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ASYMMETRY IN SOME BILATERAL TRAITS OF THE SKULL OF LONG-TAILED CHINCHILLA FROM SINGLE AND MULTIPLE LITTERS

ASYMETRIA WYBRANYCH CECH BILATERALNYCH SZKIELETU GŁOWY OSOBNIKÓW SZYNSZYLI MAŁEJ Z MIOTÓW POJEDYNCZYCH I MNOGICH

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Streszczenie. Postanowiono zbadać, czy liczba osobników w miocie wpływa na wartości wskaźników asymetrii cech metrycznych szkieletu głowy szynszyli małej? Materiałem do badań były czaszki i żuchwy szynszyli, na których oszacowano wartości 13 bilateralnych cech metrycznych. Określono współczynniki asymetrii względnej (Aw) i asymetrii fluktuacyjnej (FA). Wśród 6 cech przyległych do osi czaszki współczynnik FA był istotny ($P \leq 0.01$ i $P \leq 0.05$) w przypadku 2 cech, a wśród 7 cech odległych od osi czaszki – aż w przypadku 5. Stwierdzono wzrost wartości istotnych statystycznie współczynników FA cech bilateralnych wraz z rosnącą liczbą osobników w miocie.

Key words: asymmetry, long-tailed chinchilla, skull.
Słowa kluczowe: asymetria, szkielet głowy, szynszyla mała.

INTRODUCTION

Systemic homeostasis is an essential precondition of proper functioning at each stage of organism development. It is responsible for the organism capacity to auto-regulate all ontogenic processes and maintain dynamic equilibrium between organism endogenous factors and variable environmental factors (Møller and Swaddle 1997; Mayes 2001). In the model of bilateral symmetry of the vertebrate body, paired organs should theoretically develop identically, with molecular auto-regulatory mechanisms already existing in the early stage of embryonic development being responsible for this (Tabin and McMahon 1997; Gellon and Mc Ginnis 1998). In the process of phylogenesis, asymmetry increases together with an increase in the level of organisation and is the largest in humans (Henneberg 1974; Polak 2003), being best seen in the skull (Watson and Thornhill 1994). In literature, there are increasingly more reports devoted to the analysis of fluctuating asymmetry index as a stress indicator (Leung et al. 2000; Őzener 2010). In Polish literature, the problem of fluctuating literature is not a widespread research topic and papers concerning this area are few and refer mainly to humans (Gawlikowska-Sroka 2006; Gawlikowska et al. 2007). In view of the

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results of studies on asymmetry, it seems interesting to consider a possible effect of the number of foetuses on the value of asymmetry index. A good material of observations of that type is animals which come from a multiple pregnancy. In chinchillas, which usually give birth to one kit under natural conditions, it is possible to receive two, three or more kits per litter as a result of intense selection being carried out in their breeding. In the previous study (Baranowski and Wojtas 2011), it has been shown that a larger number of significantly asymmetric bilateral epigenetic traits occurred in the cranium and mandible specimens from animals coming from multiple litters o long-tailed chinchilla. This study aimed at answering the question whether the number of animals per litter affects the values of asymmetry indices of skull metric traits in long-tailed chinchilla.

MATERIAL AND METHODS

The research material was long-tailed chinchilla skulls obtained from the carcasses of farm animals being kept in cages in livestock buildings with controlled reproduction and under consistent environmental conditions, such as nutrition, temperature, humidity and photo-period. The traits being analysed allowing for the litter size are presented in Table 1.

Table 1. Relative asymmetry (Aw) and fluctuating asymmetry (FA) values for the traits of long-tailed chinchilla skulls allowing for litter size
Tabela 1. Wartości asymetrii względnej (Aw) i asymetrii fluktuacyjnej (FA) cech szkieletu głowy szynszyli małej, z uwzględnieniem wielkości miotu

Number of features Numer cechy	Litter size – Liczebność miotu								
	1			2			> 2		
	n	Aw	FA	n	Aw	FA	n	Aw	FA
Traits adjacent to the skull axis – Cechy przyległe do osi czaszki									
1	70	0.33	0.91	163	0.13	0.42	142	0.06	0.62
2	61	–3.91	0.56*	143	–2.60	0.55**	122	–1.48	0.42**
3	61	–0.59	0.48	141	–1.35	0.64	121	–0.40	0.42
4	70	–0.24	0.50	161	–0.16	0.68	140	–0.49	0.62
5	59	–2.34	0.60**	141	2.09	0.97**	116	–1.52	0.71**
6	70	–0.29	0.35	159	0.17	0.21	141	0.00	0.27
Traits distant from the skull axis – Cechy odległe od osi czaszki									
7	53	–2.35	0.96**	132	–2.08	0.83**	111	–2.16	0.77**
8	61	0.95	0.72**	144	–0.10	0.39*	123	–0.74	0.45
9	62	0.03	0.58	144	–0.23	1.14	124	–0.34	0.90
10	61	–2.21	0.74**	144	–1.65	0.83**	124	–1.48	0.86**
11	70	0.35	0.13	163	0.08	0.22	142	0.11	0.23
12	70	0.56	0.17*	163	0.67	0.23**	143	4.06	0.26**
13	70	0.46	0.08**	163	0.69	0.13**	141	0.58	0.16**

Explanations – Objaśnienia: Fluctuating asymmetry values marked in rows with – Wartości asymetrii fluktuacyjnej oznaczone w wierszach: * the signed-rank test significant at P ≤ 0.05 – test znaków istotny, P ≤ 0,05; ** the signed-rank test significant at P ≤ 0.01 – test znaków istotny, P ≤ 0,01; 1 – one kit – jeden osobnik; 2 – two kits – dwa osobniki; > 2 – more than two kits – więcej niż dwa osobniki w miocie.

The analysis included the values of the following traits: 1. Height of the orbit; 2. Intersection of *Sutura zygomatica maxilliaris – Prosthion*; 3. *Processus temporalis ossis zygomatica – Sutura zygomatica maxiliaris*; 4. Length of the maxillary tooth row; 5. Length of the mandibular tooth row; 6. *Ectorbitale – Entorbitale*; 7. *Protuberantia occipitalis externa – Processus paracondylaris*; 8. *Bregma – Ectorbitale*; 9. *Bregma – Processus mastoideus*; 10. *Margo parietalis squmae temporalis – Processus mastoideus*; 11. *Akrokranion – Infraorbitale*; 12. Length of the zygomatic arch; 13. Posterior margin of the *tympanic bulla – Prosthion*. Empirical data were entered into the statistical software package Statistica v.10 PL, by which the values of relative asymmetry (Aw) factor were calculated using the following formula:

$$A_w = \frac{(\bar{p} - \bar{l}) \times 100}{\bar{l}}$$

as well as the values of fluctuating asymmetry (FA) factor with the following formula:

$$FA = \frac{war\ p - l}{\sqrt[2]{war\ p \times war\ l}}$$

The significance of differences was estimated by the Wilcoxon matched-pairs test and confirmed with the Wilcoxon signed-rank test in a non-parametric module of the statistical software package Statistica v.10 PL.

RESULTS

The results obtained are presented in Table 1. The values of fluctuating asymmetry factor confirmed by the signed-rank test were significant ($P \leq 0.05$ and $P \leq 0.01$) for the traits being characteristic of the length of one of the viscerocranium regions measured from the intersection of Sutura zygomatica maxilliaris to Prosthion, length of the mandibular tooth row, area of the nuchal surface (Protuberantia occipitalis externa – Processus paracondylaris), height of the neurocranium (Margo parietalis squmae temporalis – Processus mastoideus), length of the zygomatic arch, and total skull length (from the posterior margin of the tympanic bulla to Prosthion). At the same time, the values of relative asymmetry factors for the first four traits were found to be negative, which is an indication of left-sided asymmetry, whereas two other traits were positive, indicating right-sided asymmetry. The values of relative asymmetry factors for the thirteen cranium and mandible traits being examined were characterised by a wide range, from –3.91 to 4.06.

DISCUSSION

The paired structures of animal organisms are never perfectly symmetrical. Morphologically, three types of asymmetry are being distinguished: directional asymmetry, fluctuating asymmetry and antisymmetry. The latter is characteristic of the morphological structures for which prediction of the side predominance is not possible (Szuba 1978; Palmer and Strobeck 1992). The skulls is composed of two parts: one belonging to the somatic skeleton and another belonging to the visceral skeleton. The two parts differ in the evolutionary origins and play different role. The same genes, decisively influencing the predominance of one side, are responsible for the shape of bilateral structures on the both sides of the skull. Identification of two groups of traits on the chinchilla skulls, i.e. adjacent to the skull axis and distant from it, is in agreement with the regularity described in literature that elements being situated closer to the mid-line usually preserve symmetry more easily or their asymmetry is smaller than that of the traits being situated more laterally (Hershkovitz et al. 1990; Leung et al. 2000; DeLeon 2007). In the present study, two traits being adjacent to the skull axis showed significantly significant values of fluctuating asymmetry, whereas among those being distant from the skull axis as many as four ones (Table 1).

In the study, the skulls of animals of both sexes were used. Because the effect of sex on the magnitude of asymmetry is still unclear and many studies have not shown differences between sexes at the FA level, or they are non-significant (Żądzińska 2004), i.e. an unstable predominance between sexes or lack of differences may reflect the real differences between populations, a relative asymmetry factor was used in this study, expressing the magnitude of difference between the right side and the left side of total samples. The values obtained, ranging from –3.91 to 4.06, may be considered standard and correspond to the values being characteristic of the degree of asymmetry in human skulls of different age (Rossi et al. 2003).

Fluctuating asymmetry is a product of unfavorable impact of exogenous factors on the earliest stage of ontogenesis, which results in increased organism developmental instability (Palmer and Strobeck 1992; Møller 1999). However, the effect of endogenous factors, inducing differences in the levels of fluctuating asymmetry in isolated populations, can not be excluded (Hershkovitz et al. 1990; Schaefer et al. 2006). Despite the controlled reproduction being carried out at chinchilla farm, genetic relatedness can not be avoided, often deliberately, particularly when increasing population fecundity. A significant increase in the number of animals per litter, from 1–2 to 2–3–4, may be included into a group of environmental factors being called "developmental noise" (Leung et al. 2000), and the index of fluctuating asymmetry becomes then a measure of organism developmental stability (Palmer and Strobeck 1992; Őzener 2010). In relation to such traits as the length of the zygomatic arch or the length of cranium from the posterior margin of the tympanic bulla to Prosthion, i.e. of a very long segment which involves many structures, including those belonging to neuro- and viscerocranium, the increasing number of animals per litter induced an almost two-fold increase in the value of fluctuating asymmetry.

CONCLUSIONS

On the basis of the measurements performed, it is possible to state that the increase of the number of animals per litter in long-tailed chinchilla may be a source of asymmetry in bilateral traits of the skull.

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Abstract. This study aimed at answering the question whether the number of animals per litter affects the values of asymmetry indices of skull metric traits in long-tailed chinchilla. The research material was chinchilla crania and mandibles, on which the values of 13 bilateral metric traits were estimated. Relative asymmetry (Aw) and fluctuating asymmetry (FA) factors were determined. Out of 6 traits being adjacent to the skull axis, the FA factor was significant ($P \leq 0.01$ and $P \leq 0.05$) for two, while out of 7 traits being distant from the skull axis for as many as five ones. An increase in the values of statistically significant FA factors for bilateral traits was observed with the growing number of kits per litter.

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