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Femoral morphology of Cave bears from Croatia

by

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Abstract

In this paper we present the results of the research performed on the cave bear femora from the Upper Pleistocene layers of the Croatian caves Vindija, Velika pećina, Veternica and Cerovačke pećine. The study, based on femoral biometry, morphology and biomechanics, was performed with aim to answer if there are variations within the species caused by the temporal and/or environmental differences.

Zusammenfassung

In dieser Studie präsentieren wir die Ergebnisse, die wir aus der Bearbeitung von Femora des Höhlenbären aus dem Pleistozän kroatischer Höhlen (Vindija, Velika pećina, Veternica and Cerovačke pećine) gewonnen haben. Ziel dieser Arbeit, basierend auf Biometrie, Morphologie und Biomechanik des Femur, war es, eine Antwort auf die Frage zu finden, ob es Variation gibt, die entweder durch Evolution und / oder durch Umwelteinflüsse hervorgerufen wird.

1. Introduction

Study of the cave bears in Croatia intensified in the 1980's when analysis of the Upper Pleistocene material from the caves Vindija, Veternica, Velika Pećina (NW Croatia) and Cerovačke caves (Central Croatia) has started. At the beginning this study included microevolutionary changes registered in the morphology of the cave bear teeth and metapodial bones. Later, following the principal biomechanical rules, the analysis was extended to the femora with hypothesis that differences in functional-morphology of the cave bear limbs could be affected by the paleoenvironment. Therefore a total of 160 femurs was studied (62 – Vindija, 4 – Velika pećina, 27 – Veternica and 67 – Cerovačke pećine), but considering the low frequency of material in separate layers, the femora from each site were treated together.

2. Sex dimorphism

Knowing the sex dimorphism of bears (STIRLING 1993, REISINGER & HOHENEGGER 1998) we compared 9 variables (A – greatest length, B – length between trochanter major and epicondylus, C – proximal width, D – transverse diaphysis diameter, E – antero-posterior diaphysis diameter, F – distal width, G – antero-posterior caput diameter, H – transverse caput diameter, I – collum-corpus angle of femur). We applied K-means clustering method, and two clear clusters were apparent: the first one of a higher values for the males, and the second of lower values for the females (fig. 1). Following this, males and females were treated separately in subsequent analyses.

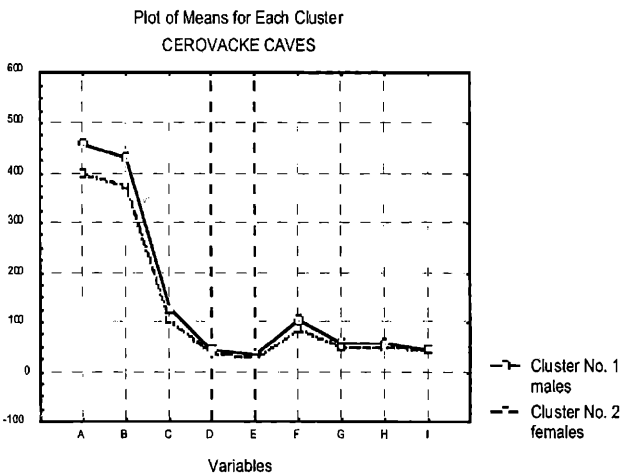

Figure 1: Example of sex separation by K – means clustering method.

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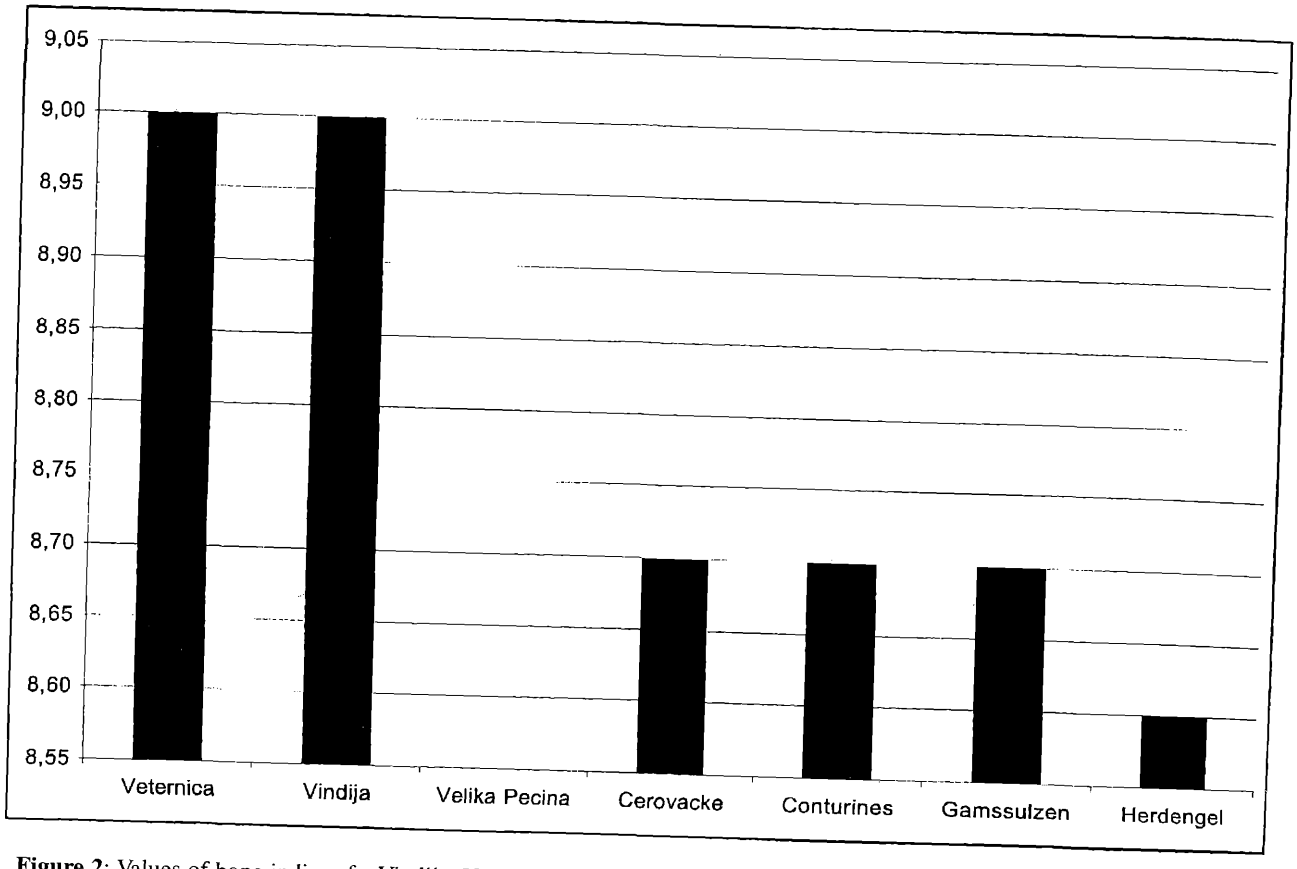

Figure 2: Values of bone indices for Vindija, Veternica, Cerovačke caves, Conturines, Herdengel and Gamssulzen.

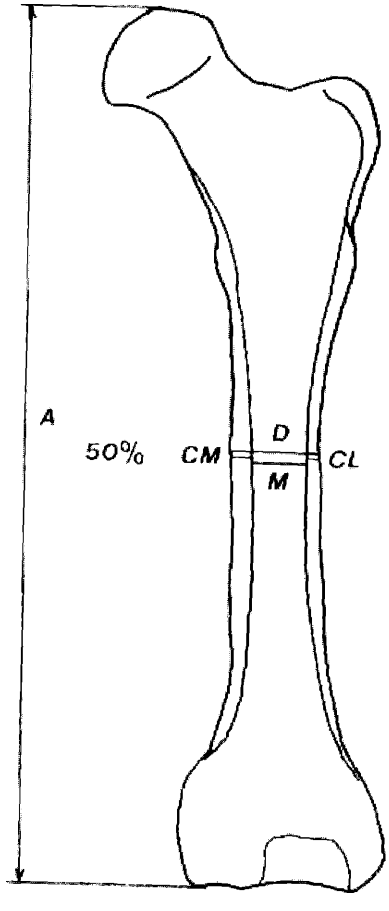

Figure 3: Measuring points for radiograph analyses.

3. Bone Index (BI)

Reflecting a type of the limb bone loading, the bone index (BI) is a ratio of the diaphysis diameters to the length between trochanter major and epicondylus. It is expressed by formula: BI= ((D+E)/2) / B. Now BI is calculated for femora from Vindija, Veternica, Cerovačke pećine, and compared to BI calculated for material from three Late Pleistocene Alpine caves: Conturines (Dolomites, at 2,775 msl., dated between 115,000 to 44,000 years B.P) Herdengel (Lower Austria, 780 msl., dated between 67,000 and 36,000 years B.P.) and Gamssulzen (Upper Austria, 1,200 msl., dated from 38,000 to 25,000 years B.P). Compared with others, the values of the BI from Cerovačke caves are very similar to those of the Late Pleistocene Alpine caves, and different from Vindija and Veternica (fig. 2).

4. Radiograph analysis

We have made radiographs for some bones from each Croatian locality, and measured outer diameter (D), inner diameter (M), lateral cortical thickness (CL) and medial cortical thickness (CM). All measures were taken at 50% of the diaphyseal length from the distal end, and perpendicular to the central axis (Fig. 3). From these parameters we calculated a general cortical index (CI), medial cortical index (CIM), lateral cortical index (CIL) and cortical area (CA). All variables are examined

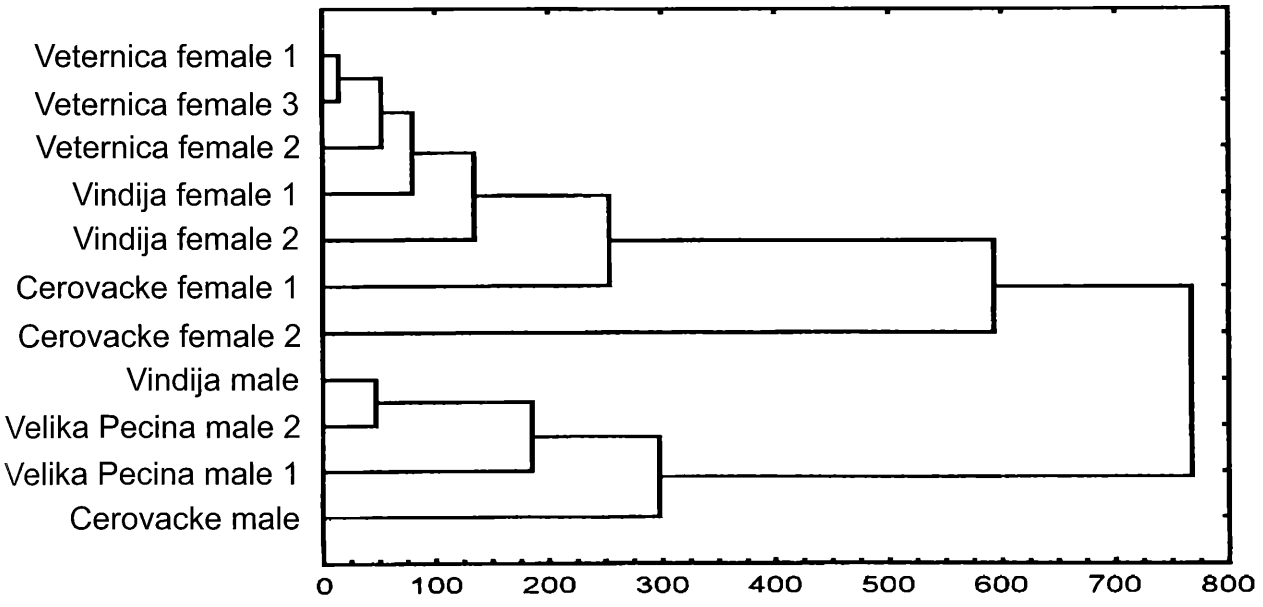

Figure 4: Tree Diagram of radiograph analysis for femora.

using Hierarchical Join (tree cluster) analysis. The dendrograms show clear separation into two classes, one contains males and the other females. Within each cluster, Cerovačke caves forms a subclass distinct from Vindija, Veternica and Velika Pećina (fig. 4).

6. Discussion

The present study has shown that, oposite to the microevolutionary changes registered on the teeth and metapodial bones, the main morphological differences (? changes) on the cave bear limb bones were not caused by time flow but by the distinct environment. Results show different limb loading and locomotory patterns: lower BI indicates smaller limb loading caused in the first place by the body mass, or by different mechanical forces. The BI values of the cave bear femora from the high mountains caves Cerovačke, Conturines, Herdengel and Gamssulzen are very similar, but lower than BI values of hilly-lowlands samples from Vindija, Veternica and Velika Pećina. The RTG-osteometry also yields evidence about differences between mountain habitat of the Cerovačke caves and others hilly-lowlands sites. All these differences are conditioned by adaptation to the environment and manifest themselves in femoral morphology. Clearly, the analysis of other bones of the extremities is necessary in order to prove that all these differences are mechanical response to habitual patterns of limb use.

Namely, the sediments of four investigated localities were deposited in different stages of the Upper Pleistocene (in the Vindija dated from 114,000 to 18,500 years B.P.; in the Veternica from 42,200 to 13,660 years B.P.; in the Velika pećina about 33,850 and 26,450 year B.P.; and in the Cerovačke caves more than 40,000 years B.P. (Krklec & Jambre_ić 1997), and their faunal assemblages dominated by the cave bears have been grouped into tree periods: Middle Paleolithic, Early Upper Paleolithic, and Late Upper Paleolithic. In the same time, geographically, the studied localities belong to two main types: hilly-lowlands (Vindija at 370 msl, Velika Pećina at 428 msl and Veternica at 306 msl situated in the NW Pannonian Croatia) and mountain (Cerovačke Pećine at 624-671 msl in the Velebit Mt. in the E Central Croatia). During the Last Glacial the hilly-lowlands region in the north-western part of the Pannonian Croatia was dominated by mixed deciduous or conifer forests. In the same time, reflecting the changes of climate and altitude, Dinarides ie. Velebit Mt. (with many peaks over 2,000m high) have supported isolated glaciers and supposedly vegetation similar to the todays alpine habitat.

7. References

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