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Comparative cranial osteology of extant and extinct *Blanus* (Squamata, Amphisbaenia)

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Abstract

The genus *Blanus* currently includes seven extant species of Palearctic amphisbaenians: *Blanus cinereus* (Vandelli, 1797) and *Blanus mariae* Albert and Fernández, 2009 live in the Iberian Peninsula, *Blanus mettetalis* Bons, 1963 and *Blanus tingitanus* Busack, 1988 in Morocco, and *Blanus alexandri* Sindaco *et al.*, 2014, *Blanus aporus* Werner, 1898 and *Blanus strauchi* (Bedriaga, 1884) in southern Anatolia, Eastern Aegean Islands, Syria, Lebanon and northern Iraq. The Iberian and Moroccan species belong to the Western Group, whereas the Asiatic species, on molecular grounds, belong to a different clade, the *B. strauchi* complex or “Eastern Group”. Using both disarticulated specimens and CT-scans of wet-preserved specimens, we conducted a comparative analysis of the cranial osteology of all extant species of *Blanus*, in order to identify diagnostic features. Our results show a very homogeneous morphology among extant members of this genus, but highlight few interspecific differences. The most relevant diagnostic character is the degree of anterior protrusion of the premaxilla, which is flat

in the Western Group but overhangs anteriorly in eastern species. Other diagnostic features are present on the parietal and the quadrate. We also performed a morphometric analysis, whose results agree with the distinction of a western and an eastern clade. Even if scarce, the above-mentioned diagnostic features can be used to decipher the phylogenetic relationships between extinct blanids from Europe and their extant counterparts. This is exemplified by the skull of the extinct *Blanus mendezi* (middle/late Miocene, Iberian Peninsula) and an isolated premaxilla assigned to *Palaeoblanus* sp. from the Gargano “Terre Rosse” (late Miocene, Italy), which based on their flat anterior outline of the premaxilla, appear to belong to the western clade.

Riassunto Attualmente, il genere *Blanus* include sette specie viventi di anfisbene paleartiche: *Blanus cinereus* (Vandelli, 1797) e *Blanus mariae* Albert & Fernández, 2009 vivono nella Penisola Iberica, *Blanus mettetalis* Bons, 1963 e *Blanus tingitanus* Busack, 1988 in Marocco e *Blanus alexandri* Sindaco *et al.*, 2014, *Blanus aporus* Werner, 1898 e *Blanus strauchi* (Bedriaga, 1884) in Anatolia meridionale, Isole orientali dell’Egeo, Siria, Libano e Iraq settentrionale. Le specie iberiche e nordafricane appartengono al Gruppo Occidentale, mentre quelle asiatiche appartengono, su basi molecolari, a un clade differente, il *B. strauchi* complex o “Gruppo Orientale”. Tramite l’utilizzo di esemplari disarticolati e scansioni tomografiche di esemplari conservati in alcol, abbiamo condotto un’analisi comparata dell’osteologia cranica di tutte le specie viventi di *Blanus*, con l’obiettivo di identificare caratteri diagnostici. I nostri risultati mostrano una morfologia estremamente omogenea tra i membri viventi di questo genere, ma evidenziano alcune differenze interspecifiche.

Keywords Comparative osteology, computed tomography, Blanidae, *Blanus mendezi*, fossil record.

Introduction

Blanus is a Palearctic genus of blavid amphisbaenians currently living in Mediterranean countries of Europe, Northern Africa and the Middle East (Sindaco & Jeremcenko, 2008; Uetz & Hošek 2016). Seven extant species are recognized (Uetz & Hošek, 2016): *Blanus cinereus* (Vandelli, 1797) and *Blanus mariae* Albert & Fernández, 2009 in the Iberian Peninsula, *Blanus mettetalis* Bons, 1963 and *Blanus tingitanus* Busack, 1988 in Morocco, *Blanus alexandri* Sindaco *et al.*, 2014, *Blanus aporus* Werner, 1898 and *Blanus strauchi* (Bedriaga, 1884) in southern Anatolia, Eastern Aegean Islands, Syria, Lebanon and northern Iraq. The fossil record is extensive and contains four nominal species: *Blanus antiquus* Schleich, 1985, *Blanus gracilis* (Roček, 1984), *Blanus mendezi* Bolet *et al.*, 2014 and *Blanus thomaskelleri* Čerňanský *et al.*, 2014, although some of them might be synonymous. Based on molecular analyses (Sindaco *et al.*, 2014; Sampaio *et al.*, 2015), two extant clades can be recognized, in further agreement with their disjunct geographical distribution: a western one including *B. cinereus*, *B. mariae*, *B. mettetalis* and *B. tingitanus*

(Western Group) and an eastern one composed by *B. alexandri*, *B. aporus* and *B. strauchi* (*B. strauchi* complex, or “Eastern Group”).

Here we report the main results of a comparative analysis of the cranial osteology of all extant species of *Blanus*, and discuss their implications for the understanding of both the phylogenetic relationships and the fossil record of this genus.

Material and Methods

Our analysis is based on five disarticulated skulls and twenty-eight CT-scans (X-ray computed tomography) of wet-preserved specimens representing all extant species. The disarticulated specimens are housed in the Department of Earth Sciences of the University of Turin, whereas the scanned ones are stored in the collections of Museo Civico di Storia Naturale di Carmagnola (Italy), Zoologische Staatssammlung München (Germany) and Museum für Naturkunde Berlin (Germany). Specimens were scanned at the ‘Abdus Salam’ International Centre for Theoretical Physics in Trieste and at the Museum für Naturkunde Berlin using a microCT scan. Later, the CT data were segmented and 3D models built with Avizo 7.0 and Volume Graphics Studio Max 2.2. A geometric morphometric analysis was performed on all species except *B. alexandri* and *B. mettetali*. Volume Graphics Studio Max 2.2 was used to get ply-files out of the CT-scans. A total of 30 landmarks were digitized with Landmark 3.0 and then analyzed with MorphoJ and the R-package “geomorph”.

Results

Blanus has an elongated, slender and hourglass-shaped skull in dorsal view, with a slight mediolateral constriction at midlength. In lateral view, the dorsal outline is rather straight, without a distinct craniofacial angle (*sensu* Zangerl, 1944). There is no step between the level of the premaxillary and maxillary teeth, as in *Bipes biporus* and *Trogonophis wiegmanni* (Gans & Montero 2008).

The morphology of each cranial bone is quite similar among all species, although there are some differences. Among others: a) posterior plates of the parietal are moderately short and wide in *B. aporus*, *B. mettetali*, *B. strauchi* and *B. tingitanus*, and longer and narrower in *B. alexandri*, *B. cinereus* and *B. mariae*; b) in lateral view, the anterior outline of the premaxilla is flat in western species, whereas it overhangs anteriorly beyond the central tooth position in eastern ones; c) on the posteromedial side of the quadrate, most species display a ridge, which is more developed in *B. aporus* and *B. strauchi* than in *B. alexandri*, *B. mariae* and *B. tingitanus*, although neither *B. cinereus* nor *B. mettetali* display any distinct ridge.

Geometric morphometrics also show differences between eastern and western species: a) western species have a proportionately larger mandible relative to the skull compared to the relatively shorter mandibles of the eastern ones; b) in *B. cinereus* and *B. mariae* the ratio coronoid height/mandibular length is higher than that of *B. strauchi*; c) in dorsal view, the premaxilla of *B. strauchi* is much more pointed than that of the western species, and not as wide as in the latter.

Discussion

Comparative osteology and morphometric analysis – The genus *Blanus* is very homogeneous in skull morphology, given that our comparative analyses of its seven extant species only identified few differences. The parietal, the premaxilla and the quadrate are the most diagnostic skeletal elements. In particular, the degree of anterior protrusion of the premaxilla appears of utmost importance, because it perfectly discriminates between the western and the eastern clades. The results of the geometric morphometrics also agree with the molecular data in discriminating between eastern and western species.

Fossil record – A precise taxonomic identification of European fossil remains of amphisbaenians is often impossible, because they are frequently represented by isolated vertebrae, which are not diagnostic even at the family rank (Estes 1983; Delfino 2003). Even when their remains are assigned to particular genera or species, their phylogenetic relationships relative to their extant counterparts are often unclear. New diagnostic features, such as the ones we have identified with our analysis, are potentially very useful to provide a more accurate taxonomic identification of fossils, as well as to further discern the evolutionary history of European fossil blanids by means of rigorous cladistic analyses.

For example, the extinct *B. mendezi*, from the middle/late Miocene (10.6 Ma) of Abocador de Can Mata (NE Iberian Peninsula; Bolet *et al.* 2014), resembles extant species of the western group in the possession of an anteriorly flat premaxilla. The same holds true for an isolated premaxilla from the late Miocene of Cava Rodisano (Gargano “Terre Rosse”, Italy), assigned to *Palaeoblanus* because it was associated to dentary remains that show the diagnostic characters of this genus (Delfino, 2002, 2003). This means either that the premaxilla should be assigned to *Blanus* or that the flat morphology of this bone is shared by *Blanus* and *Palaeoblanus*. In fact, the taxonomic validity of *Palaeoblanus* has recently been questioned by Čerňanský *et al.* (2016), and a complete revision of all fossils assigned to this genus is needed before reaching a definitive conclusion about this issue. The analysis of this and other morphological features within a rigorous cladistic framework will hopefully help to clarify in the future the phylogenetic relationships between extinct and living blanids.

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References

- Albert, E.M., Fernández, A. (2009): Evidence of cryptic speciation in a fossorial reptile: description of a new species of *Blanus* (Squamata: Amphisbaenia: Blanidae) from the Iberian Peninsula. *Zootaxa* **2234**: 56-68.

- Bedriaga, J. (1884): Nachträgliche Bemerkung über *Amphisbaena strauchi* v. Bedr. Zool Anz. **7**: 346.
- Bolet, A., Delfino, M., Fortuny, J., Almécija, S., Robles, J.M., Alba, D.M. (2014): An Amphisbaenian skull from the European Miocene and the evolution of Mediterranean worm lizards. PLoS ONE **9**: e98082.
- Bons, J. (1963): Notes sur *Blanus cinereus* (Vandelli). Description d'une sous-espèce Marocaine: *Blanus cinereus mettetali* ssp. nov. Bull Soc Sci Nat Phys Maroc **43**: 95-107.
- Busack, S.D. (1988): Biochemical and morphological differentiation in Spanish and Moroccan populations of *Blanus* and the description of a new species from northern Morocco (Reptilia, Amphisbaenia, Amphisbaenidae). Copeia **1988**: 101-109.
- Čerňanský, A., Klembara, J., Müller, J. (2016). The new rare record of the late Oligocene lizards and amphisbaenians from Germany and its impact on our knowledge of the European terminal Palaeogene. Palaeobio Palaeoenv: 1-29.
- Čerňanský, A., Rage, J.-C., Klembara, J. (2014): The Early Miocene squamates of Amöneburg (Germany): the first stages of modern squamates in Europe. J Syst Palaeontol **13**: 97-128.
- Delfino, M. (2002): Erpetofaune italiane del Neogene e del Quaternario. Unpublished PhD Thesis. Università degli Studi di Modena e Reggio Emilia.
- Delfino, M. (2003): A Pleistocene amphisbaenian from Sicily. Amphibia-Reptilia **24**: 407-414.
- Roček, Z. (1984): Lizards (Reptilia: Sauria) from the Lower Miocene locality Dolnice (Bohemia, Czechoslovakia). Rozpr Cesk Akad Ved **94**: 1-69.
- Estes, R. (1983): Handbuch der Paläoherpetologie 10A. Sauria terrestria, Amphisbaenia. Friedrich Pfeil, München.
- Gans, C., Montero, R. (2008): An atlas of amphisbaenian skull anatomy. In: Gans, C., Gaunt, A.S., Adler, K. (eds), Biology of the Reptilia. Volume 21. Morphology I. The Skull and Appendicular Locomotor Apparatus of Lepidosauria. Ithaca, New York: 621-738.
- Sampaio, F.L., Harris, D.J., Perera, A., Salvi, D. (2015): Phylogenetic and diversity patterns of *Blanus* worm lizards (Squamata: Amphisbaenia): insights from mitochondrial and nuclear gene genealogies and species tree. J Zool Syst Evol Res **53**: 45-54.
- Schleich, H.H. (1985): Neue Reptilienfunde aus dem Tertiär Deutschlands 3. Erstnachweis von Doppelschleichen (*Blanus antiquus* sp. nov.) aus dem Mittelmiozän Süddeutschlands. Münchener Geowiss Abh **4**: 1-16.
- Sindaco, R., Jeremcenko, V.K. (2008): The reptiles of the Western Palearctic. 1. Annotated checklist and distribution atlas of the turtles, crocodiles, amphisbaenians and lizards of Europe, North Africa, Middle East and Central Asia. Monografie della Societas Herpetologica Italica I. Edizioni Belvedere, Latina.
- Sindaco, R., Kornilios, P., Sacchi, R., Lymberakis, P. (2014): Taxonomic reassessment of *Blanus strauchi* (Bedriaga, 1884) (Squamata: Amphisbaenia: Blanidae), with the description of a new species from south-east Anatolia (Turkey). Zootaxa **3795**: 311-326.
- Uetz, P., Hošek J. (eds), The Reptile Database, <http://www.reptile-database.org>, accessed May 10, 2016.
- Vandelli, D. (1797): Florae et faunae Lusitanicae specimen. Mem Acad Sc Lisboa **1**: 37-79.
- Werner, F. (1898): Über einige neue Reptilien und einen neuen Frosch aus dem cilicischen Taurus. Zool Anz **21**: 217-223.
- Zangerl, R. (1944): Contribution to the osteology of the skull of the Amphisbaenidae. Am Midl Nat **31**: 417-454.