 mm thick oblique coronal slices

Axial slices were programmed on the previous images, perpendicular to the previous ones with 6 mm of thickness and 14 mm between slices (Figure 6); which gives us a distance between slices of 20 mm, which will facilitate the comparison of results with the rest of the techniques. These images were also obtained in T2FRFSE and T1SE.

Figure 6. Image of the axial slices perpendicular to the coronal slices of 6 mm thickness

The orientation of these axial series means that, as the slices are parallel to each other, the first two and the last two are very oblique, giving us an elliptical image of the bone section, the rest of the slices being reasonably perpendicular to the horn axis.
All the data were processed using the SPSS program, performing a one-way analysis of variance (ANOVA), considering group 0 as the unsheathed animals and group 1 as the sheathed ones.

RESULTS AND DISCUSSION

Radiology

By means of radiography it is possible to distinguish perfectly different parts of the horn and therefore its internal structure. No serious alterations of the internal structure of the horns were found, nor were they compatible with chronic pathological processes in the bony area of any of the horns studied. However, some alterations were observed in the area of the horn massif, such as breaks or splinters, as can be seen in the upper left part of Figure 7, but in both animals of the sheathed and un-sheathed group.

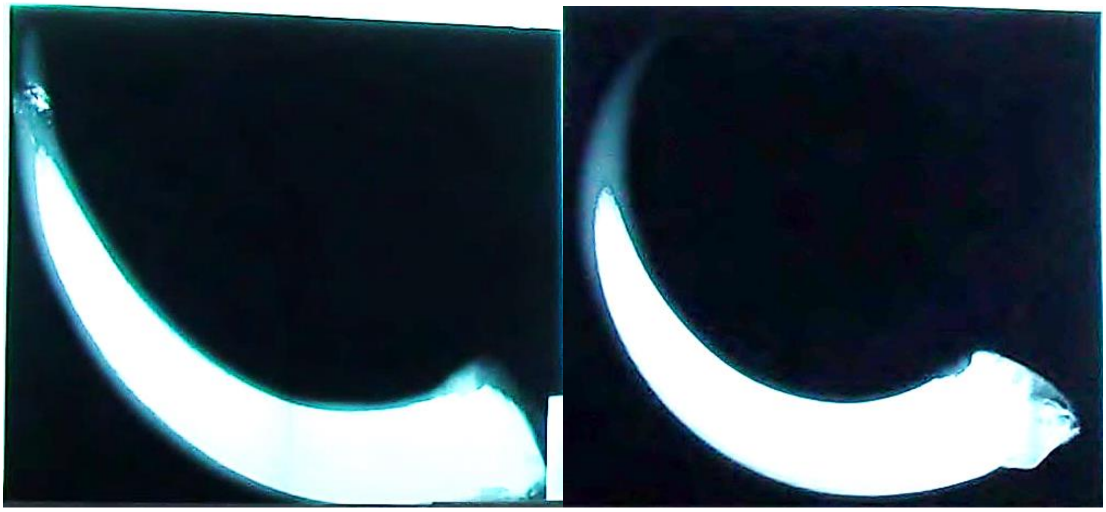

Figure 7. Radiographic images of a fractured horn and a healthy one

Densitometry

The one-way ANOVA performed between groups according to this variable, gave significant differences between groups in the values referred to the distal half of the horn called tip, as can be seen in Table 1.

Table 1. ANOVA of densitometry values obtained

	Mean Gr 0	Mean Gr 1	St Dev.. 0	St Dev. 1	df	df	DM	F	p
Tip Area	67.677	56.964	11.648	11.613	1	47	135.311	10.282	0.002
Tip BMC	120.931	97.057	26.256	24.867	1	47	657.656	10.507	0.002
Tip BMD	1.777	1.687	0.170	0.121	1	47	0.023	4.358	0.042
Base area	129.756	123.395	18.680	20.360	1	47	378.255	1.297	0.261
Base BMC	300.275	293.270	54.570	51.385	1	47	2827.126	0.210	0.649
Base BMD	2.309	2.378	0.193	0.162	1	47	0.032	1.777	0.189
Total BMC	421.207	390.326	70.647	70.330	1	47	4971.029	2.325	0.134
Total Area	197.433	180.359	25.750	29.710	1	47	761.176	4.643	0.036

The proximal area of the horn showed no differences between the two study groups, and a correlation matrix was then performed between the values obtained by densitometry and the external biometric variables, the results of which are shown in Table 2.

Table 2. Linear correlation matrix among the variables studied by conventional biometric techniques and densitometry

	External length	Internal length	Vert D Strain	Hor D Strain	Ver D Shovel	Hor D Shovel	Vert D Tip	Hor D Tip
Tip Area	0.155	-0.007	0.350	0.482	0.301	0.581	-0.464	-0.176
Tip BMC	0.098	-0.072	0.382	0.546	0.312	0.596	-0.482	-0.142
Tip BMD	0.047	-0.112	0.368	0.465	0.259	0.466	-0.428	-0.006
Base area	0.695	0.546	0.719	0.431	0.635	0.569	-0.582	-0.326
Base BMC	0.711	0.546	0.581	0.328	0.555	0.445	-0.513	-0.192
Base BMD	0.226	0.131	-0.124	-0.106	-0.020	-0.124	-0.030	0.233
Total BMC	0.587	0.399	0.586	0.448	0.541	0.556	-0.568	-0.199
Total Area	0.596	0.422	0.685	0.508	0.603	0.651	-0.620	-0.317

The correlations marked are significant at $p < 0.05$

It should be noted that there is no correlation of the area, mineral content or mineral density of the tip with the total length of the horn, either external or internal, but there is a correlation with the horizontal diameters of the stock and blade, being the inverse with the piton. In a first approximation we can interpret them as that the unsheathed horns have a higher density, due to a certain extent to their greater thickness. However, there is another possible explanation, which would be that the absence of protection of the sheath causes the bone to respond with greater calcification to trauma, produced continuously in fights, blows and other continuous mechanical effects; this last aspect has been proven in humans.

Magnetic Resonance Imaging

Finally, through magnetic resonance imaging we have clearly observed the patterns of the vascular channels and the dermis that appear as radiolucent areas; as well as the extension of the different cavities and trabecular area of the horn (Figure 9).

In the magnetic resonance images we have found very evident differences in structure between individuals, both in the extension of the cavity or trabecular zone, as well as in the patterns of the channels; but no evidence of pathological alterations has been discovered.

Once the images were processed, the biometric data obtained were subjected to a one-way ANOVA, considering the two groups mentioned above (Table 3).

Figure 9. Magnetic resonance imaging of horn; coronal and axial section with a trabecular zone of 12.9 cm in external length

Table 3. ANOVA of the biometric values obtained by magnetic resonance imaging

	Mean 0	Mean 1	St Dev. 0	St Dev.1	df	df	F	p
Total External Length	43.462	43.923	3.020	3.343	1	27	0.149	0.703
Solid Length	23.878	28.712	4.353	7.923	1	27	3.872	0.059
Trabecular Length	19.584	15.211	4.401	8.090	1	27	3.050	0.092
Total Internal Length	33.564	34.673	2.720	3.151	1	27	1.000	0.326
Total Surface Area	23.364	27.030	3.933	11.924	1	27	1.122	0.299
Solid Area	21.488	25.304	3.738	10.448	1	27	1.562	0.222
Trabecular Area	1.304	1.555	0.649	1.827	1	27	0.223	0.641
Trabecular Perimeter	4.804	4.515	1.193	2.216	1	27	0.179	0.676
Total Perimeter	17.317	18.507	1.525	3.767	1	27	1.139	0.295

I was able to verify that there were no significant differences in any of the variables considered, although the length of the solid zone without trabecular structure was close to the level of significance; being superior the part without trabecular zone in the sheathed horns.

A linear correlation matrix was performed between the biometric parameters obtained by magnetic resonance imaging and the age of the animals, without showing any significant correlation, finding within the same herd animals with very variable lengths of the trabecular zone; which has not allowed us to develop an explanation for these variations (Table 4).

Table 4. Linear correlation matrix between biometric values obtained by magnetic resonance imaging and age

	Age
Total External Length	-0.07
Solid Length	0.22
Trabecular Length	-0.24
Total Internal Length	0.18
Total Surface Area	0.82
Solid Area	0.47
Trabecular Area	0.80
Trabecular Perimeter	0.85
Total Perimeter	0.83

CONCLUSIONS

The radiological study allowed the detection of slight structural alterations in the horns assessed; therefore, it seems to be a good method for the assessment of the integrity of the internal structure of the antlers. The antlers of the unsheathed animals presented higher values of bone area, mineral content and mineral density at the distal bone zone. No differences were observed in the study carried out by nuclear magnetic resonance between sheathed and unsheathed horns; large individual variations were found that could not be correlated with any of the variables studied.

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