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SNAKE FOSSIL REMAINS FROM THE MIDDLE MIocene
STRATIGRAPHIC SERIES OF ABOCADOR DE CAN MATA (ELS
HOSTALETS DE PIEROLA, CATALONIA, SPAIN)

RESTOS FÓSILES DE SERPIENTES DE LA SERIE ESTRATIGRÁFICA DEL
MIOCENO MEDIO DEL ABOCADOR DE CAN MATA (ELS HOSTALETS
DE PIEROLA, CATALUÑA, ESPAÑA)

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ABSTRACT

Very few studies have been devoted to the Miocene snakes from Catalonia. Here we report the preliminary taxonomic attribution of ophidian vertebral remains from several middle Miocene (MN 7 and MN 8) localities of the stratigraphic series of Abocador de Can Mata (els Hostalets de Pierola, Spain): C2-B3, C3-A7, C3-B3, BCV1, C4-A1, C5-C3. Two taxa are identified: Naja sp. and “Colubrinae” indet. This constitutes the first citation of cobras from the Vallès-Penedès Basin, being indicative of a warm climate. A more precise taxonomic attribution is hampered by the fragmentary preservation of the available remains and the small size of the sample. We hope that this contribution will constitute a starting point for a renewed interest on the study of Miocene snakes from Catalonia.

Keywords: Naja, colubrines, Ophidia, Vallès-Penedès basin, middle Miocene, vertebrates.

RESUMEN

Las serpientes miocénicas de Cataluña han sido objeto de muy pocos estudios. Aquí damos a conocer la atribución taxonómica preliminar de los restos vertebrales de ofidios de varias localidades del Mioceno medio (MN 7 y MN 8) de la serie estratigráfica local del Abocador de Can Mata (els Hostalets de Pierola, España): C2-B3, C3-A7, C3-B3, BCV1, C4-A1, C5-C3. Se han identificado dos taxones: Naja sp. y “Colubrinae” indet. Ello constituye la primera cita de cobras de la cuenca del Vallès-Penedès, la cual indicaría un clima cálido. No es posible una atribución taxonómica más precisa debido a la preservación fragmentaria de los restos disponibles y el pequeño tamaño de la muestra. Esperamos que esta contribución constituya el inicio de un interés renovado en las serpientes miocénicas de Cataluña.

Palabras clave: Naja, colubrinos, Ophidia, cuenca del Vallès-Penedès, Mioceno medio, vertebrados.

1. INTRODUCTION

The ophidian fossil record from the Miocene of Catalonia is poorly known and there are no studies exclusively devoted to Miocene Catalan snakes. Besides some citations appearing in faunal lists without description of the material (e.g., Alba et al., 2006a), the most recent relevant publication is that of Crusafont Pairó and Villalta (1952). This contrasts with the situation in other Iberian basins (e.g. Bailon et al., 2002; Murelaga et al., 2004; Sanchiz, 1981; Szyndlar, 1985; Szyndlar and Schleich, 1994) or elsewhere in Europe (e.g. Rage, 1981; Młynarski, 1984; Szyndlar, 1991a,b, 2009; Venczel, 1994, 1998; Augé and Rage, 2000; Ivanov, 2000, 2001, 2002; Miklas-Tempfer, 2003; Szyndlar and Rage, 2003; Rage and Bailon, 2005), where relevant publications on Miocene ophidians have been published much more recently.

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This work intends to partially fill this gap on the knowledge of Miocene ophidians from Catalonia on the basis of recently recovered Late Aragonian material from the area of els Hostalets de Pierola (Vallès-Penedès Basin, Catalonia, Spain). In particular, the fossil remains reported here were recovered during the works of paleontological control and excavation carried out in the Abocador de Can Mata (ACM; see Alba et al., 2006a,b, 2007, 2009). To date, more than 43,000 large vertebrate remains and several thousands of microvertebrate remains have been recovered (Alba et al., 2009). Among others, this has led to the recovery of several ophidian vertebrae, although in many instances the fragmentary preservation precludes an accurate taxonomic attribution. In this work, we report the preliminary taxonomic attribution of the ophidian vertebral remains from the local series of ACM that have been thus far prepared for study.

2. GEOLOGY AND AGE

The sediments exposed on the ACM local stratigraphic series are mainly composed by clayish levels, sometimes with sandstone and conglomeratic levels intercalated. The clay levels are usually reddish to gold-yellowish coloured, with a metric to decametric thickness. Nodules, pedogenic processes, bioturbation and decoloured marks are more or less common on this beds. These deposits are interpreted to have originated in alluvial-fan marginal to distal environments, with a fluctuating radius span and transport efficiency (Casanovas-Vilar et al., 2008). The series is about 300 m-thick and includes more than 150 fossil vertebrate localities (Alba et al., 2009), which can be accurately dated on the basis of lito-, bio- and magnetostratigraphic data (Moyà-Solà et al., 2009). The series approximately ranges from 12.5 to 11.3 Ma, mainly corresponding to the MN 7 and MN 8 biozones (sensu Mein and Ginsburg, 2002: Late Aragonian, middle Miocene). The material described in this work comes from a total of six different localities, with the following estimated age: C2-B3 and C3-B3 (subchron C5An.1r, MN 7, ca. 12.2 Ma); BCV1 and C3-A7 (subchron C5r.3r, MN 7, ca. 11.9 Ma); C5-C3 (subchron C5r.3r, MN 8, ca. 11.8 Ma); and C4-A1 (subchron C5r.3r; MN 8, ca. 11.7 Ma).

3. MATERIALS AND METHODS

3.1. OPHIDIAN VERTEBRAL ANATOMY AND NOMENCLATURE

The snake vertebral column can be subdivided into four basic regions (Szyndlar, 1984; see Fig. 1): cervical vertebrae, trunk vertebrae, cloacal vertebrae, and caudal vertebrae; cervical and trunk vertebrae are collectively referred to as precloacal vertebrae. The vertebral nomenclature used in this work follows Holman (2000, after Auffenberg, 1963; see Fig. 2). Snake vertebrae are procoelus, i.e. the cranial surface of the centrum (the co-
Cervical vertebrae always display hypapophyses (a long ventral projection fused to the centrum). The trunk region displays ribs articulated with the vertebrae, whereas in the caudal region the ribs are fused to the vertebrae. Finally, both the cloacal and caudal vertebrae display hemapophyses (paired structures fused to the centrum), although the former further display lymphapophyses (fused, forked ribs), while the latter display pleurapophyses (fused, non-forked ribs). Ribs articulate with the synapophyses (also known as paradiapophyses), which are more or less subdivided into the dorsal diapophysis and the ventral parapophysis, depending on the taxa. Within the Colubridae, hypapophyses are present in all trunk vertebrae of the “Natricinae”, but are only present in the cervical vertebrae of the “Colubrinae”, whereas in the Elapidae and the Viperidae they are also present in all trunk vertebrae. As noted by Szyndlar (1991a), the traditional division of fossil Colubridae into two subfamilies, Colubrinae and Natricinae, based on the absence/presence of hypapophyses on postcervical thoracic vertebrae, partially contradicts the systematic divisions employed for extant taxa. As such, following Szyndlar (1991a), here we employ these terms informally, in order to refer to a particular vertebral morphology.

### 3.2. MEASUREMENTS

In order to distinguish the Colubroidea, Elapoidea and Viperoidea from the Booidea, the CL/NAW ratio is usually employed, where CL is the centrum length and NAW is the centrum width (Fig. 1; after Auffenberg, 1963). CL is defined as the distance between the cotyle lip and the end of the condyle, whereas NAW corresponds the width of the interzygapophyseal constriction. A CL/NAW ratio lower than 1 characterizes the Booidea, whereas the other groups display the opposite condition. Nevertheless, no reliable identifications can be reached exclusively on the basis of metrical evidence (Szyndlar, 1984), so that morphological features are also required. Measurements were based on photographs taken with a Leica IC3D stereomicroscope and photocamera connected to a computer, with the software package Leica Application Suite v.2.8.1. All measurements are given in millimeters (mm).

### 3.3. THE FOSSIL SAMPLE

All the studied specimens are housed at the Institut Català de Paleontologia (Catalonia, Spain). A list of the studied specimens, further specifying the locality of provenance and the taxonomic and anatomical identification, is reported in Fig. 3. Several specimens were recovered during screen-washing the fossiliferous sediment, while others were recovered during manual excavation.
4. SYSTEMATIC PALEONTOLOGY

Class Reptilia Laurenti 1768
Subclass Diapsida Osborn 1903
Infraclass Lepidosauria Haeckel 1866
Order Squamata Oppel 1811
Suborder Serpentes Linnaeus 1758
Superfamily Colubroidea Oppel 1811
Family Colubridae Oppel 1811
"Colubrinae" indet.
(Fig. 4A-C)

Material: IPS29786, IPS42218, IPS42237, IPS42252, IPS42253, IPS42258, IPS42296, IPS42390, IPS42392, IPS42393, IPS42445, IPS42472, IPS42501, IPS42503, IPS43580, IPS43688, IPS46481.

Identification: most of this material (15 precaudal vertebrae) comes from locality C5-C3, although two additional precaudal vertebrae are also available from C3-A7 and C4-A1. The vertebrae of cobras resemble those of large-sized “colubrines”, by being stoutly-build, with a wide but elongate centrum, a round and large cotyle, synapophyses divided into diapophysis and parapophysis, vaulted neural arch, presence of lateral foramina, etc. However, those of cobras are usually more robust than those of colubrids (mean CL/NAW ratio 1.17) and can be further distinguished from them on the basis of the presence of hypapophyses along all the precaudal region and the generally lower neural spines (Szyndlar, 1991b). Viperids also display hypapophyses on all precaudal vertebrae, but they differ from the described material in having longer hypapophyses and prezygapophyseal processes, postzygapophyses strongly expanded laterally as well as posteriorly depressed neural arches (Szyndlar, 1991b). The genus *Naja* is thus far the only elapid genus thus far recorded in Europe (Szyndlar, 1991b). An identification at the species level of our material is precluded by the lack of cranial elements. It should be noted that this taxon has not been thus far recorded from the other localities, where a “colubrine” has been identified.

Serpentes indet.

Material: IPS45771 and IPS46483.

Identification: these two vertebrae (one caudal and one precaudal), recovered from two different localities (C3-B3 and C5-C3), are left unassigned. Unlike precaudal vertebrae, caudal ones are not informative enough for providing a taxonomic assignment, and IPS46483 it too damaged to provide a reliable assignment even at the family level.

5. DISCUSSION

Miocene sites with ophidian fossil remains are well known from the early and middle Miocene of Europe (Rage, 1981; Rage and Bailon, 2005; Ivanov, 2000, 2002; Murelaga et al., 2004; Szyndlar, 1987, 2009) as well as from the late Miocene (Harzauser and Tempfer, 2004; Szyndlar, 1985, 2005; Tempfer, 2005). However, remains from the middle Miocene (particularly the MN 7 and MN 8) are generally poorly known, having been mainly recovered from La Grive Saint-Alban in France (Augé and Rage, 2000; Rage and Holman, 1984; Murelaga and Rage, 1990) and Steinheim am Albuch in Germany (Rage, 1984; Szyndlar and Rage, 2003); additional remains are also available from the MN 7 locality of Opole 2 in Poland (Mlynarski et al., 1982).

Although the ACM fossil ophidian assemblage reported here is very restricted, it resembles those from the...
above-mentioned MN 7 and MN 8 European sites, which are characterized by a modern snake fauna that, among others, includes Colubridae and Elapidae. Representatives of these taxa are recorded from the ACM series. A previous publication from the area of els Hostalets de Pierola (Crusafont and Villalta, 1952), without distinguishing between Aragonian and Vallesian levels, reported the presence of indeterminate colubrids and boids, as well as of the genus *Vipera* Laurenti, 1768. This material, however, was never figured nor described, and should therefore be revised in order to confirm these identifications. Taken together, however, the ophidian assemblages reported from the area of els Hostalets de Pierola fit quite well with the view that modern snake faunas replaced older faunas (mainly composed by Boidae) during the Early/Middle Miocene, with boids having been almost completely replaced by the middle/late Miocene (Ivanov, 2000, 2001).

The presence of a cobra of the genus *Naja* in the ACM is remarkable and constitutes the first citation of this genus from the Vallès-Penedès Basin. Nevertheless, it should be taken into account that elapids are well documented amongst the fossil snakes from the European Neogene (Szyndlar, 1985; Szyndlar and Rage, 1990; Szyndlar and Zerova, 1990; Szyndlar, 1991b; Tempfer, 2005). Most of these extinct elapids belong to the extant genus *Naja*, which is currently represented by two lineages: an Asian one (*Naja s.s.*), and an African one (represented by three additional subgenera; see Wallach et al., 2009). In the Miocene fossil record, the former lineage, apparently more primitive and perhaps paraphyletic, is represented not only by *Naja antiqua* Rage, 1976 from Morocco, but also by *N. iberica* Szyndlar, 1985 from Spain, whereas remains from Central and Eastern European localities are attributed to *N. romani* (Hofstetter, 1939), which belongs
to the Asian lineage (Szyndlar and Rage, 1990). Cranial material would be required in order to discern whether the cobra from the ACM belongs to one or the other lineage.

Like other reptiles, snakes are considered good environmental indicators (Bachmayer and Szyndlar, 1985; Szyndlar, 2005). While the identification of “colubrines” is not good paleoenvironmental markers, unless a generic attribution is available, cobras (*Naja*), together with other taxa thus far not recorded from the ACM series (*Vipera* and some boids), are amongst the most thermophilous taxa (Szyndlar, 2009). In particular, the identification of cobras from the ACM series would be indicative of a warm climate and a relatively dry environment with the presence of water nearby (Bachmayer and Szyndlar, 1985), which would be compatible with previously-published paleoenvironmental interpretations based on mammals (Casanovas-Vilar et al., 2008; Alba et al., 2009).

6. SUMMARY AND CONCLUSIONS

The fragmentary preservation of the ACM material reported here precludes in many instances a precise taxonomic attribution. At least two taxa are recorded: “Colubrines” indet. and *Naja* sp. The latter constitutes the first citation of cobras from the Vallès-Penedès Basin, being indicative of a warm environment.

Paleontological works at ACM are still ongoing, and the tasks of screen-washing of many levels and preparation of many specimens has not yet been finished. As such, many more ophiid fossil remains will be surely available for study in the future. Hence, the results presented here must be considered preliminary, although we hope that this contribution will serve as a starting point for prompting a renewed emphasis on the study of fossil snakes from the Miocene of Catalonia, and their contextualization among European fossil faunal assemblages.

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8. REFERENCES

Fossil snakes from Abocador de Can Mata


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