

ELOPTERYX REVISITED - A NEW BIRD-LIKE SPECIMEN FROM THE MAASTRICHTIAN OF THE HAȚEG BASIN (ROMANIA)

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Abstract – Putative bird remains were reported relatively early from the Maastrichtian continental beds of the Hațeg Basin. They were referred to as *Elopteryx nopcsai* Andrews, 1913 based on material collected by Nopcsa (femora, tibiotarsi), diagnosed as a large-size cormorant-like bird. Subsequently, the tibiotarsi were redescribed as belonging to two new taxa of large owls (*Bradycneme draculae*, *Heptasteornis andrewsi*).

More recently, several authors have contested the avian affinities of these remains, considering them as belonging to small non-avian theropods. The discovery of new bird-like remains is therefore remarkable, since they might potentially establish the presence of birds in the Hațeg ecosystem.

A distal right femur from the La Scoabă locality, Sînpetru, is reminiscent in size and features of the femora described initially by Andrews, showing some resemblances to steganopod femora and corresponding in size to large Recent pelicans. However, several osteological details differentiate the specimen from other fossil and Recent steganopodes, suggesting that it does not, in fact, belong to a bird.

Several non-avian theropods have a distal femur reminiscent of the Sînpetru specimen, showing an ectocondylar crest and lacking a craniomedial crest. Among these, alvarezsaurids most closely resemble the La Scoabă femur. The new specimen is thus considered to belong to an alvarezsaurid, not to a steganopod bird; it represents the second indication of the presence of this peculiar late Cretaceous theropod clade in the Hațeg Basin.

Keywords – Hațeg Basin, Maastrichtian, *Elopteryx nopcsai*, Theropoda, Alvarezsauridae

INTRODUCTION

The Maastrichtian continental deposits of the Hațeg Basin (Fig. 1) contain a rich assemblage of vertebrates, representing all major groups from fishes to mammals (see Grigorescu & Csiki, 2002, for a recent review of the fauna).

Bird remains are extremely rare within this fauna. It is only recently that (as yet unsubstantiated) reports on the presence of enantiornithine birds appeared in the media (V. Codrea, press release, 2003). Possible bird remains were also discovered in the Fântânele microvertebrate fossil site (see Grigorescu *et al.*, 1999) during the 2004 field campaign; these remains are still under study, and will not be discussed here.

However, a putative bird was among the first taxa described from the Hațeg Basin, given that Andrews (1913) erected the taxon *Elopteryx nopcsai*, based on two proximal femora. He also tentatively referred to this taxon a distal tibiotarsus, mostly because of its avian-like morphology and roughened surface texture which resembles that seen on the femora. (All the material was apparently found at Sînpetru, although information concerning exact locality data or possible co-occurrence of the specimens is not available).

Noting similarities of the femora to those of 'pelecaniform' birds (especially *Phalacrocorax* – cormorant), Andrews (op. cit.) considered the new taxon as belonging to this group.

The "Pelecaniformes" was recently shown to be polyphyletic; however, the pelecanids, sulids,

phalacrocoracids and anhingids represent a monophyletic assemblage, the Steganopodes (see Mayr, 2003). *Elopteryx*, as originally discussed by Andrews, would be thus a member of this group. He noted, however, that the provisionally referred tibiotarsus showed no resemblances to those of cormorants, its morphology suggesting a cursorial ("ambulatory", Andrews, op. cit.: p. 196) rather than a diving bird.

Subsequently, other remains from the Hațeg Basin were also referred to *Elopteryx nopcsai*. However, the affinities of these remains were much disputed. In the recent years, it has generally been agreed that they represent non-avian theropod remains, although their referral to any of the better-known theropod clades is far from being accepted (see below).

Recently, an isolated distal right femur was discovered at Sînpetru as a loose element by one of the participants (Dulai Alfréd) on the fieldtrip of the Hungarian Paleontological Society annual meeting that took place in May 2005 in Hațeg. It was offered for study to the first author, who returned it to Bucharest, where the specimen was deposited in the collections of the Laboratory of Paleontology of the University of Bucharest (FGGUB R.1957). Due to its general avian-like morphology, FGGUB R.1957 might suggest the presence of steganopodes in the Maastrichtian of the Hațeg Basin. It also invites comparisons with *Elopteryx* and their possible relationships will be addressed in the present contribution. Moreover, the probable taxonomic affinities of the new specimen are also discussed.

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Institutional abbreviations: BMNH A PAL. – The Natural History Museum, London, Palaeontology Department Collections; FGGUB – Laboratory of Paleontology, Faculty of Geology and Geophysics, University of Bucharest; MAFI – Hungarian Geological Survey, Budapest

GEOLOGICAL SETTING

The Hațeg Basin is a small inter-montane basin situated in west-central Romania, in the Southern Carpathians (Fig. 1). It has a thick, but unevenly distributed, Permian to Quaternary sedimentary cover within which several sequences can be separated, bounded by regional unconformities (e.g. Grigorescu *et al.*, 1990).

The exclusively continental, siliciclastic uppermost Cretaceous (Maastrichtian) – Lower Paleogene sequence, yielding a diverse vertebrate assemblage, is restricted to the central and western part of the basin. It was divided into two time-correlative lithostratigraphic units, the Sînpetru and Densuș-Ciula formations, differing mainly in the presence of volcanoclastic material in the latter (Grigorescu, 1992). Both represent an extensive episode of molasse deposition related to the uplift of the Southern Carpathians following the main nappe formation and stacking during the intra-Senonian („Laramian”) orogenetic phase (e.g. Willingshofer, 2000).

The type section of the Sînpetru Formation, outcropping along the Sibișel valley, south of Sînpetru village, consists of a succession of mudstones with intercalated sandstone and conglomerate beds, reddish-brown coloured in the base, but dominantly dark grey in the top of the section. Sedimentological studies (Bojar *et al.*, 2005, Therrien *et al.*, 2002) suggest the deposits were laid down in a braided fluvial setting and represent floodplain and channel deposits, respectively. Up-section, an increase in transport energy, probably related to tectonic reactivation of the hinterland, as well as palaeoclimatic changes (to a more humid and colder climate) can be documented (Grigorescu, 1992; Therrien, 2004; Bojar *et al.*, 2005). Magnetostratigraphic studies suggest that deposition of the Sînpetru section began in the latest part of Chron 32n and continued into Chron 31r (Early Maastrichtian, approx. 72-67 My; Panaiotu & Panaiotu, 2002).

The Scoabă locality is situated in the lower part of the outcropping sequence, on the left bank of the Sibișel valley. It is represented by a 30 m thick rhythmic alternation of thick and laterally extensive sandstone bodies and pedogenetically modified, mainly reddish-brown silty mudstones (see Grigorescu & Csiki, 2002: fig. 8.; locality 3 of Bojar *et al.*, 2005). Several vertebrate remains were discovered at different stratigraphic levels during the recent years in the Scoabă locality, including one almost complete *Zalmoxes* (see Weishampel *et al.*, 2003) sacrum and coossified pelvis (V. Codrea, pers. comm., 2002). As FGGUB R.1957

was found as a loose element, at the base of the section, its exact provenance is unknown.

The Sînpetru section yielded the first Upper Cretaceous vertebrate remains to be discovered in the Hațeg Basin. They were collected mainly by F. Nopcsa, a well-known palaeontologist and local landlord, who studied and described a rich assemblage of Hațeg Basin reptiles (turtles, crocodylians, pterosaurs and dinosaurs; e.g. Nopcsa, 1923). He, apparently, collected the remains subsequently described by Andrews (1913) as *Elopteryx nopcsai* from this area. Unfortunately, no locality data, other than Sînpetru, is available for any of these specimens.

SYSTEMATICS

Theropoda Marsh, 1881
Tetanurae Gauthier, 1986
Avetheropoda Paul, 1988
Coelurosauria Huene, 1914
Maniraptoriformes Holtz, 1996
Maniraptora Gauthier, 1986
?Alvarezsauridae Bonaparte, 1991
Elopteryx Andrews, 1913
Elopteryx nopcsai Andrews, 1913

Holotype: BMNH A PAL.1234, proximal left femur
Referred specimens: BMNH A PAL. 1235 (incomplete left femur, paratype – Andrews, 1913), BMNH A PAL. 1528 (distal left tibiotarsus – Lambrecht, 1929), BMNH A PAL. 1588 (distal right tibiotarsus – Lambrecht, 1929), BMNH A PAL. 4358 (distal left tibiotarsus – Andrews, 1913), FGGUB R.351 (left distal femur – Grigorescu & Kessler, 1981), FGGUB R.1957 (present paper; for comments, see below, **Taxonomic history**).

DESCRIPTION

FGGUB R.1957 represents the distalmost part of a small right femur (Fig. 2; see Table 1 for measurements) preserving the distal articular end, with incomplete condyles, as well as the distal part of the shaft. The surface of the bone is shiny, well-preserved and almost pristine, although the distal end is slightly eroded, exposing the porous inner structure of the condyles.

The distal part of the shaft is slightly triangular in cross-section. The cranial face is largely convex; the lateral face is flat, bordered caudally by a sharp ridge. The medial face is narrower, oblique medio-caudally with an angular caudo-medial edge; caudally, the shaft is broken, but was apparently flat. The cranial face of the shaft is smooth, while the lateral, medial and apparently the caudal faces are rugose, covered by a network of proximo-distally extending low, but distinct, anastomosed wrinkles. There is no mediobasal crest on the cranial face of the distal part.

The cross-section of the shaft reveals a thin layer of *compacta* (about 2 mm thick), surrounding

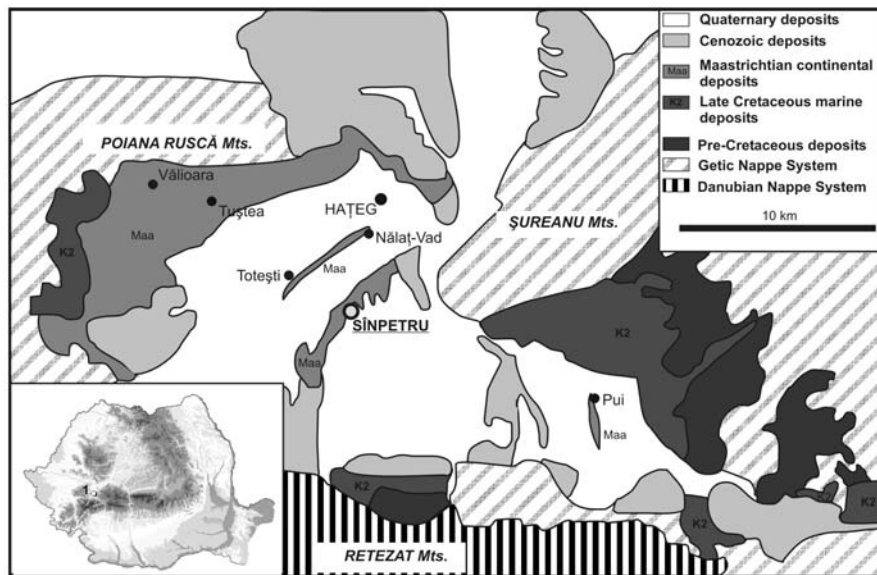


Fig. 1. Geological map of the Hațeg Basin (fossil locality underlined); inset shows position of the Hațeg Basin (1).

a large central cavity, suggesting the bone walls were thin.

The distal articular end is latero-medially expanded and relatively complex. The cranial face is largely rounded transversely. A slight concavity (representing probably a poorly defined cranial intercondylar groove) is developed only in the distalmost part, being bordered laterally and medially by low, robust protuberances raising from the edges of the corresponding condyles. In cranial view, these protuberances are also respectively laterally and medially bulging, giving the distal end an expanded outline.

Distally, the condyles are separated by a well-marked, deep and wide distal intercondylar groove; in its cranial part it is not continuous with the cranial intercondylar (extensor) groove, being separated from it by a low transverse ridge.

The caudal face is marked by a deep, triangular depression (the popliteal fossa), bounded by sharp ridges, the medial one being more angular. Distally, these are confluent with the distal margins of the medial condyle and ectocondylar ridge, respectively, while proximally they taper into the shaft and converge, almost meeting each other, toward the midline. From the caudal margin of the medial condyle, another angular crest arises and continues proximally on the caudo-medial edge of the shaft.

In the distal part, the popliteal fossa is closed by a transverse bridge formed by lateral and medial extensions of the medial and lateral condyles: we term this structure the *infrapopliteal bridge*. Whether this bridge was complete or not cannot be established, as the middle part is broken, but it appears to have originally been complete. At the base of the medial ridge bounding the popliteal fossa, a foramen pierces the infrapopliteal bridge, the canal apparently exiting on the lateral wall of the distal articular surface of the medial condyle.

As mentioned above, the condyles are eroded and incomplete; the lateral one seems to be better

preserved. However, the transversely rounded medial condyle was originally apparently somewhat larger, with a roughly rectangular outline in distal view (the medio-distal corner is broken, giving it a false triangular shape). On the medial face of this condyle, a deep circular pit is present.

The lateral condyle projects more distally than the medial one; in cranial view, it is mediolaterally narrow and distally pointed. It shows a tripartite morphology. On the caudal face, a narrow, triangular ectocondylar tuber is developed (a precursor of, and corresponding to the *crista tibiofibularis* of birds, cf. Perle *et al.*, 1994). It is separated from the lateral edge of the distal end by a shallow, rounded groove, the tibiofibular groove (*sulcus tibiofibularis*). Lateral to the *sulcus tibiofibularis*, the base of a prominence is preserved, corresponding to the external prominence of the lateral condyle described in *Mononykus* (Perle *et al.*, 1994); cranio-distal to this, there is a circular pit on the lateral face of the distal end, also present in *Mononykus* (Chiappe *et al.*, 1994: fig. 16E). The external prominence is relatively long proximo-distally. The distal articular face of the lateral condyle is complex. Caudally, the narrow crest of the ectocondylar tuber is confluent with the distal, articular part of the external prominence, while in the cranial part the articular surface is less distally extended, separated from the caudal part by a distinct step.

Table 1.

Measurements of FGGUB R.1857	mm
Preserved length	59.00
Estimated length	175.00
Transverse diameter of shaft (preserved)	21.50
Width of distal end	37.96
Width of medial condyle	22.17
Breadth of medial condyle	26.44
Width of lateral condyle	15.11
Breadth of lateral condyle	22.35

COMPARISONS AND DISCUSSIONS

The small size, thin bone walls and detailed morphology of FGGUB R.1957 indicate that it belongs to a theropod dinosaur.

Relationships to other theropods from the Hațeg Basin

The presence of several theropod taxa was reported in the past from the Hațeg Basin (see Grigorescu & Csiki, 2002 and Csiki & Grigorescu, 2003 for recent reviews). Most of these are represented only by isolated teeth (e.g. Csiki & Grigorescu, 1998, Codrea *et al.*, 2002) with only a *Saurornitholestes*-like dromaeosaurid based on cranial bones (Weishampel & Jianu, 1996).

Postcranial remains of theropods are much rarer. The material described initially by Andrews (1913) and Lambrecht (1929) as *Elopteryx* was already mentioned; it includes two incomplete femora and three distal tibiotarsi; a distal femur referred by Grigorescu & Kessler (1981) to *Elopteryx* is probably misidentified and does not belong to a theropod (see below). A dorsal

vertebral centrum of an unidentified middle-sized theropod was reported and figured by Smith *et al.* (2002) from Nălaț-Vad. Several associated forelimb elements (humerus, ulna, metacarpal, phalanges), discovered at the Tuștea nesting site, were recently identified as probable caenagnathid oviraptorosaur by Csiki & Grigorescu (2005). However, neither of these specimens can be directly compared to FGGUB R.1957, due to lack of overlapping parts.

It is consequently difficult to establish whether FGGUB R.1957 belongs to one of the formerly described Hațeg theropods. Based on size correspondence with the holotype and referred femora and presence of a wrinkled surface texture (noted previously by Andrews, 1913 and Le Loeuff *et al.*, 1992; see below) the Scoabă specimen is tentatively referred here to *Elopteryx nopcsai* Andrews, 1913. The general resemblance of FGGUB R.1957 to steganopod femora (see below), also noted by Andrews (1913) and Lambrecht (1929, 1933) in the case of *Elopteryx*, might, too, support this referral.

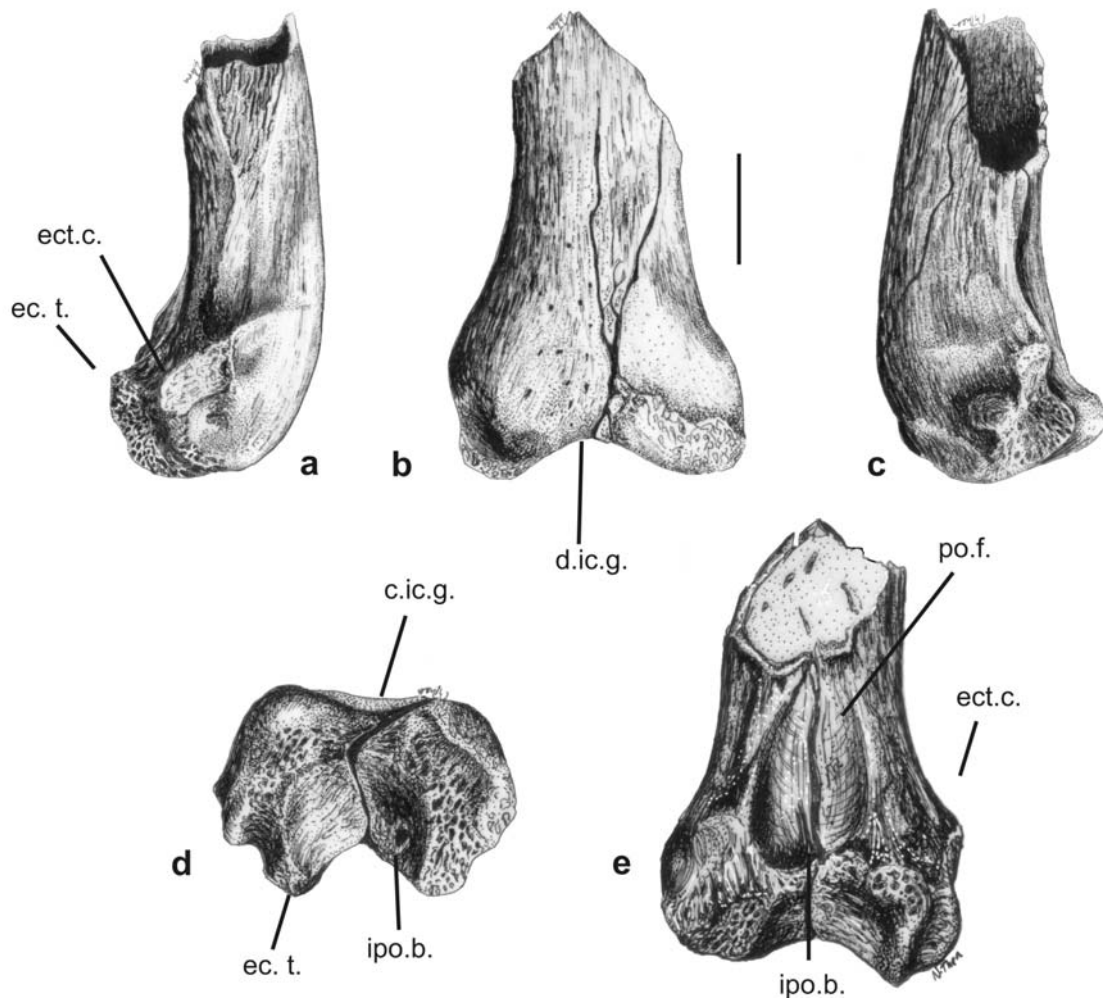


Fig. 2. *Elopteryx nopcsai*, right distal femur (FGGUB R.1957), Scoabă locality, Sînpetru, in **a** – lateral, **b** – cranial, **c** – medial, **d** – distal and **e** – caudal views. c.ic.g. – cranial intercondylar groove; d.ic.g. – distal intercondylar groove; ec.t. – ectocondylar tuber; ect.c. – ectepicondyle; ipo.b. – infrapopliteal bridge; po.f. – popliteal fossa. Scale bar – 1 cm.

Taxonomic history of *Elopteryx*

As mentioned above, *Elopteryx nopcsai* was erected by Andrews (1913) for two fragmentary femora and, tentatively, a fragmentary distal tibiotarsus, collected at Sînpetru and housed in the NHM (BMNH). Andrews (1913) designated the incomplete femur BMNH A PAL.1234 as the holotype of the new taxon. Of the other two specimens, BMNH A PAL.1235, the other femur, was referred to the same taxon due to its comparable morphology. However, the reason for referring the distal tibiotarsus (BMNH A PAL.4359) to *Elopteryx* was less reliable: Andrews noticed that the three bones apparently possess a similar roughened surface texture, which he regarded as suggestive of common taxonomic origin (op. cit.: p. 195, 196).

Subsequently, Lambrecht (1929) referred to *Elopteryx* two more specimens from Sînpetru two tibiotarsi collected by Nopcsa (BMNH A PAL.1528) and Lady Woodward (BMNH A PAL.1588). He included both *Elopteryx* and the Eocene taxon *Eostega lebedynskyi* Lambrecht, 1928, from Cluj (Transylvania, Romania) in the family Eopterygidae, a group classified in the 'Pelecaniformes' (Lambrecht, 1933).

Re-examination of this material by Harrison & Walker (1975) led to the removal of the tibiotarsi from *Elopteryx* and their referral to two new giant owl taxa: *Bradycneme draculae* and *Heptasteornis andrewsi*, for which the authors erected a new family (Bradycnemidae) within the Strigiformes. They accepted, however, the 'pelecaniform' affinities of the *Elopteryx* femora. Their interpretation of the material thus echoed the opinion of Andrews concerning the contradiction between the pelecaniform femora and the "running bird" tibiotarsi of *Elopteryx*.

More recently, an isolated fragmentary limb bone (FGGUB R.351) from Sînpetru was referred to *Elopteryx* by Grigorescu & Kessler (1981) and identified by them as a distal left femur. Csiki & Grigorescu (1998) reinterpreted it as a possible neoceratosaur distal femur. However, recent inspection of the vertebrate material collected from the Hațeg Basin and housed in the collections of the MAFI revealed the presence of a complete bone (MAFI Ob.3120a) in which the distal end is virtually identical in size and morphology to FGGUB R.351; it shows that this specimen represents instead the distal end of a moderately large metatarsal, belonging probably to a hadrosaur.

In recent years, the avian nature of the London *Elopteryx* material has been contested by many authors (Brodkorb, 1978; Elzanowski, 1983; Martin, 1983; Olson, 1985), and following them, by Grigorescu (1984), who referred to these specimens as indeterminate coelurosaurs (i.e. small, cursorial non-avian theropods). Part or all of this material was regarded as being referable to Troodontidae by Norman (1985), Osmólska (1987: *Bradycneme* and *Heptasteornis*), Paul (1988:

Bradycneme draculae and *Troodon? andrewsi*), Osmólska & Barsbold (1990: Troodontidae nomina dubia) and Howse & Milner (1993: *Heptasteornis*), although little supporting evidence was presented for these conclusions. Meanwhile Le Loeuff *et al.* (1992), synonymising both *Bradycneme* and *Heptasteornis* with *Elopteryx nopcsai*, identified it as a possible maniraptoran (i.e. either caenagnathid, dromaeosaurid or troodontid), most probable a dromaeosaurid. Finally, Csiki & Grigorescu (1998) suggested that the femora and tibiotarsi belong to different theropod taxa, "*Elopteryx*" being a derived maniraptoran, while "*Bradycneme*" might be a non-maniraptoran member of the Tetanurae.

The latest comprehensive compendium of the Dinosauria includes all these taxa, without further discussion, into the Troodontidae as *nomina dubia* (Makovicky & Norell, 2004). On the other hand, in a recent review of Mesozoic neornithine birds, Hope (2002) still listed *Elopteryx* (restricted to include only the femora, but giving an erroneous specimen number for the referred specimen, considered to represent the paratype) as a 'pelecaniform' bird, although she noted that the status of this material is still subject to controversy and requires further study. An avian affinity of *Bradycneme* or *Heptasteornis* is discarded by Hope (2002).

Finally, the most recent review of the London material by Naish & Dyke (2004) suggested that *Heptasteornis* (including only BMNH A PAL. 4359) might represent an alvarezsaurid, while *Bradycneme* represents an indeterminate maniraptoran, and *Elopteryx* (restricted to the holotype and referred femora) is either a troodontid or a non-ornithuromorphan pygostylian, but probably not an enantiornithine.

In order to assess whether FGGUB R.1957, here referred to *Elopteryx nopcsai*, supports one of the above hypotheses, a wider survey was conducted to establish its possible affinities within the Theropoda.

Affinities of FGGUB R.1957

Establishing the affinities of FGGUB R.1957 within the Theropoda is rather difficult, due to the fragmentary nature of the specimen. Although most theropod clades are diagnosed by a wealth of synapomorphies (see Chapters 3-11 in Weishampel *et al.*, 2004), few of these are derived from the femur, and especially the distal femur. Some comparisons can be made, however, in order to elucidate the relationships of the specimen.

'Ceratosaurian' (including both Coelophysoidea and Neoceratosauria) distal femora are characterized by a sharply separated tibiofibular crest (ectocondylar tuber) on the lateral condyle (e.g. Madsen & Welles, 2000); moreover, an infrapopliteal bridge is present in coelophysoids (Tykoski & Rowe, 2004), similar to the condition seen in FGGUB R.1957. However, these

theropods also have a crest-like medial epicondyle (or craniomedial crest), absent in the Hațeg specimen; the tibiofibular crest is also better separated, the caudal supracondylar ridges being parallel and not converging proximally.

Tetanurae is diagnosed, among other synapomorphies, by a prominent cranial intercondylar groove (*rotular groove*), a condition that has been reversed in several derived tetanuran clades (Holtz *et al.*, 2004b). Since this feature is lacking in FGGUB R.1957, it is probably not member of any of the basal tetanuran groups. Tetanuran distal femora are also characterized by the presence of a prominent craniomedial muscle scar (for the *M. tibialis cranialis*) bordered by a craniomedial crest. The distribution of this character state (also present in more basal theropods) suggests it represents the plesiomorphic state for Theropoda, widely distributed in basal tetanurans. The absence of this character complex in the Hațeg femur also suggests it does not belong to a basal tetanuran.

Basally in Coelurosauria, compsognathids apparently possess a shallow cranial intercondylar groove, continuous with the distal intercondylar groove (e.g. Currie & Chen, 2001), while these are separated by a shallow bony bridge in FGGUB R.1957.

Among derived coelurosaurs, basal tyrannoraptoran theropods (tyrannosauroids, ornithomimosaurids) have distal femora showing a marked cranial intercondylar groove, a prominent craniomedial muscle scar (Tyrannosauroidea, Holtz, 2004) or a thin craniomedial crest (Ornithomimosauria, Makovicky *et al.*, 2004). Lacking these characters, FGGUB R.1957 is probably not a member of any of these clades.

Among basal maniraptorans, therizinosauroids (e.g. Zhang *et al.*, 2001; Clark *et al.*, 2004) have a more robust femur with a shallow cranial intercondylar groove, different from the condition seen in FGGUB R.1957. The popliteal fossa is unusually deep, but opens both proximally and distally, where it is confluent with the distal intercondylar fossa.

Oviraptorosaurs, meanwhile, approach the condition seen in the Hațeg specimen in several respects: in the presence of a well-marked tibiofibular crest, absence of a craniomedial adductor muscle scar and associated crest, and in the lack of a cranial intercondylar groove (the latter two apomorphically reversed in Oviraptoridae). Moreover, the lateral condyle projects more distally than the medial condyle, as in FGGUB R.1957; this character is identified as a synapomorphy of the Oviraptorosauria by Osmólska *et al.* (2004). A lateral epicondyle is also present in some oviraptorids. In the basal oviraptorosaur *Microvenator celer* the largely triangular shape of the popliteal area is reminiscent of that in FGGUB R.1957 (Makovicky & Sues, 1998). Absence of an infrapopliteal bridge differentiates, however, oviraptorosaur femora from the Hațeg specimen

(e.g. Currie & Russell, 1988; Makovicky & Sues, 1998). An infrapopliteal bridge is apparently present in *Avimimus portentosus* (Vickers-Rich *et al.*, 2002), but here the ectocondylar tuber is less well developed, the medial condyle extends more distally than the lateral condyle and there is no marked ectepicondyle.

Both troodontids (Makovicky & Norell, 2004) and dromaeosaurids (Norell & Makovicky, 2004) have femora similar to FGGUB R.1957 in that there is no cranial intercondylar groove or craniomedial crest and muscle scar. However, the popliteal fossa is open distally, unlike the condition seen in FGGUB R.1957, nor is there a defined ectocondylar tuber on the lateral condyle in dromaeosaurids (Ostrom, 1976).

In alvarezsaurids the distal femur shows several characters present in FGGUB R.1957, including absence of a well-marked cranial intercondylar groove, lack of a craniomedial crest and muscle scar, as well as presence of an ectocondylar tuber. Moreover, in *Mononykus olecranus* (Perle *et al.*, 1994, Chiappe *et al.*, 1996) and *Patagonykus puertai* (Novas, 1996, 1997), the lateral condyle is projected distal to the medial one and there is a prominent ectepicondyle. Finally, an infrapopliteal bridge is reported in *Mononykus* (Perle *et al.*, 1994), and is also scored as present in *Shuvuuia deserti* (Clark *et al.*, 2002), though it is missing in *Patagonykus* (Novas, 1996, 1997) and in *Parvicursor remotus* (Karhu & Rautian, 1996, Chiappe *et al.*, 2002). The triangular shape of the popliteal fossa, bordered by proximally converging supracondylar ridges, is also shared by FGGUB R.1957 and *Mononykus*.

Among birds (Avialae), FGGUB R.1957 compares closely to steganopodes, both in general morphology and dimensions (it is similar to the large-sized pelican genera *Pelecanus crispus* and *P. onocrotalus*). However, several details differentiate it from all known fossil and Recent steganopod taxa, such as the weak distal intercondylar groove and very superficial cranial intercondylar groove (in this respect, it is more similar to *Phalacrocorax*). The shallow ridge separating the cranial and distal intercondylar fossae is not present in the surveyed steganopods. On the lateral condyle, both the *crista tibiofibularis* and the *trochlea fibularis* are weaker than in steganopods. The medial condyle is narrower, with a smaller articular surface. The presence of a prominent patellar groove (corresponding to the cranial intercondylar groove of the theropods) is considered an unambiguous synapomorphy of Ornithurae (Neornithes + Hesperornithiformes) within the Maniraptora (e.g. Chiappe, 1995, Padian, 2004); the absence of this feature in FGGUB R.1957 suggests it is probably not a member of the Ornithurae.

To conclude, the incomplete nature of FGGUB R.1957 makes rather tentative its referral to one of the theropod clades. However, this survey shows it is most closely comparable to the Late Cretaceous

alvarezsaurids, although similarities with other derived maniraptorans (especially non-oviraptorid oviraptorosaurs) are also present.

Alvarezsaurids in Europe?

The alvarezsaurids are a clade of derived theropods with a peculiar, unique morphology (especially in the forelimb), many bird-like traits and an unusual biogeographic distribution. There were first allied with avialians (e.g. Perle *et al.*, 1994, Chiappe, 1995, Chiappe *et al.*, 1996, Novas, 1996), but more recently have been regarded as closely related to, but outside of the bird clade (sister-taxon of Aves, cf. Chiappe *et al.*, 2002 or basal members of Avialae, cf. Padian, 2004), as a sister-taxon of Eumaniraptora (Troodontidae, Dromaeosauridae and Avialae; Holtz & Osmólska, 2004), as a basal maniraptoran clade, only distantly related to birds (Novas & Pol, 2002) or even as outside of Maniraptora, as a sister-group to Ornithomimidae (e.g., Sereno, 1999). Although there is no current agreement on their systematic relationships, their inclusion within the Maniraptora seems well established.

If FGGUB R.1957 is indeed referable to *Elopteryx*, then *Elopteryx* most probably represents an alvarezsaurid, even a mononykine, as its distal femur presents autapomorphic features of that clade (well-developed ectocondylar tuber and ectepicondyle, presence of an infrapopliteal bridge). Naish & Dyke (2004) suggested that, although *Heptasteornis* might represent an alvarezsaurid, the holotype material of *Elopteryx* shows a character combination that apparently excludes its membership from that clade. Two possibilities can be taken into account: either *Elopteryx* is a peculiar, autapomorphic alvarezsaurid with a posterior trochanter, or FGGUB R.1957 is referable to *Heptasteornis* instead of *Elopteryx*, in which case the presence of two similar-sized small theropod taxa should be accepted in the Hațeg fauna, both with a peculiar wrinkled surface texture, to our knowledge not yet reported in other theropods.

The palaeogeographic distribution of previously known alvarezsaurids shows an interesting, but easily understandable, pattern (see below). However, the implications of the presence of European alvarezsaurids are far-ranging, and their potential to test previous evolutionary scenarios is great.

The oldest (and most basal) members of the clade, *Alvarezsaurus calvoi* and *Patagonykus puertai* (e.g. Chiappe *et al.*, 2002) are restricted to South America, where they occur in Turonian-Santonian deposits (e.g. Makovicky *et al.*, 2005). Derived members of the family (the mononykines: *Mononykus olecranus*, *Parvicursor remotus* and *Shuvuuia deserti*) are known from the Campanian-Maastrichtian of Central Asia; a possible mononykine was also reported from the Maastrichtian of North America (Hutchinson & Chiappe, 1998). This distribution suggests an

endemic South American radiation of the clade, followed by a latest Cretaceous dispersal into Asiamerica (North America and Asia; e.g. Novas, 1996, Hutchinson & Chiappe, 1998).

The presence of alvarezsaurids in the latest Cretaceous of Europe was suggested previously by Naish & Dyke (2004) in the case of *Heptasteornis*, and is further supported (although tentatively) by FGGUB R.1957. As it now stands, all reported European alvarezsaurid remains are restricted to the Hațeg area (possible alvarezsaurid remains from the Upper Cretaceous of France are waiting for description; D. Naish and G. Dyke, pers. comm. 2005). Moreover, both Naish & Dyke (2004) and the present study suggest that these remains are referable to derived alvarezsaurids, being most similar to *Mononykus* and *Shuvuuia*. The presence of a mononykine in Hațeg is at odds, however, with the above palaeobiogeographic scenario, which implies presence of alvarezsaurids outside South America in the Campanian at earliest.

A preliminary analysis of the palaeobiogeographical significance of the Hațeg fauna (Csiki, unpubl. Ph. D. thesis) suggests that it descends from a late Early Cretaceous generalized fauna, with a few immigrant taxa from western Europe, introduced during the Late (but not latest) Cretaceous, most probably before the Campanian.

If *Heptasteornis* and/or *Elopteryx* (if FGGUB R.1957 belongs to this later taxon) indeed represent alvarezsaurids, their presence in the distinctly endemic Hațeg fauna can be explained by one of the following alternative hypotheses:

1) alvarezsaurids represent a group originating in and being endemic to South America, dispersing from there northwards, as proposed by Novas (1996), but their dispersal took place earlier than suggested previously. However, inter-American continental connections during the Late Cretaceous seem to have been restricted to the latest Cretaceous (e.g. Bonaparte, 1984);

2) alvarezsaurids had a wide geographic distribution before the Late Cretaceous, being present in both Gondwana and Laurasia. The proposed phylogenetic relationships of the Hațeg alvarezsaurids is consistent with the presence of a Laurasian alvarezsaurid clade (the mononykines). The phylogenetic relationships of the alvarezsaurids within Coelurosauria (in any of the hypotheses outlined above) is also consistent with such a early wide distribution, since all derived coelurosaurian clades had their earliest occurrence in the Barremian at the latest (see reviews in Weishampel *et al.*, 2004), suggesting a long hidden evolutionary history of the Alvarezsauridae;

3) alvarezsaurids are indeed of South American origin, and their dispersal towards (western) North America occurred in the Santonian-Campanian (as suggested by Novas, 1996), from where they were introduced rapidly to Europe, either directly or via Asia. However, current palaeogeographic reconstructions does not show continental connections of Europe with either of these

landmasses after the Cenomanian - Turonian (e.g. Smith *et al.*, 1994), nor were there close biogeographic relationships between their respective faunas (e.g. Le Loeuff, 1991, 1997, Holtz *et al.*, 2004a; but see Martin *et al.*, 2005, for an alternative view).

Finally, it should be noted that Holtz *et al.* (2004b, p. 100) have suggested that *Rapator ornitholestoides* from the Albian of Australia might be an alvarezsaurid. If their suggestion is correct (the published figures of the specimen, a probable manual digit, show it is reminiscent of those of *Mononykus* and *Patagonykus*), then alvarezsaurids may have been more widely distributed prior to the Late Cretaceous. This early and unexpected paleobiogeographic occurrence supports an early origin of the alvarezsaurids (at least by the early Late Jurassic), being concordant with hypothesis (2) listed above.

CONCLUSIONS

A small distal femur, discovered recently at Sînpetru, is shown to belong to a theropod, and is possibly referable to *Elopteryx nopcsai* Andrews, 1913, a purported steganopod bird, but is most probably a derived maniraptoran. Interestingly, it presents a character combination reminiscent of the condition reported in derived alvarezsaurids, the mononykines.

If the specimen indeed belongs to a mononykine alvarezsaurid, it would be the second report of this group in the Maastrichtian Hațeg fauna, after *Heptasteornis andrewsi* (Naish & Dyke, 2004). Whether it is referable to *Elopteryx*, as is suggested here, or to *Heptasteornis* (the presence of two different alvarezsaurid taxa, besides that of a non-alvarezsaurid *Elopteryx* is a less parsimonious hypothesis, and is disregarded for the moment), it strengthens the idea of the presence of the alvarezsaurids in the latest Cretaceous of Europe (specifically the highly endemic Hațeg fauna).

The presence of alvarezsaurids in Europe, if confirmed, challenges current hypotheses of the palaeobiogeography and evolution of the clade and requires alternative scenarios to be explained.

Further skeletal remains are needed to finally establish the presence of alvarezsaurids in Europe and to understand their relationships to other members of the clade. New discoveries, integrated into a large-scale palaeobiogeographic study of Late Cretaceous faunas, are also necessary to choose between the palaeobiogeographic scenarios suggested by the recognition of European alvarezsaurids.

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