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# Lateral asymmetry of the equine mandible

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## Abstract

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Deviations from expected perfect symmetry on biological forms can occur, and organisms develop several kinds of asymmetries. Among others there are fluctuating asymmetry and directional asymmetry (DA). DA happens whenever one side on the plane of symmetry develops more than the other side. To study the presence of DA in the horse, we obtained 11 paired linear measurements on 19 mandibles belonging to "Cavall Pirinenc Català" horse breed, a local breed from Catalonia, NE Spain. The results confirm the existence of asymmetry for certain traits, demonstrating the existence of DA. This is suspected to be caused by a masticatory preference to the left side, as it has been described for other animals. Although further investigation is needed to clarify the clinical relevance of such findings in the horse, it follows that examination and recording of chewing side preference for domestic mammals merits more consideration. The measurements presented here can also be used as a reference for researchers designing experimental studies, especially on mandibular catch-up growth, and as an aid for zooarchaeologists comparing results from dead animals with those from living equine populations.

*Keywords:* bilateral asymmetry; Cavall Pirinenc Català; hemimandible; zoometry

## Introduction

Bilateral symmetry, a key feature of vertebrate body plans, is rarely perfect, and mild asymmetries can be found in normal growth and development, as a typical adaptation of the organisms to their environment (Briones & Guiñez, 2008) (Blackburn, 2011). When deviations from expected perfect symmetry occur, organisms can develop several kinds of asymmetries, which among others are fluctuating asymmetry and directional asymmetry (DA) (Briones & Guiñez, 2008). DA happens whenever one side on the plane of symmetry develops more than the other side, and has a proportion of genetic component (Graham et al., 1993) (Carter et al., 2009).

Deviations from perfect symmetry may be measured as variances (or related measures of dispersion) of linear dimensions, shape variation involving landmarks, or continuous symmetry measures (Auffray et al., 1999) (Briones & Guiñez, 2008) (Blackburn, 2011). DA is characterized by a symmetry distribution that is not centred around zero but is biased significantly towards larger traits on either the left or the right side (Briones & Guiñez, 2008). DA is developmentally controlled and is therefore likely to have adaptive significance (Auffray et al., 1999). Here we investigate mandibular metrics of horse mandible in order to detect DA.

## Materials and Methods

### *Specimen collection*

The sample consisted of 19 well preserved and intact undamaged mandibles belonging to adult "Cavall Pirinenc Català" (CPC) horses ("Catalan Pyrenean Horse"). CPC is a very rustic horse breed for meat production in the harsh environment of the Northeastern part of the Pyrenees along the NW Spanish-French border, being compact, broad-built and predominantly chestnut with rather short limbs (Torres et al., 1983) (Infante Gil, 2011) (Figure 1). Genetic analy-

sis suggests that this small population (< 4,600 individuals) is closely related to the Breton and Comtois breeds (Infante Gil, 2011) (Figure 2). Horses are reared outdoors throughout the year and do not receive any additional food besides some low-quality straw in winter (Torres et al., 1983) (Infante Gil, 2011). Animals do not receive any systematic clinical care, and much less dental care, so one can consider that there are normal functional conditions and so functional appliances onto the dental arches. Sex for specimens was unknown. None of the mandibles presented apparent pathological deformities or malocclusions.

**Figure 1. An stallion belonging to "Cavall Pirinenc Català" (CPC) horses ("Catalan Pyrenean Horse") (photo by author)**


**Figure 2. Genetic analysis suggests that "Cavall Pirinenc Català" (CPC) horses ("Catalan Pyrenean Horse") is closely related to the Breton and Comtois breeds, and this is well reflected on head profile**

***Data collection***

To gain as much metric data as possible and to ensure that all parts of bones were represented, we chose eleven measurements according to von Driesch (Von den Driesch, 1976). These landmarks are easily and consistently identifiable and included points which allowed morphometric analysis of all parts of the mandible.

The distances were measured with a calliper ratio® 150 mm, with a 0.01 mm precision. All measurements are given in millimetres with a precision of one millimetre as allowed by the instrument.

Asymmetry is the difference between a value on the left side and the right side (Kharlamova et al., 2010). When the mean asymmetry value was significantly different from zero we referred to this as DA (Kharlamova et al., 2010), it is reflected in a "preference index" *PI*:

$$PI = [(R\text{-}L)/(R+L)/2] * 100,$$

where *R* is the value of the right hemimandible, and *L*, the value of the left hemimandible.

This standardized degree of asymmetry *PI* represented a ratio and thus had no units but made possible comparisons of any size regardless of the size of the mandible. So a subject was considered to prefer the right side in positive if $A > 0$ from a statistical point of view.

As we could not assume a normal distribution for all data, they were checked by a Wilcoxon paired test. All analyses were done with PAST v. 2.17c software (Hammer et al., 2001). Values of $P < 0.05$ were considered to be statistically significant, confidence interval was considered 95% and all data are presented as means ± SD.

## Results

Table 1 shows the results of the analysis of mandibular metric data. Mean ± s.d. and minimum and maximum values were calculated for each trait for *PI* (Table 2). The results of *PI* confirm the existence of asymmetry for certain traits, e.g. L4-8, condylar length, and L11-8 ($p < 0.05$), being the differences positive -signalling a left tendency-, and only M7-9, also significative, averaged as positive -signalling a right tendency.

**Table 1. Summary statistics for investigated bilateral traits of the left and right hemimandibles belonging to "Cavall Pirinenc Català" horse breed (n = 19)**

| | Left | | Right | |
|---|---|---|---|---|
| | Mean±s.d. (mm) | Range (mm) | Mean±s.d. (mm) | Range (mm) |
| Condylar length | 18.4±2,9 | 13.0-23.3 | 17.6±2.7 | 13.4-23.5 |
| Condylar width | 51.5±5.4 | 43.8-63.6 | 52.0±5.8 | 42.7-67 |
| L11-8 | 170.5±20.8 | 134.2-200.8 | 168.5±20.1 | 136.0-196.4 |
| L2-6 | 110.8±14.5 | 90.4-136.3 | 113.0±15.4 | 85.2-132.8 |
| L4-3 | 22.2±4.1 | 15.6-30.7 | 21.9±4.5 | 14.7-29.5 |
| L4-5 | 11.0±2.5 | 6.8-16.2 | 10.6±2.3 | 7.5-16.7 |
| L4-8 | 300.7±32.7 | 248.3-355 | 293.1±29.6 | 247.6-345.0 |
| L4-9 | 340.0±38.6 | 275.1-392.4 | 329.0±36.0 | 274.0-392.0 |
| M7-6 | 74.9±13.4 | 53.0-99.1 | 75.1±13.6 | 53.8-93.3 |
| M7-8 | 74.0±12.3 | 55.3-92 | 72.2±13.8 | 51.1-93.6 |
| M7-9 | 90.7±11.1 | 72.5-114.0 | 92.5±11.8 | 70.4-114.8 |

**Table 2. The degree of lateral asymmetry of mandibles for standardized asymmetry ($SA = [(R-L)/(R+L)/2] * 100$) belonging to "Cavall Pirinenc Català" horse breed (n = 19). Significative values, which can be considered to present Directional Asymmetry, appear in bold**

| Measurement | Mean±s.d. | *W* | Sig. |
|---|---|---|---|
| *L*4-3 | -1.5±12.8 | 102 | N.S. |
| *L*4-5 | -2.6±16.3 | 117 | N.S. |
| Condylar width | 0.9±2.8 | 106 | N.S. |
| *L*4-8 | -2.5±3.4 | 145 | P < 0.05 |
| *L*4-9 | -3.2±7.5 | 147 | N.S. |
| *L*2-6 | 1.9±7.5 | 133 | N.S. |
| Condylar length | -4.2±8.3 | 129 | P < 0.05 |
| *L*11-8 | -1.2±2.1 | 147 | P < 0.05 |
| M7-6 | 0.2±4.8 | 115 | N.S. |
| M7-8 | -2.8±6.7 | 139 | N.S. |
| M7-9 | 1.8±3.4 | 149 | P < 0.05 |

s.d.: Standard Deviation, *W*: Wilcoxon paired test, N.S.: non significative

## Discussion

This preliminary study aimed to detect directional asymmetry on horse mandibles. Analysis was based on linear measurements taken from eleven anatomic points, from 19 mandibes from adult "Cavall Pirinenc Català" horses ("Catalan Pyrenean Horse"). This assessment cannot be performed accurately using conventional radiographs because of the superimposition of craniofacial bony structures and positioning errors during the acquisition of radiographs.

Most of our subjects showed masticatory preference, mainly to the left side. It is commonly accepted that strictly unilateral chewing has a high potentially traumatic effect on dentition, jaw muscles and the temporomandibular joint. Precisely in this study registered highly discriminative bony parts were masticatory muscles attachments: most ventral angle of the *fossa masseterica* (insertion of superficial and deep masseter, and zygomaticomandibular muscles) and ventral part of the medium part of the diastema presented the highest loading values (insertion of medial pterygoid muscle) (Watson et al., 2014). Bony attachments of muscles with a facial (not masticatory) function (as the buccinator muscle) (Spataru et al., 2013) did not show so high variability. Being bone an active tissue undergoing a continuous process of remodelling and repair (Dias et al., 2011). Digastricus muscles, another important masticatory functions, could not be studied because they attach to the median aspect of each hemimandible.

Most of the studies do favour the existence of laterality in chewing process although there are some differences with regard to used methodology, such as the exact method to reveal it. Our results, and in line with other researches in this breed (Parés-Casanova, 2014) (Parés-Casanova & Morros, 2014) (Parés-Casanova & Reig, 2015), indicate that many species show preference to one side in their chewing pattern. Similar results have been obtained by other authors for other species, including wild ones (Zamanlu et al., 2012) (Singleton, 2015).

Although discussion of the interaction of factors that can alter mandibular morphology is beyond the scope of this article, it remains clear that mandible is a good indicator of lateralized functions. Much remains to be done, however, to understand how the many processes involved in forming the mandible interact to join its components together into a coherent functional unit. Now, it would be necessary to understand how asymmetry patterns could have performance consequences in the CPC horse and if there is a side preference in chewing hard or soft food.

## Conclusion

"Cavall Pirinenc Català" horses ("Catalan Pyrenean Horse") show a masticatory preference to the left side. We believe these results have important practical implications and that they must be to be taken into account in orthodontic treatments. Additional support for the participation of genetic factors in the determination of this lateralized behaviour in this breed is now needed.

### Conflict of interests

The author had no financial or personal relationships with other people or organizations that could inappropriately influence his work. He declares that there were no competing interests regarding the publication of this paper.

### Ethics Statement

This study was carried out in bones from naturally dead animals and in any case they were euthanized, so no Ethics Committee agreement was considered to be unnecessary.

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