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Preface

# An island of dwarfs — Reconstructing the Late Cretaceous Haţeg palaeoecosystem

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ABSTRACT

The Cretaceous was a special time in the evolution of terrestrial ecosystems, and yet the record from Europe in particular is patchy. This special issue brings together results of multidisciplinary investigations on the Late Cretaceous Haţeg area in southwestern Romania, and its continental fossil assemblage, with the aim of exploring an exceptional palaeoecosystem from the European Late Cretaceous. The Haţeg dinosaurs, which seem unusually small, have become especially well known as some of the few latest Cretaceous dinosaurs from Europe, comparable with faunas from the south of France and Spain, and preserved at a time when most of Europe was under the Chalk Seas. Eastern Europe then, at a time of exceptionally high sea level, was an archipelago of islands, some of them inhabited, but none so extraordinary as Haţeg. If Haţeg truly was an island (and this is debated), the apparently small dinosaurs might well be dwarfs, as enunciated over 100 years ago by the colourful Baron Franz Nopcsa, discoverer of the faunas. The dwarfing of dinosaurs, and other taxa, is explored in this volume. The Haţeg dinosaurs appear to be very latest Cretaceous (Maastrichtian) in age, and they provide unique evidence, at a time when there are few dinosaurs known from Europe, about some of the last faunas before the KT mass extinction. Further, the flora and fauna (ostracods, fishes, frogs, turtles, lizards, crocodilians, pterosaurs, dinosaurs, and mammals) have never been reviewed comprehensively, and we provide here the current best evidence of what was there, and how the taxa fit in a global context.

## 1. Islands and dwarfs

The unusual nature and composition of island faunas, as well as the causes underlying these oddities, have been a matter of scrutiny since Darwin's (1859) and Wallace's (1860, 1876) revolutionary contributions to the biological sciences. Islands are remarkable in the ways they control (and, by consequence, allow for tracking and understanding) evolutionary phenomena such as speciation (e.g., Mayr, 1942), survival of dwindling evolutionary lineages within refugia (e.g., Vartanyan et al., 1993; Guthrie, 2004; Vargas, 2007) or, conversely, extinction of such lineages restricted to over-shrunken habitats (e.g., O'Regan et al., 2002), development of significant within-clade evolutionary divergence (adaptive radiations sensu Simpson, 1953; e.g., Fritts, 1984; Schluter, 2000; Grant and Grant, 2002; Glor et al., 2004; Baker et al., 2005; Parent et al., 2008) often occurring at a fast pace (e.g., Kapralov and Filatov, 2006; Millien, 2006; Herrel et al., 2008), as well as phyletic size changes ("dwarfing" and "giantism"; e.g., Foster, 1964; Sondaar, 1977; Vartanyan et al., 1993).

Of these special evolutionary features of island biotas, size changes by island colonists has received wide attention, beginning with early reports of oversized birds (Owen, 1843) and tortoises (Harlan, 1827), as well as those of miniaturized mammals (Busk, 1867; Adams, 1874; Bate, 1903). This pattern of certain (usually large-sized) animals becoming smaller, while others became larger after colonizing an island habitat, was identified as one of Nature's recurrent phenomena ("rules") by Foster (1964), and named as such ("island rule") by Van Valen (1973). The processes of phylogenetic size changes (dwarfing/giantism) that occur on islands (the "island rule") became one of the hallmark aspects of the theory of island biogeography (MacArthur and Wilson, 1967; Whittaker, 1999; Cox and Moore, 2005), despite ongoing controversy on its generality, patterns and underlying causes (for a review, see Benton et al., 2010-this issue).

Examples of insular dwarfism in the fossil record are not uncommon; however, these have mainly been described from the Pliocene–Pleistocene (see, e.g., de Vos et al., 2007 and references therein), while far fewer cases have been documented from earlier time periods (e.g., Dalla Vecchia, 2002; Sander et al., 2006; Benton et al., 2006). This rarity is at odds with the fact that one of the earliest documented examples of a fossil assemblage with putative insular dwarfs was the latest Cretaceous reptilian fauna of the Haţeg Basin (southern Carpathians, western Romania). This fauna was suggested to have inhabited an island at the eastern margin of a palaeo-archipelago stretching across Tethyan Europe during most of the Cretaceous, with the particularly small size of its dinosaurs a direct consequence of their restrictive habitat (Nopcsa, 1914). Although the Haţeg dinosaurian assemblage was subsequently often cited as a

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classical example of an island dwarf palaeofauna, this claim has not been investigated in detail up to now; moreover, the dwarf status of some of the dinosaurian components was questioned recently by Le Loeuff (2005) and Pereda-Suberbiola and Galton (2009).

## 2. The European Late Cretaceous ecosystems: islands of palaeodiversity

The Late Cretaceous continental assemblages of Europe are somewhat overshadowed by the much better studied ones from North America and Asia, as well as by those described recently from South America. This is largely because of the more extensive outcrops of continental units in all these areas compared to those in Europe, correlated with the larger number of fossiliferous localities (see, e.g., the reviews of Weishampel et al., 2004; and Kielan-Jaworowska et al., 2004 for dinosaurs and mammals, respectively), as well as the higher diversity of local faunal assemblages relative to those described from Europe. Starting as early as 1915 (Nopcsa, 1915), the different European Late Cretaceous faunas were often interpreted as depauperate compared to those known from other continental landmasses (low alpha diversity, i.e., raw local species richness; see Whittaker, 1972) both at the level of the major clades present, and of the number of individual taxa represented; moreover, the overall composition of the European Late Cretaceous palaeobiocoenosis was considered to be comparatively less diverse (gamma diversity, i.e., total diversity across a larger geographical area; Whittaker, 1972). This low-level diversity was considered to be complemented by several other unusual features, such as the survival of several basal tetrapod lineages up to the terminal Cretaceous, giving these faunas a "primitive" aspect (e.g.; Nopcsa, 1915, 1923; Weishampel et al., 1991; Gaffney and Meylan, 1992), the relative uniformity of the faunas across the different parts of Europe (see, e.g., Nopcsa, 1915; Le Loeuff, 1991) supporting relatively low beta diversity (i.e., degree of differentiation of local assemblages along habitat gradients or simply between different part of a larger area; Whittaker, 1972), and the ambiguous palaeobiogeographic affinities of this Late Cretaceous ecosystem, in which the mixture of taxa of either southern (Gondwanan) or northern (Laurasian) origin blurred its biogeographic individuality (Le Loeuff, 1991; Le Loeuff and Buffetaut, 1995; Le Loeuff, 1997). These special palaeobiological features of the European Late Cretaceous assemblages were paralleled by their particular palaeogeographic–tectonic setting, inhabiting an archipelago with a geography undergoing large-scale temporal and spatial fluctuations (e.g., Tyson and Funnell, 1987; Smith et al., 1994; Dercourt et al., 2000; Csontos and Vörös, 2004), quite unlike the larger, spatially continuous continental landmasses of North America and Asia (e.g., Smith et al., 1994).

Recent advances in the study of Late Cretaceous European ecosystems appear to support the emergence of a significantly different picture for this part of the world, as foreshadowed by Rage (2002). Discovery of rich and diverse fossil assemblages ranging from the Cenomanian of France (e.g., Vullo and Néraudeau, 2008) to the Santonian of Hungary (Makádi et al., 2006; Ősi and Rabi, 2006) and to the Campanian–Maastrichtian of the Ibero–Armorican landmass (e.g., Barroso-Barcenilla et al., 2009; Company Rodriguez et al., 2009) have revealed much greater alpha and gamma diversity within Late Cretaceous European ecosystems than had been thought before, while also pointing to a greater beta diversity than previously acknowledged. A recent review of the palaeobiogeographical affinities of these faunas (Pereda-Suberbiola, 2009) has presented a rather complex picture of their inter- and intra-province relationships. In view of these recent additions to our knowledge of Late Cretaceous European ecosystems, an update on the Haţeg palaeobiota and its environment appears necessary in order to better understand its position and relationships within a European palaeobioprovince.

## 3. The Late Cretaceous Haţeg Island — current research and prospectus

The Haţeg area became a focus of geological and palaeontological interest after the discovery of remains of fossil vertebrates in continental beds (Nopcsa, 1897) referred subsequently to the uppermost Cretaceous as equivalents of the "Rognacian" or "Garumnian" of Western Europe (Nopcsa, 1905, 1915, 1923). Subsequently, through the efforts of Nopcsa and, after him, of several other researchers, a large amount of data has been amassed on the Upper Cretaceous deposits and their biotas from the Haţeg Basin (see a synthesis of this research in Grigorescu, 2010-this issue). While early work was mainly concerned with establishing the age and geological context of the deposits, as well as description of the most conspicuous members of the macrofauna, more recent research activity has been more multidisciplinary, bringing together specialists working in different fields of geosciences, from palaeozoology and palynology to stable isotope geochemistry and palaeomagnetism. The main aim of this activity (although not always stated) was to achieve as complete as possible a reconstruction of this latest Cretaceous island ecosystem and to better understand its relationships with other contemporaneous ecosystems from Europe and abroad (e.g., Csiki and Grigorescu, 2007). Documenting research efforts on the Haţeg localities and faunas over the past 111 years since they were discovered reveals an all-time peak in the number of scientific papers in the past 15 years (see Csiki, 2005; Csiki and Grigorescu, 2007; Grigorescu, 2010-this issue).

Several results of this increased recent research activity on Haţeg have already been published, most notably on the vertebrate palaeontology, sedimentology, and distribution of the Maastrichtian vertebrate-bearing beds, but other topics are less well represented. This volume brings together 14 contributions that address previously less well represented research topics, from igneous petrography and stable isotope analyses to ichnology (dinosaur eggs) and taphonomy; the institutional affiliations and research interests of the 27 researchers co-authoring these contributions reflect well the breadth of international cooperation involved in this research project.

The introductory chapter of the issue (Grigorescu, 2010-this issue) offers an overview of the previous research done on the Upper Cretaceous deposits of the Haţeg area and their palaeontological content, focusing mainly on the early years and the seminal and prodigious activity of Baron Franz Nopcsa. The data synthesized in this overview are supplemented by the historical information offered by the other contributions to this issue.

Although not directly concerned with the Late Cretaceous Haţeg Island and its continental ecosystem, the next two contributions to this volume, focusing on the marine deposits directly beneath the vertebrate-bearing beds, are nevertheless integral parts of the ongoing multidisciplinary research in the area. They are critical in establishing the age of the Haţeg continental deposits, which do not contain such age-diagnostic fossils as the better-dated underlying marine deposits. This information is here updated and supplemented by Melinte-Dobrinescu's (2010-this issue) contribution on calcareous nannoplankton biostratigraphy, which suggests that, despite earlier reports (e.g., Stilla, 1985; Pop, 1990), marine deposition in the area continued only as late as the latest Campanian, thus allowing continental deposition to start in the earliest Maastrichtian. These age constraints are confirmed by stable isotope studies reported by Melinte-Dobrinescu and Bojar (2010-this issue) through the identification of several time-significant isotope excursions in these marine deposits. Moreover, climatic trends identified in the late Late Cretaceous (as recorded by the marine deposits) are hypothesized to continue into the Maastrichtian as well, thus contributing to our understanding of the dominant palaeoclimate in the Haţeg area after its emergence.

The age constraints offered by the study of the underlying marine deposits are supported by palaeomagnetic studies on the continental