Volume : 2 | Issue : 7 | July 2013 • ISSN No 2277 - 8179

Deviation from perfect symmetry in the bovine mandible

Veterinary

KEYWORDS : fluctuating asymmetry, jaw, mandibular foramen, Meckel's cartilage, Pyrenean Brown

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ABSTRACT

Fluctuating asymmetry refers to small random deviations from perfect symmetry in bilaterally paired structures; it is thought to reflect an organism's ability to cope with genetic and environmental stress during development and its utility as an indicator of such stresses is based on the assumption that perfect symmetry is an a priori expectation for the ideal state of bilateral structures. Nineteen dry dentate and complete mandible samples belonging to different living bovine breeds were studied to assess the whole symmetry between their hemimandibles. Eleven linear distances between different landmarks allowed its evaluation. The fluctuating asymmetries were found to have a geometrical mean of zero, indicating a good individual quality in the specimens studied, although the detected DA in the mandibular ramus shows that the main masticatory muscle can have a left to right dominance, but with no clinical importance. 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 who must evaluate results from buried animal studies for comparison with living bovine populations.

INTRODUCTION

The fluctuating asymmetry (FA) is the deviation from perfect bilateral symmetry caused by environmental stresses, developmental instability, and genetic problems during development. It is thought that the more perfectly symmetrical an organism is, the better it has been able to handle developmental stress and the more developmental stability it has. FA, then, may be a measure of good genes that is difficult or impossible to mask.

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 (Graham *et al.*, 2010). The classic measure of FA is the variance (or standard deviation) of the difference between the values of a trait on the left and right sides. If $d_i = l_i - r_i$, where d_i is the *signed* left–right asymmetry of individual i, l_i is the value of the trait on the left side, and r_i is the value of the same trait on the right side, then a measure of FA is $\mathrm{Var}(d_i)$ or its square root (standard deviation) (Graham *et al.*, 2010). In perfectly symmetrical objects, these points will be mirror images of one another. Ordinarily, FA is symmetrically distributed about a mean of zero. Directional asymmetry (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. Antisymmetry (AS) is characterized by being centred around a mean of zero; antisymmetric traits have either a platykurtic or a bimodal distribution about a mean of zero (Graham *et al.*, 2010). Both DA and AS are developmentally controlled and are therefore likely to have adaptive significance. FA, on the other hand, is not likely to be adaptive as symmetry is expected to be the ideal state (Van Valen, 1962; Palmer, 1994; Gangestad and Thornhill, 1999).

The research presented here tries to assess the whole symmetry between bovine hemimandibles. To the author's knowledge, no similar works have been done on this species to date. 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 who must evaluate results from buried animal studies for comparison with living bovine populations.

MATERIAL AND METHODS

The first step in measuring the asymmetry of bilaterally symmetrical structures was determining matching points on the left and right sides. Eleven linear distances were obtained on each hemimandible on the lateral (height first variables) and medial aspects (last three variables):

SUP-PM$_2$	From the oral border of the alveoli of the I$_4$ to the oral border of the alveolus of pM$_2$
VME-MEN	From the base of the mandible along a vertical line to the mental foramen
MEN-DME	From the diastema of the mandible along a vertical line to the mental foramen
MEN -NOT	From the mental foramen to the deepest point of the mandibular notch
MEN-CON	From the mental foramen to the *condylion*, the most superior point of the condylar process
NOT-ANG	From the deepest point of the mandibular notch to the angular notch
LEN	Condylar length
WID	Condylar width
NOT-MAN	From the deepest point of the mandibular notch to the base of the mandible along a vertical line from the mandibular foramen
MAN-GON	From the base of the mandible along a vertical line from the mandibular foramen to the *gonion caudale* (the most aboral point of the ramus)
ANG-MAN	From the angular notch to the base of the mandible along a vertical line from the mandibular foramen

Nineteen dentate and complete mandibles from bovines were measured. The sex of these samples was unknown but all of them belonged to living European commercial breeds (such as Pyrenean Brown, Aubrac, Charollais, Friesian, and Salers). According to eruption of the third molar (M_3), three age classes were established: about 6 months of age (non-erupted M_3, n = 1), about 12 months (erupting M_3, n = 6), and more than 24 months (fully erupted M_3, n = 12). Mandibles were halved along the median line and both halves were used for the study. Some of the mandibles presented pathological deformities or malocclusions but all of them were included in the total sample. The individual sex and breed of each specimen were not known. As all specimens were from a commercial abattoir and no *ex professo* killing of animals was carried out, no ethical permission was requested.

Non-Parametric Multivariate Analysis of Variance (NPMANOVA) was applied to discriminate differences between age groups according to a correlation matrix for all linear measurements, using 9,999 permutations. To obtain measures of DA, if the means of these *signed* differences between sides differed significantly from zero (using *t*-paired tests to evaluate significance), then DA was assumed to be present (Van Valen, 1962). If no DA is present, and the distribution of these signed differences is normal, then variation in these differences represents classical FA (Palmer, 1994). AS, described statistically in terms of a bimodal distribution, was assessed visually. Data were analysed using PAST – "Paleontological Statistics Software Package for Education and Data Analysis" (Hammer *et al.*, 2001) available at http://www.nhm.uio.no/norlex/past/download.html).

RESULTS AND DISCUSSION

The range and mean of linear measurements are presented in Table 1. No differences appeared between age groups ($F = 3.494$, $p < 0.05$), so samples were studied all together. Statistical results of *non-signed* differences appear in Table 2. All traits had a geometric mean of zero, but five of them (WID, MEN-CON, LEN, NOT-MAN, and ANG-MAN) did not appear to be normally distributed, all of them being related to the mandibular ramus. Except for ANG-MAN, non-normally distributed differences were leptokurtic. DA was assumed to be present in LEN and ANG-MAN (Table 3), presenting a left and a right biased distribution, respectively. According to the distribution (no bimodal distribution), no AS appeared.

Many studies on human mandibles have shown that the mandible is an asymmetric bone (Pierrakou, 1990; Ponyi *et al*., 1991; Westesson *et al*., 1994; Mattila *et al*., 1995; Türp *et al*., 1998; Boratto *et al*., 2002; Edler *et al*., 2003; Captier *et al*., 2006) but until now no such studies have been done for cattle, at least to the author's knowledge. According to the results obtained in this research, a trend of left to right dominance was observed in the condylar length and the distance between the angular notch and the mandibular foramen. This left dominance was found in all specimens.

This can be explained by the fact that important muscles of mastication are attached on the mandibular ramus: the lateral pterygoid (*m. pterygoidei lateralis*) and temporal (*m. temporalis*) muscles. Considering that FA is the most reliable measure of developmental instability (Graham *et al*., 2010), it would indicate a good individual quality in the specimens studied, although the detected DA in the mandibular ramus would show that the main masticatory muscle can have a left to right dominance, although with no clinical importance.

ACKNOWLEDGEMENTS

The commercial abattoirs Valira SA and Mafriseu SA kindly provided the heads.

Table 1. Range and mean of linear measurements. Values in millimetres.

	VME-MEN	MEN-DME	WID	MEN-NOT	MEN-CON	SUP- PM_2	LEN	NOT-ANG	NOT-MAN	MAN-GON	ANG-MAN
Min	14.7	6.8	42.7	247.6	274.0	85.2	13.0	134.2	53.0	51.1	70.4
Max	30.7	16.7	67.0	355.0	392.4	136.3	23.5	200.8	99.1	93.6	114.8
Mean	22.0	10.8	51.7	296.9	334.4	111.9	17.9	169.5	75.0	73.1	91.5

Table 2. Statistical results of signed differences of linear measurements (in millimetres). Parameters in bold present a non-normal distribution ($p < 0.05$).

	VME-MEN	MEN-DME	WID	MEN-NOT	MEN-CON	SUP- PM_2	LEN	NOT-ANG	NOT-MAN	MAN-GON	ANG-MAN
Min	-6.8	-3.6	-3.6	-30.0	-94.4	-5.3	-0.7	-6.7	-7.1	-10.4	-4.0
Max	7.8	2.6	3.4	15.0	42.0	16.0	45.0	5.0	4.0	6.5	11.6
Mean	-0.22 ±2.89	-0.31 ±1.69	0.47 ±1.43	-7.52 ±10.97	-10.96 ±26.42	2.24 ±5.50	31.74 ±9.12	-2.02 ±3.55	**0.18 ±3.33**	-1.73 ±4.53	1.70 ±3.26
SE	0.66	0.38	0.33	2.51	6.06	1.26	2.09	0.81	0.76	1.04	0.74
Median	-0.6	-0.5	0.4	-7.0	-2.9	1.1	32.0	-2.5	0.9	-2.3	1.3
Skewness	0.597	0.003	-0.840	-0.094	-1.502	0.762	-2.499	0.586	-1.113	-0.017	1.376
Kurtosis	3.317	-0.334	3.577	-0.012	5.582	0.858	9.477	-0.380	0.353	-0.561	4.094
Geom. Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W	0.918	0.971	0.893	0.992	0.830	0.943	0.726	0.939	0.860	0.978	0.893
.p (normal)	0.104	0.804	0.036	1.000	0.003	0.302	0.000	0.256	0.010	0.911	0.037

Mean± Standard Deviation

SE: Standard Error

W: Shapiro-Wilk

Table 3. Significances of the signed differences between sides not normally distributed.

	WID	MEN-CON	LEN	NOT-MAN	ANG-MAN
.t	1.453	-1.809	15.170	0.237	2.275
p(normal)	0.163	0.087	<<0.00001	0.814	0.035

REFERENCE

- Boratto R., U. Gambardella, P. Micheletti, L. Pagliani, L. Preda, T.L. Hansson. 2002. Condylar-mandibular asymmetry, a reality. Bull Group Int Rech Sci Stomatol Odontol 44:52-56. | - Captier G., J. Lethuilier, M. Oussaid, F. Canovas, F. Bonnel. 2006. Neural symmetry and functional asymmetry of the mandible. Surg Radiol Anat 28: 379-386. | - Edler R., D. Wertheim, D. Greenhill. 2003. Comparison of radiographic and photographic measurement of mandibular asymmetry. Am J Orthod Dentofacial Orthop 123:167-174. | - Gangestad S.W., R. Thornhill. 1999. Individual differences in developmental precision and fluctuating asymmetry: a model and its implications. J Evol Biol 12:402-416. | - Graham J.H., S. Raz, H. Hel-Or, E. Nevo. 2010. Fluctuating Asymmetry: Methods, Theory, and Applications. Symmetry 2:466-540. | - Hammer Ø., D.A.T. Harper, P.D. Ryan. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontol Elect 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm (accessed December 29th 2012). | - Mattila M., M. Kononen, K. Mattila. 1995. Vertical asymmetry of the mandibular ramus and condylar heights measured with a new method from dental panoramic radiographs in patients with psoriatic arthritis. J Oral Rehabil 22:741-745. | - Palmer R.A. 1994. Fluctuating asymmetry analysis: a primer. In: MarkowTA (ed.) Developmental Instability: Its Origins and Evolutionary Implications. London: Kluwer Academic. | - Pierrakou E. 1990. Asymmetry of the mandible. Study of 386 mandibles in vitro. Hell Period Stomat Gnathopathoprosopike 5:13-16. | - Ponyi S., G. Szabo, J. Nyilasi. 1991. Asymmetry of mandibular dimensions in European skulls. Proc Finn Dent Soc 87:321-327. | - Türp J., K. Art, W. Vach, K. Harbich. 1998. Mandibular condyles and rami are asymmetric structures. J Craniomandib Pract 16:51-56. | - Van Valen L. 1962. A study of fluctuating asymmetry. Evol 16:125-142. | - Westesson P.L., R.H. Tallents, R.W. Katzberg, J.A. Guay. 1994. Radiographic assessment of asymmetry of the mandible. AJNR Am J Neuroradiol 15:991-999. |