SEX DIMORPHISM OF THE SCAPULA IN THE EUROPEAN BISON (*BISON BONASUS L.*)

Tomasz Szara, Franciszek Kobryńczuk, Henryk Kobryń, Bartłomiej Bartyzel, Aleksandra Nowicka
Department of Morphological Sciences, Warsaw Agricultural University, Faculty of Veterinary Medicine, ul. Nowoursynowska 159, 02–776 Warszawa, Poland, tel./fax: +48 22 8473783; e-mail: szara@alpha.sggw.waw.pl

Abstract. The aim of this study was the elaboration of discriminant function differentiating the scapula of males and females of the European bison. The materials comprised the scapula bones of 58 individuals (30 males and 28 females). The linear measurements were used for Fisher's discriminant functions, allowing the separation of bones according to sex. The effect of age of the animal on sex dimorphism was also investigated. The female scapula bones , contrary to males, with age lose the traits of sex dimorphism.
Key words: European bison, scapula, sex dimorphism.

STUMBRO (*BISON BONASUS L.*) MENTĖS LYTINIAI SKIRTUMAI

Santrauka. Šio darbo tikslas − detaliai ištirti ir nustatyti stumbro patinų ir patelių mentės skirtumus. Ištirta 58 individų mentės (30 stumbrų ir 28 stumbrių). Skirtingos lyties kaulams atskirti buvo taikoma Fisherio formulė. Gyvulių amžiaus įtaka lyčiai taip pat buvo tirta. Patelių mentės kaulai, skirtingai nei patinų, su amžiumi praranda lytinius skirtumus.
Raktažodžiai: stumbras, mentė, lytinis dimorfizmas

Introduction. Osteometric investigations have so far been carried out on pelvic bone (Kobryń, Kaba 1986), sacral bone (Szara et al; 1993), metapodials (Kobryńczuk, 1997) and sternum of European bison (Kobryń, Kobryńczuk, 1998).

It has been stated that by using appropriate statistical methods it is possible to determine the sex of the animal to which the examined part of skeleton belonged. The authors of the following study have taken the effort of investigating the issue of sex dimorphism in scapulae of this species.

Material and methods. The material consisted of 58 scapulae of European bison (30 males and 28 females) bred in the nature reserve of Białowieża. The age of the individuals was established according to the European Bison Pedigree Books (Żabiński, 1947-65; Raczyński, 1972). Using the method Duerst (1926), modified by Empel & Roskosz (1963) the following measurements of the bones to be analysed were taken:

greatest length (a), basal length of the spina scapulae (b), greatest width (c), smallest width of the collum scapulae (d), longitudinal dimension of the glenoid cavity (e), transversal dimension of the glenoid cavity (f) and the height of the spina scapulae (g)

The mean values of these parameters for males and females, and their basic statistical characteristics are listed in Table 1.

Table 1. **Mean values of the scapula measurements (mm) in the European bison. The symbols are explained in the body of the paper**

	Symbols of the measurements						
	a	b	c	d	e	f	g
Males (n=30)							
Avg	499.7	403/66667	298.13333	79.1	81.5	69.933333	64.033333
Min	422	334	240	62	64	64	50
Max	542	436	342	102	90	83	75
SD	25.28479	21.40953	23.23008	6.661003	5.302894	3.78685	6.578352
Females (n=28)							
Avg	417.17857	335.21429	240.32143	64.678571	69.964286	57.214286	49.892857
Min	292	232	164	45	59	46	35
Max	458	366	277	72	79	66	60
SD	43.90314	35.58231	30.09621	6.896341	5.167435	4.732528	7.088537

The essentiality of the differences was evaluated using the T-Student test. Correlation coefficients (r) for each pair of parameters were analysed, separately for males and females. All the possible quotients were counted, each parameter being divided by others. For further investigation only those quotients that varied statistically for males and females were taken into consideration. Basing on the sum of variances and covariances of quotients for males and females, and on the result between their mean values for both sexes, the matrix was constructed. Its solving led to the elaboration of a discriminative function that allows best to determine the sex of an examined bone (Fischer, 1936). It was assumed that positive coefficients (z) would determine male bones, and the negative – the female ones.

In order to establish how the sex dimorphism of the scapula changes, the correlations between the independent variable of age (w) and the dependent value of the discrimination coefficient (z) were analysed (Fig. 1).

The value of the vertical angle of the isosceles triangle circumscripted on the scapula was counted by using the following trigonometrical formula:

$$tg\frac{\alpha}{2}=\frac{2be-e}{2ab}$$

where symbols a, b and e stand for the values of selected measurements.

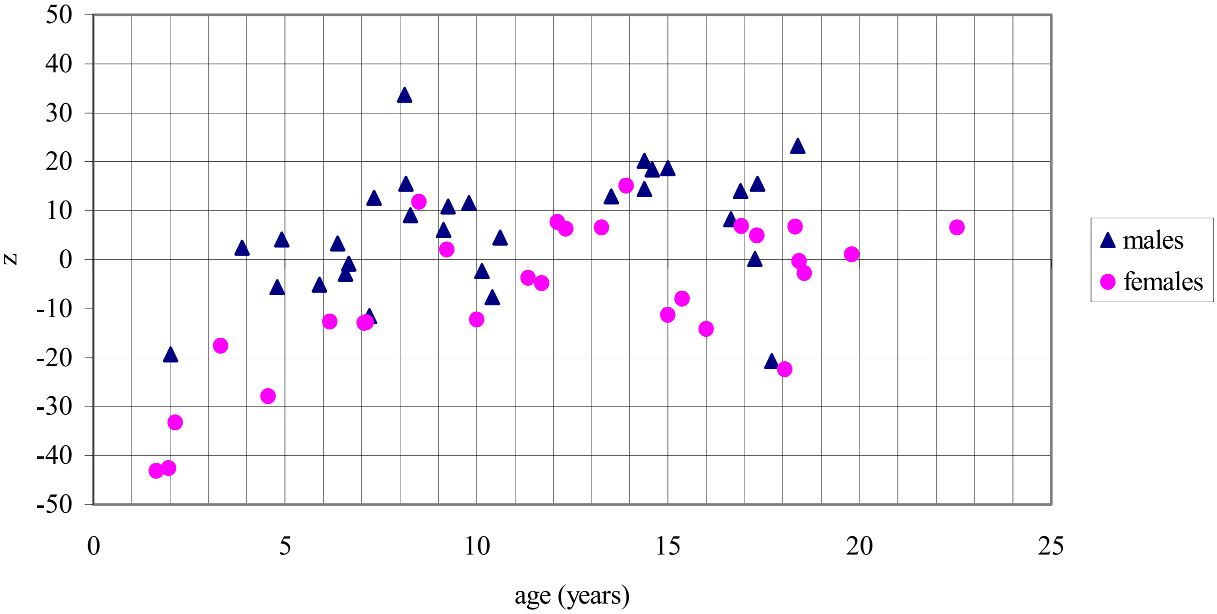

Figure 1. **Discriminating coefficient values of examined individuals**

Results. Mean values of the seven scapula measurements are essentially greater for males (P≤0.01). Their variability is lower for males than for females. The variability is the lowest in males for the greatest length of the scapula (a), and in females for the longitudinal dimension of the glenoid cavity (e).

Similarly in both sexes, the most variable parameter in the dimension is the height of the spina scapulae (g).

In female individuals, a height correlation (P≤0.01) of single parameters is to be observed. The greatest correlation coefficient being the one for the greatest length of the scapula and the basal length of the spina scapulae (b, r=0.089). Mean values of correlation coefficients are lower for males. Their longitudinal dimension of the glenoid cavity (e) does not visibly correlate with other essential parameters. Moreover, the value of the correlation coefficient for the pair of measurements f – g is irrelevant in male individuals.

Similarly for both sexes, both dimensions of the glenoid cavity show the least correlation coefficients.

It may be due to the low absolute value of those parameters in comparison with others, which in turn may add to a significant relative error in measurements. However, the greatest mean correlation coefficients for both sexes refer either to the greatest length of the scapula or to the smallest length of the collum. The isosceles triangle with the apex pointing downwards circumscripted on the scapula, and the average of parameters is similar for both sexes, as its vertical angle has 36 degrees in mode individuals and 34 degrees – in females.

Therefore on average no vital differences in the shape of scapula according to sex are observed. Out of all possible quotients of each pair of parameters only three (x_1, x_2, x_3) with a significant difference (P≤0.01) of mean values with regard to sex were found. Those are:

$$x_1=\frac{e}{c}$$

$$x_2=\frac{g}{e}$$

$$x_3=\frac{g}{a}$$

The following discriminant function was constructed basing on the given quotients:

$z = -672\ x_1 - 73\ x_2 + 694\ x_3 + 159{,}25$

where x_1, x_2, x_3 stand for the values of appropriate quotients.

The value of discrimination coefficient for a male individual with average quotients of the scapula amounts to +5.94, and to – 5.95 for a female, which gives the result (distance) of 11.89 points. By analysing individual values of discrimination coefficients it is easily noticeable that 10 out of 30 males (33%) have scapulae similar in shape to there in female ones. In turn, 12 females out of 28 (43%) have scapulae similar in shape to the ones in males.

Most females above 12 years of age have scapulae of male shape. This fact allows to make the assumption that with the age the exposure of sex dimorphous traits becomes more evident in males, whereas decreasing in females.

After an analysis of the correlation, its coefficients were obtained as follows: r = 0.37 for males, and r = 0.686 for females. The dependence on the age (w) and the value of the discrimination coefficient (z) is illustrated by the following regression equation:

males z = 0.999w – 4.423,

females z = 1.780w – 28.310.

The regression coefficient is higher in females (1.780) than in males (0.999).

Due to that fact, regression lines cross in the first quarter of coordinate system.

The crossing point of the lines theoretically determines the age when scapulae of female individuals are in all cases identical in shape to the male ones. This theoretical age was defined using the following equation:

0.999w – 4.423 = 1.780 w – 28.310

The discrimination coefficient of a female scapula of the above age amounts to (z) = +26.00, the scapula being in this period a bone of typically male traits.

Discussion. The individual shapes of appendicular skeleton in males and females, not only in the European bisons, are observed in all of the cases where the individuals of different sex and of equal age have unlike body weight, which is greater in males.

Therefore, the lack of the sex dimorphism of an examined bone is not paradoxical if the weight of the bone is approximately the same for a 5-year- old male and a15–year– old female. As the weight grows, juvenily slender long bones become massive (thickset, solid), such changes occur in the metapodial bones and humerus of the European bison (Kobryńczuk, 1996, 1997) being a sign of greater exposure of sex dimorphism in males, and of its regression with regard to females. In spite of this, long bones of appendicular skeleton of the European bison can be categorised according to sex by using the simplest methods (Empel, Roskosz, 1962).

Unfortunately, the same cannot be said about the scapula. The goal of constructing a discriminative function that would differentiate male and female scapulae on the grounds of the parameters has not been morphology of the given bone and to its function in the osseo-articular chain of the thoracic limb in the European bison.

The scapula is neither a pipe-shape bone nor has articulations on both ends. The weight supported by the thoracic limb does not rest on scapula only; it is also the function of humerus with the help of pectoral muscles, which are attached to humerus and sternum. The scapula is to a certain degree free from the pressure of the trunk and so less prone tovector forces than the lower situated long bones.

The values of the quotients x_2, x_3 are higher for males, in contrast to the value of the x_1 quotient, which is greater for females.

It results from the relatively large width (basis) of a male scapula and of its height of the spina, and longitudinal dimension of the glenoid cavity being rather small. The trygonometry of scapula also proves that the bone in question is shorter and wider in male individuals. The height of the spinal scapulae in males is due to a well-developed trapezius muscle, a part of well-expressed withers. The glenoidal cavity is more circular in male individuals than in females, allowing for a greater possibility of ad – and abductory movements in the humeral joint. This may be in connection with, for instance, fighting for females.

Conclusions

1. Scapula bones of European bison characterize sexual dimorphism in 67% of males and 57% of females.
2. The effect of age on the dimorphic traits of scapula is greater in females than in males.

References

1. Duerst J. U. Vergleichende Untersuchungsmethoden am Skelett bei Saugern. Urban and Schwarzenberg, 1926. Vol. 7. P. 125-530.
2. Empel W., Roskosz T. Das Skelett der Gliedmassen des Wisnts, Bison bonasus (Linnaeus, 1758). Acta Theriol., 1963, 7.Vol. 13. P. 259-330.
3. Fisher R. A.: The use of multiple measurements in taxonomic problem. Annals Eug., 1936. Vol. 7. P. 179-188.
4. Kobryń H., Kobryńczuk F. Determination of the sternum sex dimorphism in the European bison with the help of discriminative function. Polish Journal of Veterinary Sciences. 1998, Vol. 1, No 1, P. 17-19.
5. Kobryńczuk F.: The estimation of sexual dimorphism features of bones in the European bison using the discriminant functions. I. Metapodial bones. Ann. Warsaw Agricult. Univ.-SGGW, Vet. Med., 1997. Vol. 20. P. 3-11.
6. Szara T., Roskosz T., Kobryńczuk F., Chrabałowski Z.: Sex dimorphism of the sacral bone in the European bison, Bison bonasus (L.) Ann. Warsaw Agricult. Univ.-SGGW, Vet. Med., 1993. Vol. 18. P. 37-43.
7. Świeżyński K.: The skeletal musculatur system of the European bison, Bison bonasus (Linnaeus, 1758). Acta Theriol., 1962, Vol. 6. P. 165-218.
8. Żabiński J (Ed.) Pedigree book of the European bison. PWN. Warszawa. 1947-1965. P. 1-370.
9. Żabiński J., Raczyński J., (Eds) European bison pedigree book 1965-1969. PWN Warszawa. 1972. P. 1-78.

2003 06 02