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Holocene remains of the Pine marten (*Martes martes*) from the Tatra Mts. (Poland) – skull morphology and population structure (Carnivora: Mustelidae)

Zmienność morfologiczna czaszek holoceńskiej populacji kuny leśnej (*Martes martes*) z jaskiń tatrzańskich i populacji współczesnej (Carnivora: Mustelidae)

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Abstract. A morphological analysis of 36 skulls of the pine marten *Martes martes* (Linnaeus, 1758) collected in caves in the Tatra Mts. (southern Poland) was carried out. Special attention was paid to age and sex structure of this Holocene population. The results of skull measurements of the subfossil population were compared with those of recent pine marten populations from Poland.

INTRODUCTION

The paper is aimed at the analysis of skull morphology of subfossil remains of the pine marten *Martes martes* (Linnaeus, 1758) from Poland regarding age and sex structure of the population. So far, no studies have been focused particularly on this aspect. Most publications are devoted to morphological comparison of skulls between *Martes martes* and *Martes foina* (Erxleben, 1777). The differences between the two species were presented by Anderson (1970), Altuna (1973), Steiner & Steiner (1986) using non-metrical parameters, and Gerasimov (1985) using a multivariate analysis of variance. In Europe, the skull morphology of martens was studied in various aspects and according to various criteria: age classes – Röttcher (1965), Habermehl & Röttcher (1967), sex dimorphism Bree et al. (1970), Rossolimo & Pavlinov (1974), as well as variability and asymmetry of dentition of pine and beech martens in Poland (Wolsan 1985, 1986, 1989) and in Europe (Reig 1989). The above mentioned publications were aimed only at comparisons of recent populations of the two marten species, whereas there are no articles comparing recent and subfossil populations.

MATERIAL AND METHODS

Several hundreds of caves are known in the Tatra Mts., mostly in their western part. These caves are characterized by specific ecoclimate and fauna. The material of 36 pine marten skulls was collected in the following Tatra caves: Czarna (7 specimens), Zimna (4), Mała Świstówka (1), Miętusia (1), Chochołowska (2), Bielska (1), Ptasia Studnia (6), Niedźwiedzia (1), Za siedmioma Progami (12), Wysoka (1). The studied material was collected between 1961 and 1981, mostly by K. Kowalski, A. Woźnica,

M. Zagórny, M. Gębołys, B. W. Wołoszyn and has been deposited in the Institute of Systematics and Evolution of Animals, PAS, in Kraków.

The subfossil skulls of the pine marten were found on the surface of cave floor and most probably are of the Holocene age.

The following measurements were taken: condylobasal length (CBL), alveoli condylobasal length (CBLa); zygomatic width (ZYW); postorbital width (PorW); mastoid width (MstW). Males and females were distinguished on the basis of differences in alveoli condylobasal length (CBLa) and zygomatic width (ZYW).

We used the simplified age classification presented by Buchalczyk & Ruprecht (1989), based on the following characters: (1) state of preservation of sutura internasalis, s. nasomaxillaris, s. nasofrontalis, and s. maxillofrontalis; (2) degree of tooth wear; and (3) crista sagittalis development.

Three age classes were distinguished: (I) young individuals, contours of s. nasomaxillaris, s. nasofrontalis, and s. maxillofrontalis visible; beginning of crista sagittalis formation; rough surface of the toothrow; presumed age: 5–8 months; (II) mature specimens, crista sagittalis situated below the line, rough surface of the toothrow; presumed age: between 9 months and 2 years; (III) old individuals, long crista sagittalis, smooth surface of the toothrow, some teeth may be missing; age: 2 years or more.

The data on skull morphology of the studied Holocene population were compared with the results of measurements of the recent marten population taken from the publication by Reig & Ruprecht (1989). These authors studied *Martes martes* from four regions of Poland: Masurian and Pomeranian Lakelands, Wielkopolska-Kujawy Lowland, Białowieża Forest, and Silesia.

Since the subfossil material was damaged, it was impossible to take some of the measurements usually taken on recent material. The CBL length of the skull of recent specimens is measured from the anterior margin of incissivi to the posterior margin of *condylus occipitalis*. However, incisors are missing in most subfossil skulls, therefore the CBLa was taken. Results of both measurements taken on the same recent

Table 1. Range and mean values of skull measurements of subfossil and recent martens (males and females separately). Explanations: CBLa – alveolar condylobasal length; CBL – condylobasal length; ZYW – zygomatic width; PorW – postorbital width

Tab. 1. Zróżnicowanie holoceńskiej populacji kun ze względu na różnorodność badanych parametrów.

	Holocene		Recent	
measurement	mean±SD	min–max	mean±SD	min–max
females				
CBLa	74.97±1.83	72.15–78.33	78.5±4.46	72.15–88.15
CBL			75.0±4.27	75.50–81.60
ZYW	42.68±2.75	36.47–48.69	45.3±2.40	43.00–48.00
PorW	18.25±1.38	16.35–21.50	17.3±6.30	15.30–20.00
males				
CBLa	83.18±2.22	79.80–88.15		
CBL			85.6±1.70	82.0–87.90
ZYW	47.29±2.62	43.23–50.70	51.1± 3.20	47.6–55.20
PorW	19.24±0.83	17.77–21.01	19.1±6.50	15.8–21.30
all individuals				
CBLa	78.50±4.46	72.15–88.15		
CBL			82.2±1.43	78.75–84.75
ZYw	44.20± 3.46	36.50–50.70	48.2±1.35	45.30–51.60
PorW	18.50±1.55	15.25–22.55	18.2±1.16	15.50–20.65

specimens were compared. An average difference between the two measurements was 0.6 mm, i.e. 0.01%, being within statistical error limits.

An analysis regarding sex and age structure of the population was carried out. Statistical significance level of all differences was below 0.005. Values were transformed before the statistical analysis. All P--values reported are two tailed, the T-test of the differences between two means was performed.

RESULTS

Sexual dimorphism and population structure

Both the Holocene and recent marten populations exhibit a distinctive sex dimorphism: males are larger than females. The distinguishing characters are: condylobasal length (CBL) or alveoli condylobasal length (CBLa), and zygomatic width (ZYW). In the subfossil population, differences in CBL and ZYW between the two sexes are statistically significant ($p<0.001$). Based on these characters, we classified 15 specimens as females, and 11 as males (Fig. 1), while skull dimensions of the remaining 10 specimens did not allow their classification.

Comparison of subfossil and recent material

Within the sex groups, the Holocene marten skulls are shorter than the recent ones by 3.85 mm on average (statistically significant difference, $p<0.005$; Table 1).

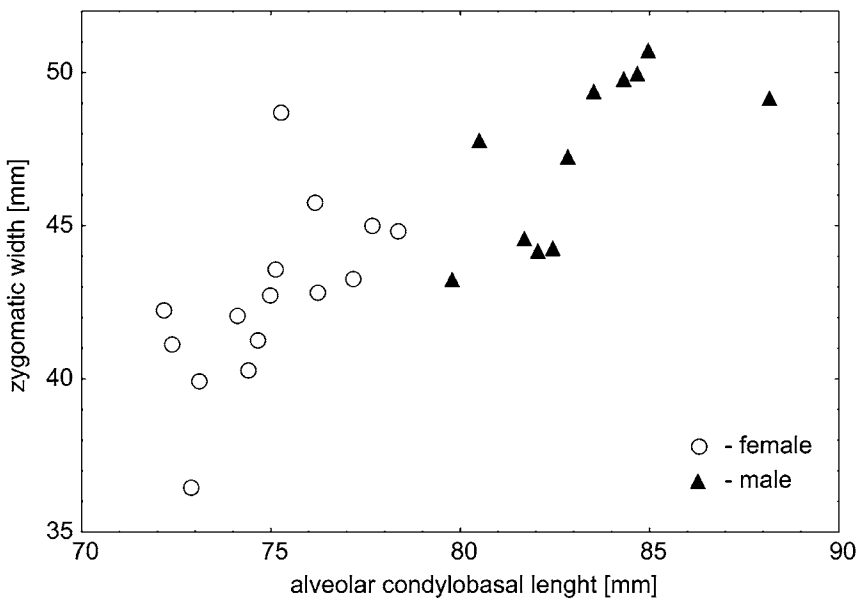

Fig. 1. Skull dimensions of Holocene martens – sex groups.
Rys. 1. Zróżnicowanie holoceńskiej populacji kun ze względu na płeć.

Fig. 2. Sex and age structure of the studied Holocene marten population.
Rys. 2. Struktura populacji holoceńskiej pod względem płci i wieku.

Age of individuals

The Holocene marten sample comprises 36 specimens. Most of them are adults from the II age class (n=24). Older specimens (of III age class) are less numerous (n=10), and only two individuals were classified as young.

DISCUSSION

Trogloxenes – animals inhabiting caves incidentally or using them as seasonal shelters – are the most numerous group in the fauna of caves. The pine marten *Martes martes* is one of such species: it occurs in caves sporadically but gets through cave corridors far from the entrance.

The authors analysed the structure of a subfossil marten population on the basis of skull morphology. Our results show that the Holocene martens had on average by 3.85 mm smaller skulls than the recent ones. This difference may be related to thermoregulation requirements in different climatic conditions: according to Bergmann's rule animals living in warmer climate tend to have a relatively higher body surface to body mass ratio (e.g. smaller body size) than animals living in colder climate where reduction of relative body surface (e.g. larger body size) is favored. It is likely that the remains of martens from the Tatra caves originate from the Holocene optimal climatic period, Atlantic or Subatlantic, when smaller individuals could easily radiate excess of heat. The results of radiocarbon dating (C^{14}) of the subfossil material could bring a definitive answer to this question.

The age structure analysis was carried out using simplified age categories proposed by Buchalczyk & Ruprecht (1989). These authors assessed the age of 596 marten specimens, grouping them into five age groups. For the small Holocene sample (n=36) we reduced age groups to three. Mature specimens prevailed in our material, while old animals (of 2 or more years of age) were by half less numerous. Young individuals (of less than 8 months) were rare – only two specimens out of the 36. The low proportion of young animals indicates that caves were used by martens as temporary shelters or hunting grounds, not for raising offspring (Fig. 2).

PODSUMOWANIE

Zbadano holoceńską populację kun leśnych (*Martes martes*) z jaskiń tatrzańskich. Wybrane parametry pomiarów czaszki porównano z pomiarami wykonanymi na materiale współczesnym. Mniejsze rozmiary populacji holoceńskiej (Tab.1) wskazują zgodnie z Regułą Bergmanna, że badana populacja zasiedlała ten teren w cieplejszym klimacie, prawdopodobnie w optimum klimatycznym Holocenu.

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