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Original article

Metapodial bones of *Ursus* gr. *spelaeus* from selected caves of the North Italy. A biometrical study and evolutionary trend

*Les métapodes de l'*Ursus *gr.* spelaeus *de quelques grottes du Nord de l'Italie. Études biométriques et tendance évolutive*

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ABSTRACT

The cave bear evolution is characterized by some specific trends, including the increase in size, the progressive complication of the tooth surface and the gradual strengthening of the metapodial bones. Important indicators of the evolutionary level are the morphodynamic index of $P^4/_4$ and the plumpness index of the metapodial bones. Only recently, the morphological and morphometric analysis was complemented by genetic analysis – particularly of mtDNA. As a consequence, mainly based on genetics, new taxa have been proposed, for some of whom the exact taxonomic rank (species or subspecies?) is still under discussion. However, the new evolutionary model presents some problems because the genetic data alone are not sufficient to ensure a specific distinction and the morphodynamic and morphometric data do not support a specific distinction between the cave bear populations. The morphometric analysis performed on numerous metapodial bones belonging to some Italian (Buco dell'Orso, Covoli Velo and S. Donà di Lamon) and European populations seems to confirm, on the whole, a level of diversity not higher than that of a subspecies, allowing at most the identification of some local evolutionary trends, as assumed for the populations which have been living in the Italian peninsula.

Mots clés :
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RÉSUMÉ

L'évolution de l'ours des cavernes est caractérisée par des tendances particulières, incluant l'augmentation de la taille, la complexification progressive de la surface des dents et le renforcement progressif des os des métapodes. D'importants indicateurs de niveau évolutif sont l'indice morphodynamique de $P^4/_4$ et l'indice de la rondeur des os des métapodes. Ce n'est que récemment que l'analyse morphologique et morphométrique a été complétée par l'analyse génétique – particulièrement du mtDNA. En conséquence, des nouveaux taxons ont été proposés sur des critères génétique, et le rang taxonomique exact (espèces ou sous-espèces ?) de certains d'entre eux est encore en discussion. Cependant, le nouveau modèle évolutif présente certains problèmes car les seules données génétiques ne sont pas suffisantes pour une distinction spécifique, et les données morphométriques et morphodynamiques ne justifient pas une distinction spécifique entre les populations d'ours des cavernes. L'analyse morphométrique effectuée sur de nombreux ossements métapodes appartenant à différentes populations italiennes (Buco dell'Orso, Covoli Velo and S. Donà di Lamon) et européennes semble confirmer, dans l'ensemble, un niveau de diversité pas plus élevé que celui des sous-espèces, ce qui permet tout au plus l'identification de certaines tendances évolutives locales, comme on le suppose pour les populations ayant vécu dans la péninsule italienne.

1. Introduction

Among the Quaternary mammalian fauna, the cave bear (*Ursus* gr. *spelaeus* Rosenmüller, 1794) has ever powered a great curiosity. Its large diffusion in Europe and in part of Asia, has permitted

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the scientific community to study a great amount of fossils and consequently to have abundant data to better know this vertebrate inside both its specific variability and its habitat of life. Recent studies on mtDNA, have deeply changed the evolutionary picture of cave bears. Moreover, different morphometric and morphodynamic researches with the same finality, have reached different conclusions with respect to genetic ones (Athen, 2006, 2007; Athen and Pfretzschner, 2005, Hofreiter et al., 2002; Münzel and Athen, 2009; Orlando et al., 2002; Rabeder, 2011; Rabeder et al., 2011; Rossi and Santi, 2011). Inside this topic there are the studies about the $P^4/_4$ and the metapodia of the cave bears from Austria, Germany, Slovenia and Croatia (Rabeder, 1983, 1999; Rabeder et al., 2011 and so on).

Notwithstanding that in recent years news about the Italian cave bears have carried more detailed data, in the scientific community they are rather less known (Bona, 2004; Bona et al., 2004; De Carlis et al., 2005; Rossi and Santi, 2001a, b, 2007, 2011, 2013; Santi and Rossi, 2001a, b, 2006, Santi et al., 2003, 2011). The consequence is a confusion on both the specific level and the evolutionary degree.

Subject of this work is to morphometrically study the metapodial bones of the cave bears coming from some selected caves located in Lombardy and Veneto regions (North Italy) (Grotta del Buco dell'Orso, Laglio–Como), San Donà di Lamon (Belluno) and Covoli di Velo (Verona) (Fig. 1). This analysis has been elaborated to evaluate the possible presence of different species in the cave bear group and to advance a view on the phylogenetic step of the Italian speleians.

2. Materials and methods

Metapodial bones come from three selected caves: Grotta del Buco dell'Orso (Laglio, Como–Lombardy), San Donà di Lamon (Belluno–Veneto) and Covoli di Velo (Verona–Veneto). In this work fossils from other caves (Grotta del Cerè, Verona, and Buse di Bernardo–Trento) are also considered in order to have other elements of comparison. We have utilized the parameters codified by Von den Driesch (1976) and Withalm (2001) (Fig. 2). In this research we have measured 616 fossils also standardized with those of the Gamssulzen cave (Austria). In particular we have utilized the Plumpness index (PI) (Withalm, 2001) and K-Index (KI) (Guzvica and Radanovic-Guzvica, 2000) to indicate some evolutionary traits.

In some paragraphs and graphs the name of the caves have been abbreviated (see list in Fig. 2).

2.1. Plumpness Index (IP) and K-Index (KI)

The **Plumpness Index** concept was introduced by Withalm (2001), and it consists of the "Distal epicondial width/Total Length) × 100" of the metapodial; he considered it as a good tool in the evolutionary view of the cave bears. In fact, an increase of this index can correspond to a major evolutionary degree of the bear. Different studies have utilised the metapodial to advance more considerations on both the morphometry and the evolution of the cave bears (Withalm, 2001; Athen and Pfretzschner, 2005; Toškan, 2006; Sabol et al., 2009; Rabeder et al., 2010 and so on).

A part of our research will be devoted to the use of the PI and its meaning for the Italian populations.

Also the K-Index (KI) is a ratio to preliminarily identify the evolutionary step of the cave bears.

2.2. Morphodynamic Index (IM)

In this work another important index will be utilized: the **Morphodynamic Index** of the $P^4/_4$ (Rabeder, 1983, 1999) to have another control on the evolutionary step. Table 1 shows the most important caves where the fossils come from, their radiometric data and the morphodynamic index of the $P^4/_4$. Further, more diagrams have been performed to compare the Italian cave bears data with those of the main foreign caves, mainly of Austria and Slovenia where different taxa of bears are genetically identified. Finally, the presentation of the data will be advanced for every single cave starting from the westernmost one, the Grotta del Buco dell'Orso.

3. The selected caves

Briefly in this section, the selected caves will be described starting from the more western one, the Grotta del Buco dell'Orso, followed by the morphometrical data of the metapodia.

3.1. Grotta del Buco dell'Orso (Laglio, Como)

The geographical position and a section of the Grotta del Buco dell'Orso (Cornalia, 1858–71) are observable in Fig. 3. This cave is about 300 m long, 15 m tall, opens at 648 m a.s.l. and is located in the neighbourhood of the Laglio village. A micritic limestone rock of the Lower-Middle Lias composes it, the direction is initially ENE-WSW, passing to WNW-ESE successively with a series of fractures with a NNW-SSE direction. The studies on both its stratigraphy and palaeontology are rather rare; only Cornalia (1858–71) elaborated an undetailed stratigraphy. This author individuated 6 levels in which only the second (from the base) was fossiliferous. Only recently some research on cave bear bones stored in the Museo Civico of Storia Naturale in Milan, in the Sistema Museale d'Ateneo of the University of Pavia and in the Classic high school "A. Volta" in Como, were developed (Rossi and Santi, 2001b; Santi and Rossi, 2001a, b; Santi et al., 2003). The data have shown the presence only of the species *Ursus spelaeus* Rosenmüller, 1794; unfortunately the radiometric data are missing.

Two hundred and four metapodial fossils come from this cave (115 metacarpalia and 89 metatarsalia); in Table 2 the means and the standardized means (referred to the Gamssulzen cave) of the parametrical values and the more indicative index, are reported. The main frequencies of the parametric values fall into intermediate fields, consequently the Buco dell'Orso population is rather homogeneous.

3.2. San Donà di Lamon (Belluno)

The position of the San Donà di Lamon zone is indicated in Fig. 4. A series of caves composed this area; the most important ones are the Bus de la Bela, Bus de la Vecia and Bus de le Tose forming the Grotta di San Donato. The main fossiliferous area is composed of an alternated succession of both two corridors and two rooms totally 150 m in length. The soil of the last room (the most internal ones) is the only one covered by a strong stalagmitic deposit; here the main *Ursus* fossils have been found (Dal Piaz, 1900). Some studies on the cave bears from San Donà di Lamon have recently been elaborated (i.e. Reggiani, 1997). Also for these bear populations a classification into the *Ursus spelaeus* Rosenmüller, 1794 and the absence of the *U. deningeri* and *U. arctos* is advanced. As well as for some other caves, unfortunately the radiometric data are missing, preventing the elaboration of a detailed evolutionary trend.

A total of 252 metapodial fossils comes from this cave (119 metacarpi and 133 metatarsi), and they are stored into the Museo Civico di Storia Naturale in Verona; Table 3 shows both the means of parametric values and the standardized ones. The main frequencies of the values of the parameter fall in the intermediate fields. As well as the Buco dell'Orso population, the San Donà di Lamon one was also rather homogeneous.