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Systematic paleontology (Vertebtrate paleontology)

The age of immigration of the vertebrate faunas found at Gargano (Apulia, Italy) and Scontrone (l'Aquila, Italy)

L'âge d'immigration des faunes de vertébrés du Gargano (Pouilles, Italie) et Scontrone (l'Aquila, Italie)

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A B S T R A C T

Recently a discussion is taking place about the Scontrone (l'Aquila) and Gargano (Apulia, Italy) mammal faunas and the age of their immigration. Mazza and Rustioni (2008) dated the Scontrone mammal fossils as Tortonian on the basis of their position in the *Lithothamnium* Limestone and came to the conclusion that some elements of the Scontrone and Gargano faunas must have colonised the area in Oligocene or Early Miocene times. Van den Hoek Ostende et al. (2009) disagreed with this interpretation and suggested a Late Miocene (10 Ma) age for the time of immigration. We think the arguments to place Scontrone in the Tortonian are not convincing. An analysis of the potential ancestors of each of the Gargano faunal components shows that a Messinian age for the immigration is fully compatible with the distribution of these ancestors in the European Miocene.

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R É S U M É

Récemment les faunes de mammifères de Scontrone (l'Aquila) et Gargano (Pouilles, Italie) et le moment de leur immigration ont été discutés. Mazza et Rustioni (2008) dataient les fossiles de Scontrone comme Tortonien sur la base de leur position dans le Calcaire à *Lithothamnium* et arrivaient à la conclusion que quelques éléments des faunes de Scontrone et du Gargano devaient avoir colonisé la région à l'Oligocène ou au Miocène ancien. Van den Hoek Ostende et al. (2009), en revanche, proposaient Miocène tardif (10 Ma) pour le moment de l'immigration. À notre avis, les arguments pour placer Scontrone dans le Tortonien ne sont pas convaincants. L'analyse des ancêtres potentiels de chacun des éléments de la faune du Gargano montre qu'un âge Messinien pour l'immigration est tout à fait compatible avec la distribution de ces ancêtres dans le Miocène Européen.

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1. Introduction

The fissure fillings of Gargano (Apulia, Italy) have yielded, among many other taxa, remains of the peculiar artiodactyl *Hoplitomeryx* (Leinders, 1984) and the giant

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insectivore *Deinogalerix* (Freudenthal, 1972). These two genera were reported from coastal sediments at Scontrone (Abruzzo, Italy) Mazza and Rustioni, 1996; Mazza and Rustioni, 2008. According to the section published by the last authors, the bone beds containing the fossils belong to the Scontrone Member of the *Lithothamnium* Limestone Formation. They attributed an Early Tortonian age to the fossiliferous beds and on that basis concluded that *Hoplitomeryx* and *Deinogalerix* colonised the Abruzzo-Gargano area in the Late Oligocene or in the Miocene, but before the end of the Langhian (before approximately 15 My ago).

That paper led to a reaction by Van den Hoek Ostende et al., 2009, who disagreed on the ancestry of *Hoplitomeryx* and concluded a 10 Ma age for the colonisation of Scontrone/Gargano. In this article we will analyse the arguments and propose an alternative age.

This study was presented as an oral communication at the International Conference on Vertebrate Palaeobiogeography, Bologna, September 2009.

2. Scontrone stratigraphy

Rustioni et al., 1992 said that the Scontrone fauna is found in the *Lithothamnium* Limestone and attributed a Turolian (Tortonian/Messinian) age to it; Mazza and Rustioni, 2008 changed this into Early Tortonian: these authors said that the high frequency of *Elphidium crispum* at the base of the section suggests that it is not older than Serravallian. It would be younger than the First Regular Occurrence of *Neogloboquadrina acostaensis*, astronomically dated to 10.554 Ma. However, the benthic foraminifer *Elphidium crispum* cannot be considered a reliable stratigraphic marker and its frequency is more an ecological argument, linked e.g. to water depth; the only thing the authors prove is a maximum age of 10.5 Ma, but they fail to give a minimum age for the fauna. In their view the migration into the area took place through a landbridge connecting Gargano with the Dalmatian coast (a theory already expressed by Freudenthal, 1971 and which drowned in the Middle Miocene, about 14 Ma ago. They concluded that the migration must have taken place earlier than that age.

On the other hand, Patacca et al., 2008 gave an age of late Early Messinian for the top of the *Lithothamnium* Limestone, 15 m above the Scontrone Member. If that is correct the Scontrone vertebrates may well be of Early Messinian age. In fact, Patacca et al., 2008 stated "In conclusion, the paleontological data available in the Scontrone area allowed us to constrain the age of the vertebrate bone beds between a probable Middle Miocene and the Early Messinian".

The same authors (op. cit., p. 62) stated: "[in Northern Majella] the base of the *Lithothamnium* Limestone has a Tortonian age not older than the N16 zone, as established by the identification of the First Regular Occurrence of (the planktonic) *Neogloboquadrina acostaensis* in the upper portion of the underlying *Orbulina* Limestone (about 15 m beneath the base of the *Lithothamnium* Limestone)" and "It follows that the basal portion of the *Lithothamnium* Limestone and consequently the entire vertebrate-bearing Scontrone Member are surely Tortonian and date back at

about 10 Ma". However, assuming the data are correct, the latter statement has two flaws:

- it merely proves that the base of the *Lithothamnium* Limestone is younger than 10.554 Ma, but it does not mean that it is of Tortonian age;
- even if its base is Tortonian in Majella, this only implies a Tortonian age for the Scontrone fossiliferous beds if the base of the *Lithothamnium* Limestone at Scontrone and Majella are synchronous. The *Orbulina* Limestone, underlying the *Lithothamnium* Limestone in Majella, is absent at Scontrone. So, at Scontrone the Miocene sedimentation started later than in Majella; at Scontrone the basal part of the *Lithothamnium* Limestone may be younger than in Majella and at present there is no way to know how much younger. It lies uncomformably on Cretaceous beds and the bone beds lie about 3 m above that unconformity. Furthermore the bone beds are accompanied by root traces witnessing a second sedimentary hiatus. So, one cannot know the exact position of the bone bed within the *Lithothamnium* Limestone.

Patacca et al., 2008 further stated (op. cit. p. 55) "North of Scontrone the *Lithothamnium* Limestone [is] conformably overlain by hemipelagic deposits (*Turborotalia multiloba* Marl). . .". Since *Turborotalia multiloba* is considered a marker for the late Early Messinian (First Regular Occurrence is 6.415 Ma, according to Hilgen and Krijgsman, 1999, the *Lithothamnium* Limestone at Scontrone (or part of it) may well be of Messinian age.

The sections of Majella were described by di Napoli Alliata, 1964, who stated that the *Lithothamnium* Limestone is doubtlessly of Tortonian age, but that it is difficult to fix the lithological limits because of the high variability of the calcarenites that form the limestone. He also said that his *Lithothamnium* Limestone ("unit II") includes part of the underlying *Globigerina* Limestone ("unit 1") and part of the overlying unit III that is attributed to the Messinian. One may conclude that the transition Tortonian/Messinian is somewhere within the *Lithothamnium* Limestone. Most of the *Lithothamnium* Limestone is a high-energy deposit of material transported from the near platform by turbiditelike currents, poorly sorted, coarse, thick-bedded massive beds with *Lithothamnium* and Byozoa.

Apparently the depositional conditions at Scontrone are different (Patacca et al., 2008) and that is exactly what one expects in such coastal environments. Each site has its own characteristics, detailed correlations with other sites are impossible and the age of the base of the Limestone may vary due to local conditions.

Mazza and Rustioni, 2008 mentioned low sedimentation rates in coastal lagoons. We think, however, one cannot make such a general remark. The rate is more a result of the erosional conditions in the hinterland than of the lagoon in itself. The example cited by Mazza and Rustioni, 2008, Kiritimati (Christmas Island) in the Kiribati republic, is a small island, 320 km^2 surrounding a lagoon of the same size, maximum altitude 13 m above sea level and with low annual precipitation (900 mm on average per year), certainly not a good example to compare with Scontrone. A quick search on internet gave sedimenta-

tion rates in coastal lagoons of between 1 and 5 mm/year (e.g. http://www.electronic-earth.net/4/23/2009/ee-4-23-2009.pdf); taking the low value of 1 mm/year this would mean only 15,000 years for the 15 m of sediment that separate the Scontrone bone beds from the level dated as late Early Messinian. Concluding, a Messinian age for the Scontrone bone beds is quite possible and a Tortonian age is not proven.

3. Faunal analysis

The dating of the Scontrone vertebrate fossils by Mazza and Rustioni, 2008 apparently has much to do with the presence of a landbridge that would facilitate the entrance of the fauna in the area. But, a landbridge is not a necessary element for the colonisation of an island. Other mechanisms, like the sweepstake model (Van den Hoek Ostende et al., 2009) are equally acceptable and even preferable in the case of an unbalanced island fauna, where important taxonomic groups are absent. Furthermore, the Dalmatia-Gargano landbridge reappeared during the Messinian, about 7 Ma ago, and that leads to the conclusion that the arguments for an Oligocene migration are mainly of a paleontological nature and above all based on the interpretation of the taxonomic position of the Hoplitomerycidae. In the following, we will analyse the paleontological evidence that may be derived from the different taxa present in the Gargano faunas.

3.1. Hoplitomeryx

The great differences of opinion between various authors about the taxonomic relationships of this genus make it difficult to infer conclusions on its age: Leinders, 1984 supposed a cervoid ancestor close to *Amphimoschus*; Moyà-Solà et al., 1999 saw *Micromeryx* as a possible ancestor; van der Geer (2008) stated that in fact we do not know the phylogenetic position of this group. Mazza and Rustioni, 2008 interpreted the hoplitomericids as "holdovers from a very archaic stock of artiodactyls, which spread into the Abruzzo–Apulian area prior to the rise of bovids, cervids and giraffids. There, they were eventually trapped and rapidly endemised, persisting to the very end of the Miocene". Of course they may be right, but there is no evidence to prove their point and on that basis one cannot assume an Oligocene age for the colonisation of the area.

Amphimoschus is known from MN4–5. If that is the ancestor, the colonisation cannot be younger than about 14 Ma ago. *Micromeryx* is known from MN5 to MN11 (Gentry et al., 1999) and maybe the first part of MN12 (van der Made et al., 2006); it might account for an Early to Middle Turolian immigration.

Apart from these considerations we wish to make a remark about the question of the reconstructed skull, posed by Mazza and Rustioni, 2008. These authors hinted that the specimen may be composed of material from various individuals. However, the material was extracted from a small block of matrix and the fragments fitted perfectly. Unfortunately, at the time, the Leiden Museum had a new and not yet expert preparator; the specimen became damaged, but there can be no doubt on its authenticity: the lateral horns on skull RGM 260.944 and the nasal horn belong to one single individual.

3.2. Deinogalerix

Van den Hoek Ostende, 2001 mentioned the close relationship between this genus and *Parasorex*. The latter genus, cited as *Pseudogalerix* by Freudenthal, 1971, is represented in many localities of Gargano by a species of normal size, not different from mainland species. According to Van den Hoek Ostende *Parasorex* appears in MN7/8 (about 12 Ma ago) and its distribution is typically Late Miocene of western Europe. In eastern Europe *Schizogalerix* has a similar time distribution. Mazza and Rustioni, 2008 said, without further arguments that the ancestor of *Deinogalerix* must be sought for in an insectivore present in the Balkan area prior to the end of the Langhian, some 2 million years earlier than the earliest *Parasorex*.

3.3. Muridae

Two genera of murids are present in the Gargano faunas: *Mikrotia* and *Apodemus*. *Mikrotia* is characterised by an increasing number of crests in the lower first molar (m1) during its evolution. The oldest species is somewhat larger than normal mainland murids, but its dental pattern is not basically different from *Apodemus*, with an unpaired anterior cusp at the anterior end of m1 and all successive additions of crests pass through a stage with such an anterior cusp. This approaches *Mikrotia* to *Apodemus*, rather than to other murids that do not have such a cusp. In our opinion the large *Mikrotia* and the normal-sized *Apodemus* from Gargano are members of a common stock, just like the case of *Deinogalerix* and *Parasorex*. *Apodemus* is known from the Middle Turolian onward (MN12, about 7.2 Ma ago) or even Early Vallesian (MN9), depending on the taxonomic interpretation (Freudenthal and Martín Suárez, 1999). The *Apodemus* from Gargano is fairly advanced morphologically, resembling Late Turolian and Ruscinian species of *Apodemus* (Freudenthal and Martín Suárez, 1999).

Some authors e.g. (Abazzi et al., 1993; Freudenthal, 1976) have hinted at a possible relationship between *Mikrotia* and the genus *Stephanomys* (known from MN12 onward). We think, however, this is a parallel development that coincides in time.

3.4. Cricetidae

Freudenthal, 1985 recognised four genera of Cricetidae in Gargano: *Hattomys*, *Cricetus*, *Cricetulodon* and *Megacricetodon*. The presence of the latter genus is problematic and may be due to contamination during processing in the laboratory (at the time Spanish Aragonian and Gargano samples were being processed simultaneously). Updating the classification according to Freudenthal et al., 1998, the *Cricetulodon* material is better classified as *Neocricetodon* (senior synonym of *Kowalskia*), the *Cricetus* material should be transferred to *Apocricetus* or *Pseudocricetus* and *Hattomys* may well be derived from one of these. They are typically Turolian/Ruscinian and *Neocricetodon* is known from the Vallesian, Turolian and

Ruscinian. Freudenthal, 1985 found the Turolian Crevillente faunas to present the best possible ancestors for the Gargano Cricetidae, but maybe Central or Eastern European cricetids are a better source.

3.5. Gliridae

This family is represented in Gargano by two genera: *Dryomys* and the endemic giant *Stertomys*. *Dryomys* has been reported from the Late Miocene (MN11) of Dorn-Dürkheim, and an alternative ancestor of the Gargano *Dryomys* may be *Eliomys* from the Late Miocene (MN12 and 13) of Spain, France and Germany. Possible ancestors of *Stertomys*, like *Myomimus dehmi* and *M. maritsensis* were reported from Chomateres and Pikermi, MN12, Greece (Koufos, 2006) and Messinian (MN13) deposits in Spain (Azanza et al., 1989) and Greece (de Bruijn, 1989; Daxner-Höck, 1995).

3.6. Lagomorpha

Prolagus apricenicus (Mazza, 1987) from Gargano may be derived from the *P. michauxi* lineage, which is documented in a number of MN13 localities in the Teruel Basin, Spain (van Dam et al., 2001), Rema Marmara, MN12, Greece (Koufos, 2006) and Maramena, MN13, Greece (de Bruijn, 1989); possibly related forms have been reported from
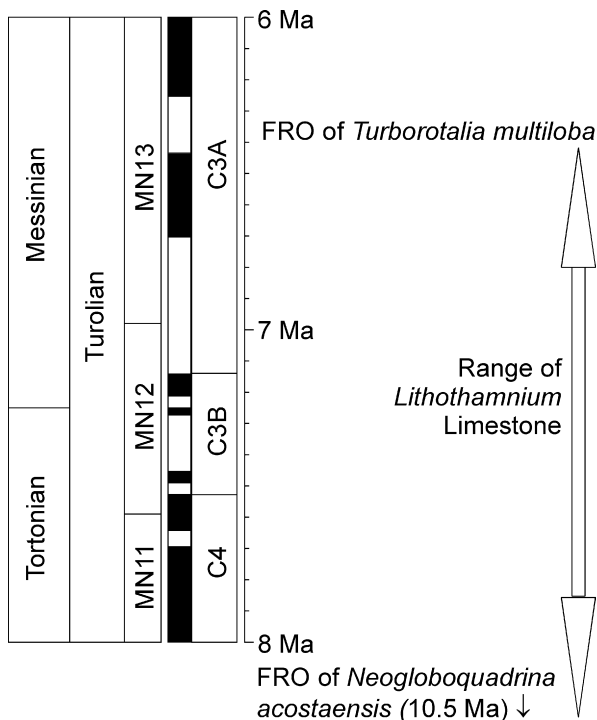

Fig. 1. Position of the lower limit of the Messinian and the First Regular Occurrence (FRO) of *Neogloboquadrina acostaensis* and *Turborotalia multiloba*.
Fig. 1. Position de la limite inférieure du Messinien et de la première occurrence régulière (FRO) de *Neogloboquadrina acostaensis* et *Turborotalia multiloba*.

Table 1
Presence of possible ancestors of the Gargano fauna in western (W) and central-eastern (E) Europe in the Turolian.
Tableau 1
Présence de possibles ancêtres de la faune de Gargano dans l'Europe de l'Ouest (W) ou du Centre-Est dans le Turolien.

	MN12	MN13
Parasorex	W	W
Schizogalerix	E	E
Micromeryx	W	
Apocricetus	W	W
Pseudocricetus	E	E
Neocricetodon	WE	WE
Apodemus	WE	WE
Myomimus	WE	WE
Dryomys	W	W
Eliomys		W
Prolagus	WE	WE

Monte Castellaro, Capo di Fiume and Brisighella, MN13, Italy (Angelone, 2007).

3.7. Aves

The only thing that can be said about the Gargano birds is that their ancestors are not older than La Grive (MN8) (Ballmann, 1973).

4. Biochronology

In Fig. 1 the right hand column gives the calibration of the magnetic polarity column to the time scale ATNTS04 (Gradstein et al., 2004). On the left hand side the GSSP of the Messinian is placed at 7.251 Ma, according to Hilgen et al., 2000. The correlation of the MN units to the magnetic scale is from Krijgsman et al., 1996.

The oldest age constraint for the Scontrone vertebrates is Early Tortonian planktonic Foraminifera Zone N16 (FRO of *Neogloboquadrina acostaensis*, 10.554 Ma). The youngest constraint is late Early Messinian (FRO of *Turborotalia multiloba*, 6.415 Ma).

Fig. 2 shows that – within these time limits – potential ancestors for nearly all of the Gargano faunal components are present in MN unit 12 and 13, equivalent to the Messinian (and final Tortonian). This age apparently is the best estimate for the colonisation of Gargano and Abruzzo. MN unit 12 covers the latest Tortonian and Earliest Messinian and may well be a time-equivalent of the *Lithothamnium* Limestone. So it seems that the Scontrone fossils represent more or less the moment of colonisation of the area and there is no need to infer a much earlier colonisation.

Many authors (Freudenthal, 1971; Mazza and Rustioni, 2008) have supposed the immediate source area of the Gargano fauna to be Dalmatia and unfortunately faunas of suitable age in that area are unknown. Knowledge of such faunas would certainly help to understand the colonisation of Gargano better. In Table 1 we list the presence of possible ancestors in western and central-eastern Europe in MN12 and MN13. We cannot draw a preference for an eastern or western origin of the migration; one should not forget, however, that the eastern European record is less complete.
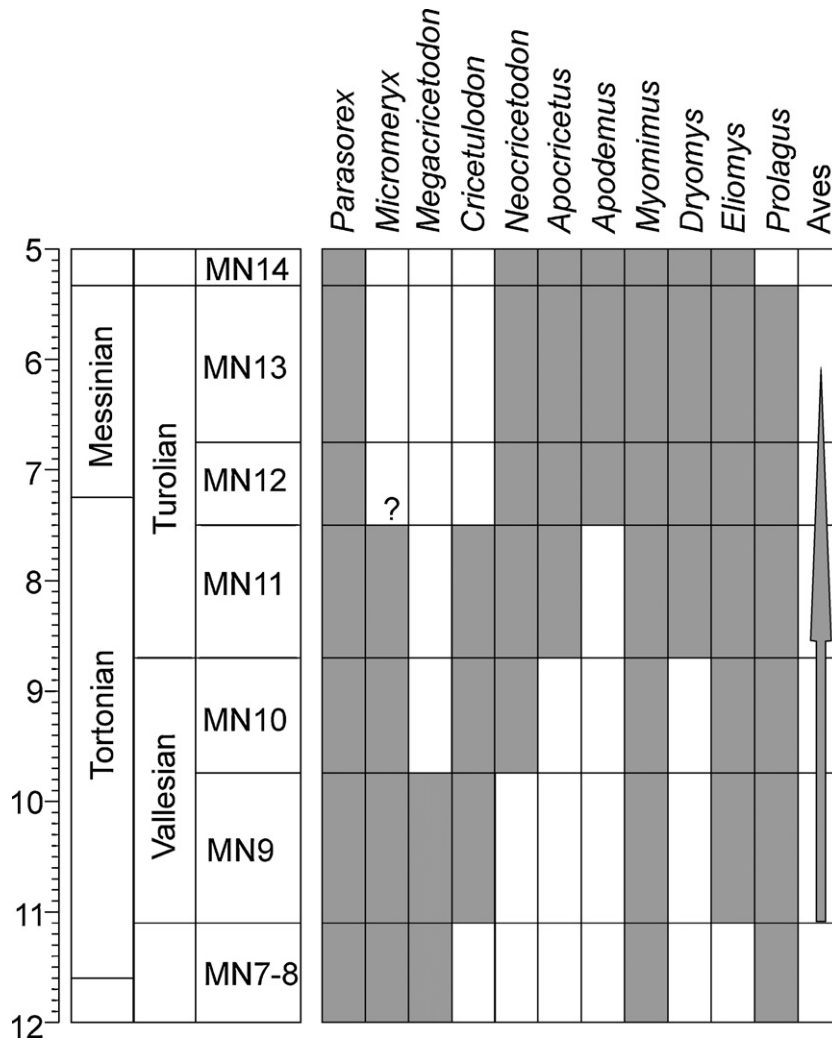
Fig. 2. Distribution of the potential ancestors of the Gargano faunal components.
Fig. 2. Répartition des possibles ancêtres des composantes fauniques de Gargano.

Van den Hoek Ostende et al., 2009 accepted an age of about 10 Ma for Scontrone and said this fits surprisingly well with the Gargano fauna, which contains murids, *Parasorex*-like galericines, *Dryomys* and *Cricetulodon*. However, 10 Ma is Early Vallesian (MN9) and at that time *Dryomys* is not yet present and murids are present, but extremely scarce and *Apodemus* is absent. An age of between 7.5 and 7 Ma seems to be a good fit for both the Scontrone and Gargano faunas and is compatible with a Late Tortonian or Early Messinian age of the *Lithothamnium* Limestone.

5. Conclusions

The simplest model to explain the immigration in Gargano and Scontrone is one single immigration wave, dated between 7 and 7.5 Ma. There is no need for a more complex model of several migration waves as argued Mazza and Rustioni, 2008 and there are no data that support such a complex model.

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