NEOGENE PARK – Vertebrate Migration in the Mediterranean and Paratethys – RCMNS Interim Colloquium, 1-3...

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R.C.M.N.S. Interim Colloquium

Vertebrate Migration in the Mediterranean & Paratethys
Neogene Park

1-3 MARCH 2011 - SCONTRONE (L'AQUILA), ITALY

ABSTRACT BOOK

EDITED BY

Giorgio CARNEVALE, Etta PATACCA & Paolo SCANDONE

R.C.M.N.S. Interim Colloquium

NEOGENE PARK

1 – 3 March 2011, SCONTRONE (L'AQUILA), ITALY

ABSTRACTS & PROGRAM

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R.C.M.N.S. Interim Colloquium

PROGRAM

Monday 28th February

17:00-18:30 Registration

18:30 Welcome reception

Tuesday 1st March

9:00-10:00 Registration

10:00-10:30 Opening ceremony

11:00-13:15 **SESSION 1** – Chairman: *Louis DE BONIS*

1.1. *Werner E. PILLER* – CHANGING MIOCENE FAUNAL COMPOSITION AS INDICATOR FOR MARINE MIGRATION PATHWAYS BETWEEN THE CENTRAL PARATETHYS AND THE MEDITERRANEAN

1.2 *Jordi AGUSTÍ* – MAMMALIAN DISPERSALS AND EXTINCTIONS IN THE LATE NEOGENE OF WESTERN EURASIA

1.3 *Anastassios KOTSAKIS* – NEOGENE MEDITERRANEAN INSULAR VERTEBRATE ASSEMBLAGES

13:15-15:00 **LUNCH**

15:00-18:00 **SESSION 2** – Chairman: *Jordi AGUSTÍ*

2.1 *Etta PATACCA & Paolo SCANDONE* – TERTIARY EVOLUTION OF THE APULIA PALEOGEOGRAPHIC DOMAIN

2.2 *Lars VAN DEN HOEK OSTENDE* – AMONG OTHER ISLANDS: GARGANO!

2.3 *Sevket SEN* – AFRICAN NEOGENE MAMMALS IN THE MIDDLE EAST: WAYS AND WHYS

2.4 *Paul MAZZA, Sandro LOVARI, Federico MASINI, Marco MASSETI & Marco RUSTIONI* – LAND MAMMAL COLONIZATION OF ISLANDS IS A MULTIFACTORIAL PRODUCT: A CRITIC TO THE UNWISE USE OF MODELS

20:00 **DINNER**

Wednesday 2nd March

9:00-10:40 **SESSION 3** – Chairman: *Walter LANDINI*

3.1 *Alexandre F. BANNIKOV* – SUCCESSION OF THE BONY FISH FAUNAS IN THE EASTERN PARATETHYS DURING THE MIOCENE

3.2 *Davit VASILYAN* – LATE PALEOGENE AND NEOGENE FOSSIL FISHES OF ARMENIA

3.3 *Giorgio CARNEVALE* – THE MESSINIAN FISH FAUNA OF CAPO DI FIUME, ABRUZZO, CENTRAL ITALY: TAPHONOMY AND PALEOECOLOGY

3.4 *Davit VASILYAN, Madelaine BÖHME, Viacheslav CHKHIKVADZE & Michael WINKLHOFER* – PALAEOBIOGEOGRAPHY AND PALAEOCLIMATIC SIGNIFICANCE OF EURASIAN CENOZOIC GIANT SALAMANDERS – CRYPTOBRANCHIDAE (CAUDATA: AMPHIBIA)

3.5 *Massimo DELFINO & Maria Adelaide ROSSI* – FOSSIL CROCODYLIDS FROM SCONTRONE (EARLY TORTONIAN, ITALY) AND THE LATE MIOCENE MEDITERRANEAN CROCODYLID BIOGEOGRAPHY

10:40-11:30 **COFFEE BREAK**

11:30-12:50 **SESSION 4** – Chairman: *Sevket SEN*

4.1 *Stephen J. GODFREY* – THE MIOCENE VERTEBRATE FAUNA OF CALVERT CLIFF, MARYLAND, U.S.A.

4.2 *Sam MATSON, Marco G. BENVENUTI, Oriol OMS, Mauro PAPINI & Lorenzo ROOK* – PRIMATE TURNOVER IN THE BACCINELLO-CINIGIANO BASIN: STABLE ISOTOPE ANALYSES AND FAUNAL TURNOVER OF A LATE MIOCENE VERTEBRATE-BEARING SUCCESSION IN SOUTHERN TUSCANY (ITALY)

4.3 *Simone COLOMBERO, Chiara ANGELONE & Marco PAVIA* – PRELIMINARY DATA ON FOSSIL RODENTS FROM THE VERTEBRATE SITES MONCUCCO AND VERDUNO (POST-EVAPORITIC MESSINIAN, PIEDMONT, NW ITALY)

4.4 *Maria Rita PALOMBO* – SIZE CHANGE IN INSULAR MAMMALS: SCRUTINIZING ASSUMPTIONS OF A HOTLY DEBATED QUESTION

12:50-15:00 **LUNCH**

15:00-16:40 **SESSION 5** – Chairman: *Anastassios KOTSAKIS*

5.1 *Matthijs FREUDENTHAL & Elvira MARTÍN-SUÁREZ* – THE LATE MIOCENE COLONIZATION OF GARGANO AND SCONTRONE

5.2 *Federico MASINI, Paolo Maria RINALDI, Andrea SAVORELLI & Marco PAVIA* – A NEW SMALL MAMMAL ASSEMBLAGE FROM THE PIRRO 12 "TERRE ROSSE" FISSURE FILLING (GARGANO, SOUTHEASTERN ITALY)

5.3 *Andrea SAVORELLI* – NEW DATA ON THE GARGANO (APULIA) CRICETIDS FROM THE MIOCENE "TERRE ROSSE"

5.4 *Boris VILLIER & Lars VAN DEN HOEK OSTENDE* – NEW DISCOVERIES FROM GARGANO (APULIA, ITALY) ABOUT THE GIANT HEDGEHOG *DEINOGALERIX*

5.5 *Marco PAVIA* – FOSSIL BIRDS FROM THE NEOGENE OF THE GARGANO (APULIA, SE ITALY)

16:40-17:10 **COFFEE BREAK**

17:10-18:10 **SESSION 6** – Chairman: *Matthijs FREUDENTHAL*

6.1 *Federico MASINI & Flaviano FANFANI* – THE SMALL SIZED GALERICINI FROM F32 "TERRE ROSSE" FISSURE FILLING (GARGANO, SOUTHEASTERN ITALY) AND ITS BIOCHRONOLOGICAL IMPLICATIONS

6.2 *Boris VILLIER & Lorenzo ROOK* – CARNIVORES IN ISLAND FOSSIL RECORD: NEW DATA FROM GARGANO TERRE ROSSE FAUNAS

6.3 *Paolo Maria RINALDI & Federico MASINI* – PHYLOGENETIC RELATIONSHIPS OF GENUS *STERTOMYS* (GLIRIDAE) FROM THE "TERRE ROSSE" FISSURE FILLINGS (GARGANO, APULIA)

20:00 **GALA DINNER**

Thursday 3rd March

9:00-10:40 **SESSION 7** – Chairman: *Lorenzo ROOK*

7.1 *Paul MAZZA* – THE SYSTEMATIC POSITION OF HOPLITOMERYCIDAE REVISITED

7.2 *Maria Rita PALOMBO, Pere BOVER & Roberto ROZZI* – THE ENDEMIC BOVIDS FROM SARDINIA AND THE BALEARIC ISLANDS: THE STATE OF ART

7.3 *Daniela E. WINKLER* – DENTITION AND DIET: NEW 3D-METHODS HELP TO DISCOVER DENTAL ADAPTATIONS IN THE EXTINCT BOVID *MYOTRAGUS*

7.4 *Antonella Cinzia MARRA, Nikos SOLOUNIAS, Giuseppe CARONE & Lorenzo ROOK* - PIKERMIAN "GUESTS" IN THE LATE MIOCENE OF CALABRIA, SOUTHERN ITALY

7.5 *Peter JONIAK* – BIOSTRATIGRAPHICAL INTERPRETATION OF TUĞLU FORMATION IN ÇANKIRI BASIN (CENTRAL ANATOLIA, TURKEY) BASED ON NEWLY COLLECTED SMALL MAMMALS ASSEMBLAGES

10:40-11:20 **COFFEE BREAK**

11:20-12:50 **SESSION 8** – Chairman: *Paul MAZZA*

8.1 *Dawid Adam IURINO & Raffaele SARDELLA* – GEOGRAPHICAL DISTRIBUTION AND 3D RECONSTRUCTION OF THE LATE MIOCENE SABERTOOTHED CAT *AMPHIMACHAIRODUS* EX GR. *KABIR* (FELIDAE, MAMMALIA)

8.2 *Patrizia ARGENTI, Angela BALDANZA & Roberto BIZZARRI* – LONG-LASTING EARLY PLEISTOCENE CONTINENTAL SCENERY ACROSS THE TUSCAN-UMBRIAN BOUNDARY (CENTRAL ITALY): FAUNAL ASSEMBLAGES, SEDIMENTOLOGICAL FEATURES AND PALEOENVIRONMENTAL EVOLUTION

8.3 *Marco CHERIN* – THE EARLY PLEISTOCENE MAMMAL FAUNA FROM PANTALLA (PERUGIA, CENTRAL ITALY). PRELIMINARY DATA

8.4 *Etta PATACCA & Paolo SCANDONE* –

12:50-15:00 **LUNCH**

15:00-17:00 **GENERAL DISCUSSION** – Chairman: *Werner E. PILLER & Jordi AGUSTÍ*

17:00-18:00 *ETTA PATACCA, PAOLO SCANDONE, PAOLO MAZZA & GIORGIO CARNEVALE* - INTRODUCTION TO THE FIRST POST-CONFERENCE EXCURSION (SCONTRONE AND CAPO DI FIUME SECTION)

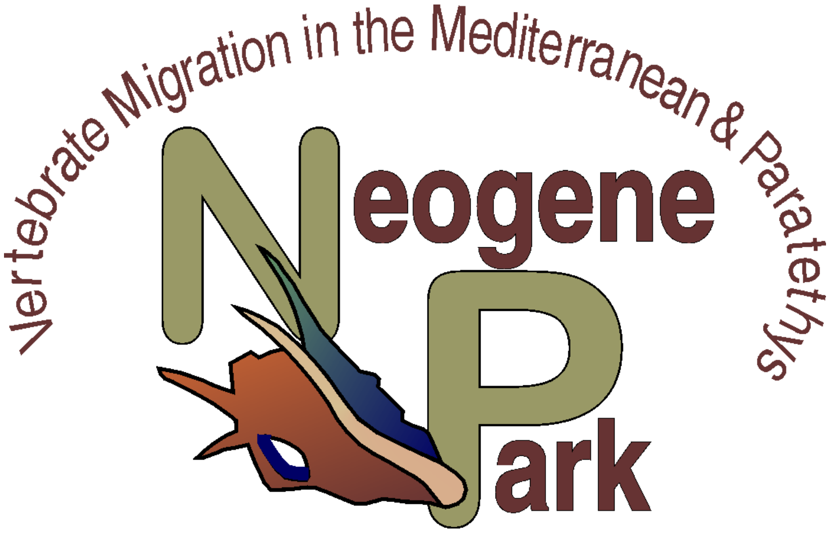
20:00 **DINNER**

Friday 4th March

9:30-17:00 – Visit to the Scontrone fossil site; detailed sections in the Miocene carbonate deposits of the *Lithothamnium* Limestone Formation in the Scontrone area.

Saturday 5th March

9:30-17:00 – Upper Oligocene-Messinian deposits of Majella (Bolognano Group, Gessoso-Solfifera Formation and *Congeria* Marls) and Porrara (Capo di Fiume section). The excursion is planned to end with a visit to the Alto-Aventino Geopaleontological Museum in Palena.


Vertebrate Migration in the Mediterranean & Paratethys
Neogene
Park

ABSTRACTS

CONTENT

MAMMALIAN DISPERSALS AND EXTINCTIONS IN THE LATE NEOGENE OF WESTERN EURASIA

Jordi AGUSTÍ

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It has been increasingly clear that the late Neogene was a crucible period in order to understand the beginning of the "modern" climatic dynamics in the Northern Hemisphere. This dynamics started at about 9.6 Ma, when a significant increase in the latitudinal climatic gradient in Europe is recorde according to the palynological record. This event is associated with the significant turnover pulse known as the "Vallesian Crisis". We now have a very much clear picture of the sequence of events associated with the Vallesian Crisis. Thus, as a difference with Western Europe, this event is not seen as an actual crisis in Eastern Europe where, instead, an increase in the diversity of the grazer taxa is recorded. The abrupt character of the Vallesian Crisis as classically reported from Western Europe is probably a consequence of the increase of seasonality in this region and the significant increase of deciduous elements, replacing the dominant subtropical forest which prevailed before. Most of the mammalian fruit-eaters faced extinction at that time in Western Europe. In Eastern Europe, such a change occurred well before, at the beginning of the Vallesian. As a difference with Eastern Europe, the persistence of subtropical conditions in Western Europe accelerated the crisis in this region when seasonality and latitudinal gradient increased at 9.6 Ma.

A second main event in the late Miocene is linked to the so-called Messinian Salinity Crisis. As with the Vallesian Crisis, now it is possible to achieve a high degree of resolution concerning the sequence of events affecting the dispersal dynamics in the Western Mediterranean associated with the Messinian. Particularly, the thick continental record in the Fortuna Basin (southern Spain) enabled us to establish an accurate chronology for the main mammalian events in the Western Mediterranean between 7.6 and 4.8 Myr, thus covering the whole Messinian interval. A first mammalian event at about 7.2 Myr records a significant turnover in the muroid rodent associations. A second mammalian event is characterized by the dispersal of the murid *Paraethomys* and of a number of large mammals indicating a first Africa-Iberia exchange at about 6.1 Myr. Finally, a third mammalian event involved the dispersal of the gerbil rodents from northern Africa. This one is clearly associated with the onset of the evaporite deposition and the MSC between 5.96 and 5.33 Myr.

LONG-LASTING EARLY PLEISTOCENE CONTINENTAL SCENERY ACROSS THE TUSCAN-UMBRIAN BOUNDARY (CENTRAL ITALY): FAUNAL ASSEMBLAGES, SEDIMENTOLOGICAL FEATURES AND PALEOENVIRONMENTAL EVOLUTION

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The present-day area across western Umbria and Tuscany, largely corresponding to the southern Chiana Valley basin, holds three main Vertebrate fossiliferous Sites (Pietrafitta, Selvella and Farneta) and several spotted minor sites or single findings (Gioiella, Paciano, Pozzuolo, Vaiano, Collelungo, Fontignano, Cetona), covering a wide time range along the Early Pleistocene, from Costa S. Giacomo to at least Farneta Faunal Units (Argenti, 2004). As the fossil assemblages and the facies analysis lead to reconstruct pervasive and long-lasting continental conditions, both lateral environmental articulation and geological evolution are documented (Cattuto et al., 1983; Ambrosetti et al., 1989; Bizzarri, 2006; Barchi et al., 2007; Pazzaglia, 2007; Bizzarri et al., 2008; Argenti et al., in press). The Costa S. Giacomo F.U. is documented by local occurrence of *Anancus arvernensis* remains into river channel gravels (Vaiano: Argenti, 2004; Cetona: Boscato et al., 2008). Deposits belong to a braided river dominated alluvial plain environment, where thick gravely and sandy channels, with large cross-stratifications, alternate to sandy-silty plain massive sediments lacking of recognizable sedimentary structures (Bizzarri, 2006; Argenti et al., in press). This high-energy environment was associated to the Città della Pieve deltaic environment evolution (Bizzarri, 2006; 2007; Bizzarri & Baldanza, 2009). The main fossil records regard Tasso and, basically, Farneta Faunal Units. Besides the large elephants (*Mammuthus meridionalis*) of the Farneta Abbey fossil site, fossil vertebrate findings in the Trasimeno Lake area are very ancient (starting from 18th century) and frequent (Argenti, 2004, with bibliography). Near the Chiusi Lake a mammal assemblage with *Mammuthus meridionalis* and *Megaceroides dicranios* was found. Near Vaiano (Casa Palazzi) a mammal assemblage bearing a large-size elephant, coming from clay deposits, and remains of *Equus stehlini, Leptobos vallisarni, Axis* (*Pseudodama*) *nestii, Eucladoceros dicranios* coming from sandy river current transport deposits was collected. All remains are referred to Tasso F.U. (De Giuli, 1986). Late Villafranchian remains of elephant and *Leptobos* aff. *L. vallisarni* were documented in the Sanfatucchio vicinity. Remains of *Mammuthus meridionalis* and *Stephanorhinus* sp., referable to Early Pleistocene, were found near Pozzuolo. At the beginning of the 20th century some remains of *Pachycrocuta brevirostris* (advanced form), referred to Farneta F.U., were found near Paciano. In the neighbourhood of Gioiella and Selvella, enclosed in the river channel sands, some transported mammal remains have been collected, including teeth-less horse mandible fragment (*Equus* sp.), a long bone fragment (undeterminable), a hyena coprolite, an *Axis* (*Pseudodama*) *nestii* not complete right radium, an elephant tibia portion and a fragment of amphibian (Anura). IN the same the Gioiella-Selvella area (Pod. La Croce), remains of *Equus ex gr. bressanus- süssenbornensis sensu* Rustioni et al. (1995), attributable to Farneta F.U., have been collected. Near Petrignano del Lago a Late Villafranchian mammal assemblage with *Elephantidae* indet. and *Equus stenonis* was found. In the Tavernelle-Pietrafitta Basin, the Pietrafitta lignite mine returned a very rich fossil vertebrates' assemblage, attributable to Farneta F.U.: *Sorex* cf. *S. minutus*, *Macaca sylvana florentina*, *Panthera gombaszoegensis*, *Pannonictis nestii*, *Ursus etruscus*, *Mammuthus meridionalis*, *Equus* sp., *Stephanorhinus* cf. *S. hundsheimensis*, *Megaceroides obscurus*, *Pseudodama farnetensis*, *Leptobos* aff. *L. vallisarni*, *Castor fiber*, *Mimomys pusillus*, *Microtus* (*Allophaiomys*) cf. *M.* (*A.*) *ruffoi*, *M.* (*A.*) *chalinei*, *Oryctolagus* cf. *O. la costi*, *Podiceps grisegene*, *Phalacrocorax* cfr. *P. carbo*, *Ixobrychus* sp., *Cygnus* aff. *C. colombianus*, *Anas penelope*, *A. clypeata*, *A. crecca* vel *A. quequerdula*, *Aythya aretina*, *A. sepulta*, *Mergus merganser*, *M. serrator*, Anatidae, Rallidae, *Gallus* n. sp., *Emys orbicularis*, *Natrix* sp., *Vipera ammodytes, Latonia* cf. *L. ragei*, *Rana* gr. *R. ridibunda* and several fish (Argenti, 2004 with bibliography). Near Fontignano some remains of *Mammuthus meridionalis* and *Hippopotamus antiquus* referable to Late Villafranchian (probably Farneta F.U.) were found during the 19th Century (Argenti, 2004 with bibliography).

During the final Middle Villafranchian - Late Villafranchian interval, three main depositional environments, all referred to a continental context, are documented in the area (Bizzarri, 2006; Pazzaglia, 2007; Barchi et al., 2007; Bizzarri et al., 2008; Argenti et al., in press). In the T. Tresa area, alluvial fan and piedmont deposits outcrop, and their occurrence seems to be confined to Tasso F.U.. In the Tavernelle-Pietrafitta area, a progressive transition from lacustrine to palustrine and fluvial deposits took place during the Tasso - Farneta interval. Finally, sandy and silty-clayey deposits are widely diffused in the area from the Farneta Abbey to the Città della Pieve hills. Deposits are still related to a fluvial environment: the prevailing sandy sedimentation, with common St and Sp cross-laminations, indeed, testifies to a less energetic and more organized river flow. The river pattern was still braided, although a higher sinuosity is expected. Sandy channel deposits are intermingled to clay, the latter bearing paleosoils and sheetflood deposits and indicative of a wider and more stable alluvial plain.

A paleoenvironmental and paleogeographic reconstruction can be proposed: during late Middle Villafranchian, the southern Chiana Valley was characterized by high energy rivers, draining toward the near marine coast and building a large and steady fan-delta in the Città della Pieve. At the same time, the Tavernelle-Pietrafitta area represented an intermountain, bunged basin. In correspondence of the Tasso F.U. interval, occasional connections occur among Tavernelle lacustrine environment and the sea nearby, whereas a wide and articulated alluvial plain environment occupied the southern Chiana Valley Basin. This environment, characterized by sandy braided rivers and large open spaces, developed in the whole investigated area up to, at least, Farneta F.U.; furthermore, the Pietrafitta palustrine environment can be now hypothesized as a lateral and temporary abandoned river branch. The evolution model underlines a progressive sea-retreat south-westward, probably representing the first signal of the regional extensional tectonics which deeply modified the area and the whole Tyrrhenian side of Italy, from Middle Pleistocene onward.

Several recoveries indeed confirm the transition to present-day conditions in the area starting from Middle Pleistocene: in the 19th century, an Early-Middle Pleistocene of *Equus* sp., *Canis* sp. and *Mammuthus* sp. was found into the yellowish sands between Trasimeno Lake and Chiusi Lake. Moreover, in the 19th century in the Collelungo-Ravigliano area (Tresa Valley) an assemblage with Elephas antiques, Rhinocerontidae indet., Bovidae indet. And Pachycrocuta sp., probably referable to Middle Pleistocene (Argenti, 2004) was documented. East from the Gioella - Sanfatucchio alignment, Late Paleolithic-Eneolithic tools together with Late Pleistocene mammal remains (*Elephas antiquus, Bos primigenius, Bison priscus, Equus caballus*: De Giuli, 1986; Argenti et al., in press) have been collected.

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SUCCESSION OF THE BONY FISH FAUNAS IN THE EASTERN PARATETHYS DURING THE MIOCENE

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The youngest Miocene assemblage of Paratethian marine fishes is rich and diverse and it is found in the Upper Maikopian (Sakaraulian, correlated to the upper Aquitanian and lower Burdigalian) beds in the North Caucasus (SW Russia), Crimea (Ukraine), Azerbaijan and Abkhazia. There are 49 taxa of late Maikopian bony fishes representing 43 genera, 29 families and 9 orders: *Sardinella brevicauda* (Menner, 1949); *Pomolobus antiquus* (Smirnov, 1936); *Alosa genuina* Daniltshenko, 1960; *Glossanodon adolescens* Prokofiev, 2005; *Merluccius lednevi* Bogatshov, 1933; *M. errans* (Smirnov, 1936); *Palaeomolva smirnovi* (Daniltshenko, 1953); *P. monstrata* Fedotov, 1974; *Bregmacerina antiqua* (Smirnov, 1936); *Onobrosmius sagus* (Fedotov, 1974); *O. parcus* (Daniltshenko, 1960); *O. oligocaenicus* (Bogatshov, 1933); *"Lophius"* sp.; *"Belone" crior* Smirnov, 1936; Holocentridae: gen. et sp. indet.; *Aeoliscus apscheronicus* (Lednev, 1914); *Aulostomus fractus* Daniltshenko, 1960; *Syngnathus altus* Daniltshenko, 1960; *Nerophis gracilis* Sergienko, 1971; Percoidei *inc. sed.* gen. et sp. indet.; *Priacanthus longispinus* Lednev, 1914; *Lednevia oligocenica* (Smirnov, 1936); *Echeneis urupensis* Daniltshenko, 1958; *Seriola* sp.; *S. smithvanizi* Bannikov, 1996; *Scomberoides spinosus* (Smirnov, 1936); *Selar fedotovi* Bannikov, 1990; *Alepes pin* Bannikov, 1985; *Caranx quietus* Bannikov, 1990; *Decapterus praegracilis* Bannikov, 1990; *D. fusiformis* Bannikov, 1996; Caranginae gen. indet.; *Leiognathoides minutus* Daniltshenko, 1980; *"Sparus"* sp.;; *Spicara islamdagica* (Prokofiev, 2001); *Caucasisciaena ignota* (Smirnov, 1936); *Mugil latus* Switchenska, 1957; *"Blennius"* sp.; *Bestiolablennius eugeniae* Prokofiev, 2001; Gobiidae gen. et sp. indet.;; *Caprovesposus* sp.; Gempylidae gen. et sp. indet.; *Hemithyrsites maicopicus* Daniltshenko, 1960; *Anenchelum lednevi* (Menner, 1949); *Scomber gnarus* Bannikov, 1979; *Sarda memorabilis* Daniltshenko, 1980; *Pinichthys fractus* Bannikov, 1985; *Arnoglossus distinctus* Switchenska, 1981; *Buglossidium apsheronskiense* Bannikov, 2001. Most commonly collected fishes are sardine *Sardinella brevicauda*, hake *Merluccius errans*, bluefish *Lednevia oligocenica* and mackerel *Scomber gnarus*. The presence of the genus *Aeoliscus* indicates that the climate of the late Maikopian time was close to tropical. Most of fishes are definitely pelagic, however, in the Sakaraulian fish fauna of the Easter Paratethys bottom dwellers such as anglerfish, blennies and gobies appear for the first time. Also the flatfishes (Bothidae and Soleidae) became relatively commonly collected, however, these were represented mostly by the pelagic larvae, as well as the coral surgeonfish *Caprovesposus* sp. Typical meso- and bathypelagic fishes are absent, except for the very rare trichiurids and gempylids.

After the refreshment during the Kotsakhurian time, in the Tarkhanian and early Chokrakian (upper Burdigalian – Langhian), Eastern Paratethys again is characterized by the marine or semimarine conditions. Fish discoveries in the Caucasus and Crimea were made in the deep-water facies of the Tarkhanian and Chokrakian, i.e., so called *Spirialis* Clays (NN4-NN5). There are 24 taxa of late Maikopian bony fishes representing 22 genera, 18 families and 8 orders: *Clupeonella humilis* (Meyer, 1851); *Sardina prisca* W.Daniltshenko, 1969; *Pseudohilsa brevicauda* (Lednev, 1914); *Vinciguerria merklini* Daniltshenko, 1946; *Bregmaceros* cf. *B. filamentosus* (Priem, 1908); *Palaeogadus atropatanus* (Bogatshov, 1933); *Palaeomolva andrussovi* (Bogatshov, 1933); *P. tarchanica* Daniltshenko, 1947; Hemiramphidae (?) gen. et sp. indet.; *Myripristis sorbinii* Bannikov, 1987; *Priacanthus fortis* Daniltshenko, 1980; *"Lednevia"* sp.; *Scomberoides spinosus* (Smirnov, 1936); *Selar weileri weileri* (Bogatshov, 1933); *Selar weileri ampliscutulatus* Bannikov, 1990; *Decapterus abbreviatus* (Bogatshov, 1933); *Parasphyraena apsheronica* Switchenska, 1968; *Mioblennius fraudulentus* Bannikov, 1998; *Ammodytes* sp.; *"Diplogrammus"* sp.; Gobiidae: gen. et sp. indet.; *Lepidopus lateralis* Daniltshenko, 1980; *Arnoglossus sumgaiticus* Switchenska, 1981; *Archaeotetraodon jamestyleri* (Bannikov, 1990). In the Tarchanian of the Caucasian Basin mesopelagic lightfishes (genus *Vinciguerria* from the family Phosichthyidae) appear for the first time after the Rupelian. This indicates that anoxic bottom water layer was located considerably lower than in the late Maikopian time. In the fish fauna clupeids and (at least in the Tarchanian of the Crimea) *Vinciguerria merklini* strongly predominate. Since *Spirialis* Clays are deep-water facies of the Tarkhanian and Chokrakian, shallow water coastal syngnathoids are unknown from there. Composition of the fish fauna indicates the climate of the Tarkhanian – Chokrakian time close to tropical (presence of the genus *Bregmaceros*). Most of fishes are definitely pelagic, however, there are also discoveries of the bottom-dwellers (mostly juvenile) Blenniidae, Ammodytidae, Callionymidae, Gobiidae and Bothidae. Generic composition of fishes of the Tarkhanian – Chokrakian Basin differs greatly from that of the Late Maikopian assemblage: in common are only the genera *Palaeomolva*, *Priacanthus*, *Selar*, *Decapterus*, *Arnoglossus* and, probably, *Lednevia*.

Close to the end of the Chokrakian the salinity of the Eastern Paratethys became reduced, and semi-marine Karaganian Basin is characterized by the endemic euryhaline clupeids, atherines *Atherina prima* Switchenska, 1959, mullets

Mugil karaganicus Switchenska, 1973 and flatfish *Arnoglossus ovalis* Switchenska, 1981. The barracuda *Parasphyraena apsheronica* was inherited from the Chokrakian fauna. In the Konkian time (equivalent of middle Serravalian) the basin again turned to be normal marine, however, Konkian fishes are only scarcely known: *Clupeonella* sp. and *Mugil finitimus* Switchenska, 1973 from the Caucasus and *Protonymus gontsharovae* Sytchevskaya et Prokofiev, 2007 from the Taman' Peninsula. This can be explained, on the one hand, by the fact that the Eastern Paratethian hydrologic conditions mostly prevent the fish burial, and, on the other hand, by the scanty excavations.

The Sarmatian fishes of the Eastern Paratethys are better known than those of the Karaganian and Konkian. Rich fish fauna was collected from the two Lower Sarmatian (Volhynian) localities: in the northwestern Caucasus (Pshekha River) and in the northern Moldavia (Naslavcea village). Systematic compositions of both assemblages are different. In the Tsurevsky locality (left bank of Pshekha River) were collected *Sardinella sardinites* (Heckel, 1850); "*Clupea*" *inflata* Vukotinović, 1870; *Micromesistius* sp. nov.; Syngnathidae gen. et sp. indet.; Carangidae gen. et sp. indet.; *Mullus* sp.; *Mugil* cf. *M. minax* Bogatshov, 1933; *Trachinus* sp.; *Callionymus* cf. *C. macrocephalus* Gorjanović-Kramberger, 1882; *Pomatoschistus* sp.; *Proantigonia* sp.; *Scomber* aff. *S. caucasicus* (Bogatshov, 1933); *Bothus* sp. nov. and Soleidae gen. et sp. indet. In the Karpov Yar ravine (Naslavcea village) the following taxa were collected: *Sardinella sardinites* (Heckel, 1850); Clupeidae gen. et sp. indet.; "*Prolebias*" sp.; *Atherina suchovi* Switchenska, 1973; Syngnathidae gen. et sp. indet.; Percoidei gen. et sp. indet.; *Lates gregarius* Bannikov, 1992; *Morone ionkoi* Bannikov, 1993; *Sparus brusinai* (Gorjanović-Kramberger, 1882); *Naslavcea fundata* (Bannikov, 1990); *Mullus moldavicus* Switchenska, 1959; *Polydactylus frivolus* Bannikov, 1989; *Mugil acer* Switchenska, 1959; *Symphodus salvus* Bannikov, 1986; *Clinitrachoides gratus* (Bannikov, 1989); *Pomatoschistus* sp.; *Gobius* sp.; "Soleidae" gen. et sp. indet. Perhaps an impeded connection between the Noth Caucasian and Moldavian basins happened during the early Sarmatian time, and both the two localities were formed in different environments. Relative impoverishment of the systematic composition of the Sarmatian fishes of the Eastern Paratethys can be explained not so much by lower salinity of its waters but by their unfavourable chemical composition (increased alcalinity). In addition to the Tsurevsky and Naslavcea localities, some other fish taxa were recorded from different Sarmatian localities of the former USSR: *Sarmatella vukotinovici* (Gorjanović-Kramberger, 1884); *Paratrisopterus avus* Fedotov, 1971; *Atherina impropria* Switchenska, 1973; *Sparus brevis* (Lednev, 1914); *Sciaena knyrkoi* Daniltshenko, 1980; "*S. pimenovae*" Bogatshov, 1955; *Mugil chadarini* Bogatshov, 1933; *Proantigonia dagestanica* Baciu, Bannikov et Tyler, 2005 and *Platichthys svitschenskajae* (Dzhafarova, 1976). Eastern Paratethys became completely enclosed in the beginning of the late Miocene and it was episodically connected to the open sea in the Maeotian (= late Tortonian). The Maeotian fishes are poorly known: Bogatshov (1942) recorded from the Eastern Paratethys two herrings, problematical *Lepidopus* and four inadequately described new species: *Matarchia* (=*Scomber*) *spuria*, *Chrysophrys* (=*Sparus*) *diatomacea*, *Merluccius maeoticus* and *Labrax* (=*Morone*) *vogdti*.

THE MESSINIAN FISH FAUNA OF CAPO DI FIUME, ABRUZZO, CENTRAL ITALY: STRATIGRAPHY, TAPHONOMY AND PALEOECOLOGY

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The Capo di Fiume site is located at the north-eastern margin of the Monte Porrara. The fossiliferous section outcrops with a reduced lateral extension along the state road n° 84 "Frentana" a few kilometers south of the town of Palena, in the Chieti province, Abruzzo, Italy. This site is part of the Porrara tectonic unit (Patacca et al. 1992), which consists of a thick lithostratigraphic succession of Jurassic-Cretaceous shelf carbonates overlain by upper Cretaceous to Eocene distal ramp deposits. The Cretaceous-Paleogene distal ramp deposits are usually unconformably overlained by Miocene (Langhian – Tortonian) heterozoan limestone (Bryozoan – *Lithothamnium* Limestone), comparable to that of the Bolognano Formation (see Di Napoli Alliata, 1964; Crescenti et al., 1969). In the north-eastern margin of the Monte Porrara, however, the Cretaceous distal ramp carbonates (Saccharoidal Limestone) are overlained by terra rossa soils, covered by marls and clayey marls, followed by a rhythmic succession of diatomitic marls and calcareous marls and, successively, by hemipelagic argillites and turbidites.

The succession outcropping at Capo di Fiume has been discussed by many authors (e.g., Bellatalla et al., 1992; Carboni et al., 1992; Patacca et al., 1992; Mazza et al., 1995; Miccadei & Parotto, 1998; Carnevale, 2003), who described its lithological and paleontological features with different degrees of detail. Carboni et al. (1992) presented a description of the lower part of the succession, evidencing the progressive transition from continental to fully marine facies. As reported above, the succession overlies on Upper Cretaceous carbonates, represented therein by light-brown calcilutites. The base of the succession consists of terra rossa soils with interspersed nodular calcarrous and ferrouginous pisolitic concretions. Fissile marls and laminated argillites (*Lithothamnium* Limestone equivalent) lie upon the terra rossa soils. These deposits contain abundant mollusk remains and record the passage from palustrine to brackish (freshwater marshes, tidal creeks, swamp, estuarine bay) paleobiotopes. Marine deposits (Tripoli Formation equivalent) lie upon the freshwater to brackish marls; these deposits consist of not less than six cycles of alternated dark grey calcareous marls and finely laminated ichthyolitiferous diatomitic marls. The first marine cycle exhibits a relatively complex architecture, whereas the succeeding cycles primarily consists of a sharp alternation of calcareous marls and diatomitic marls. In general, the sequence is characterized by a progressive decrease of the thickness of the diatomitic marl intervals, which ranges from about 180 cm in the first cycle to 50 cm in the sixth one.

The age of the continental to paralic portion of the succession is unclear. According to Mazza & Rustioni (1996), the terra rossa soils may be correlated to the vertebrate-bearing deposits of Scontrone, which date back to the Tortonian, approximately 10 Ma (see Patacca et al., 2008a). More generally, the bauxites may be correlated to the Oligo-Miocene terra rossa soils that are widespread in the central Adriatic area (Patacca et al., 2008b). On the other hand, the marine portion of the succession is well constrained from a biostratigraphic point of view. The presence of the benthic foraminiferan *Bulimina echinata* in the dark grey marls underlying the first diatomitic marl interval is clearly indicative of a Messinian age (see Colalongo et al., 1979); the appearance of *Bulimina echinata* in the Mediterranean is estimated to have occurred at about 6.8 Ma. Moreover, a Messinian age of the upper portion of the succession is also supported by the occurrence of *Turborotalita multiloba* in the calcareous dark grey marls of the sixth cycle; the first common occurrence of this planktonic foraminiferan dates back to 6.4 Ma (Sprovieri et al., 1996; Krijgsman et al., 1999). Therefore, the marine sediments of the Capo di Fiume section were deposited mainly in the lower portion of the Messinian stage between about 6.8 and 6.4 million years ago.

Overall, the diatomitic marls outcropping at Capo di Fiume consist of a dense series of clastic-biogenic (diatomitic) couplets. Several types of laminae have been identified based on chromatic characters, thickness, lateral extension and other morphological features. These were analyzed at the nannoscale in order to define their paleoenvironmental significance. Based on a slightly modified version of the classification proposed by Chang et al. (1998), at least four types of laminae have been recognized, including: detrital (clastic) laminae; thin biosiliceous laminae; thick and continuous diatomaceous laminae containing monospecific or oligospecific assemblages of *Coscinodiscus* spp. and/or *Thalassionema nitzschioides*; and thick and discontinuous diatomaceous laminae, which consists of compact and strongly amalgamated diatom flocs containing oligospecific assemblages of *Thalassionema nitzschioides* and/or *Coscinodiscus* sp. and representing the sedimentary product of aggregated diatom mats characterized by densely interlocked frustules.

The macrofossil content of the diatomitic marls is relatively rich and includes well-preserved articulated skeletal remains of teleost fishes primarily represented by the clupeid *Spratelloides gracilis*, a single nearly complete articulated skeleton assigned to the ochotonid species *Prolagus* cf. *apricenicus* (see

Mazza et al., 1995), bird feathers, rare decapods crustaceans, insects, and bivalves apparently in life position and plant remains (leaves, seeds, pine cones, fruits). Foraminiferans are rather scarce in the laminated diatomitic marls exclusively represented by ammoniids, bolivinids and rare dwarfed globigerinids (Carboni et al., 1992; Patacca et al., 1992).

Articulated skeletal remains of teleost fishes are relatively abundant in the diatomitic marls of the first two cycles, which also include very rare mass mortality layers. Fish remains are less common in diatomitic marls of the upper four cycles. Fish skeletons are mainly associated with thick continuous laminae of *Thalassionema nitzschioides* and/or *Coscinodiscus* sp. The origin of the thick continuous laminae of *Coscinodiscus* spp. appears to be related to the so-called "Fall dump", a massive sedimentation of diatoms that have grown episodically in the Deep Chlorophyll Maximum during periods of water stratification (Kemp et al., 2000); the origin of thick continuous laminae of *Thalassionema nitzschioides* are associated to high productivity and nutrient abundance (Schuette and Schrader, 1981; Sancetta, 1982; Abrantes, 1988) and possibly represent the sedimentary evidence of bloom events. The preservation of fish skeletal remains is primarily due to the action of the bacterial and fungal film that proliferated on the mucilage of the diatom flocs, promoting the rapid mineralization of the bones; the sedimentary action of microbial/fungal film appears to be manifold since it protected the sediment from erosion sustaining the formation of laminated deposits, inhibited the decomposition of carcasses, scavenging and endofaunal settling and, promoted the rapid phosphatization of the bones and the mineralization of organic components.

The large part of the fossil fishes are very well preserved and nearly complete. Some specimens are incomplete, showing evidence of scavenging activity and/or weak hydrodynamic transport. The single largely incomplete specimen of the Nile perch, *Lates* cf. *niloticus*, exhibits the anatomical and biostratinomical characters of a prolonged post-mortem floating. Evidence of predatory activity and biological packaging primarily involving the planktivore round herring *Spratelloides gracilis* are relatively common.

Several hundreds of specimens have been analyzed, among which not less than 22 taxa belonging to 14 families have been identified (see e.g., Carnevale & Landini, 2000; 2001; Carnevale, 2002; 2003). The dussumierine clupeid *Spratelloides gracilis* sharply dominates the assemblage, represented by more than 75% of the recognized specimens. This planktivore species is represented by both adult and juvenile individuals and certainly constituted the trophic nucleus of the fish assemblages. The comparative analysis of the ecological categories indicates that the assemblage primarily consists of demersal neritic (*Boops roulei*, *Callionymus* sp., *Capros* sp., *Diplodus* cf. *oranensis*, *Diplodus* sp., *Epinephelus* sp., *Halobatrachus* cf. *didactylus*, *Pagrus* sp., Pomacentridae indet., *Syngnathus* sp.) and coastal epipelagic taxa (*Alosa elongata*, *Etrumeus teres*, *Sardina pilchardus*, *Spratelloides gracilis*, *Trachurus* sp.), with a diverse contingent of migratory pelagic and oceanic species (*Diaphus edwardsi*, *Lestidiops sphekodes*, *Maurolicus* cf. *muelleri*, *Merluccius* sp., *Myctophum columnae*, *Paralepis albyi*). The Nile perch is the only freshwater/marginally paralic taxon recognized in the assemblage.

The comprehensive paleoecological analysis of the fish assemblage suggests that the deposition of the diatomitic marls occurred not far from the coastline in a moderately shallow basin surrounded by rocky or coral reefs and seagrass beds and influenced by the open sea. The presence of the Nile perch unequivocally indicates that a river system also contributed to the physiography of the basin. The heterogeneous composition of the assemblage, which is characterized by the co-occurrence of coastal and opportunistic pelagic taxa, is consistent with the unstable eutrophic conditions indicated by the monospecific or oligospecific accumulations of *Coscinodiscus* spp. and/or *Thalassionema nitzschioides* that formed the biogenic substrate of the fish bearing diatomitic laminae.

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THE EARLY PLEISTOCENE MAMMAL FAUNA OF PANTALLA (PERUGIA, CENTRAL ITALY). PRELIMINARY DATA

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The study area is located along the southwestern branch of the Tiberino Basin, a Plio-Pleistocene continental basin extended from San Sepolcro to Terni (central Italy), describing an upside-down “Y” shape.

The stratigraphic succession studied near the village of Pantalla (province of Perugia) is reasonably referred to the S. Maria di Ciciliano Formation and it is composed by an alternation of paleosols, crevasse-splay and channel deposits. Fossil remains were found within two strata. The lower one, consisting of silty sands and interpreted as crevasse-splay deposits, yielded abundant and well preserved mammalian remains, concentrated in a very small area (about 2 m^2). The mammal assemblage includes a small-medium sized deer (*Pseudodama* cf. *P. nestii*), a bovine (*Leptobos* ex gr. *merlai-furtivus*), a suid (*Sus* cf. *S. strozzii*), a dog (*Canis* cf. *C. etruscus*), two cats (*Lynx* cf. *L. issiodorensis* and *Panthera* cf. *P. gombaszoegensis*), and a still undetermined Mustelidae. Skulls, expecially belonging to the carnivoras, are the most abundant elements and are very important because they enriched significantly the fossil mammalian record from the Tiberino Basin. The prevalent presence of Voorhies Groups II & III (Voorhies, 1969) suggests a fluvially winnowed assemblage (Behrensmeyer, 1975).

Fossils from the upper level come from a paleosol rich of vegetal remains (roots and charcoal), terrestrial gastropods, and bones and teeth of terrestrial mammals. The macromammal fauna within this bed is restricted to herbivora, including the bony remains of a horse (*Equus* sp.), a small-medium sized deer (*Pseudodama* cf. *P. nestii*), and a bovine (*Leptobos* ex gr. *merlai-furtivus*), as well as rare *Pseudodama* cf. *P. nestii* teeth. The mandible of a micromammal (*Apodemus* cf. *A. dominans*) was also located in this level. Post-cranial elements and teeth were more-or-less randomly distibuted throughout the paleosol and bones were cracked and isolated; only in two cases articulated elements were found. The absence of fluvially sorting evidence and the “mosaic” pattern of bone surface cracking suggest a pedogenetic origin of the fossil accumulation (Gentili et al., 1997).

The mammal remains found in the two strata can be considered a single assemblage referable to the late Villafranchian Mammal Age.

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PRELIMINARY DATA ON FOSSIL RODENTS FROM THE VERTEBRATE SITES MONCUCCO AND VERDUNO (POST-EVAPORITIC MESSINIAN, PIEDMONT, NW ITALY)

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Over the past two years several excavations conducted by the University of Torino, Earth Science Department, investigated some outcrops of the topmost Messinian deposits of the Tertiary Piedmont Basin (TPB). It was thus possible to find fossil assemblages of large and small vertebrates. In particular, the small mammals remains are exceptionally rich.

We studied in detail the sites of Moncucco (northern part of the TPB) and Verduno (southern part of the TPB). Both sites are included in the continental deposits of the Formazione di Cassano Spinola (post-evaporitic Messinian) (Dela Pierre et al., 2007; Clari et al., 2008; Bernardi et al., 2010).

In Moncucco nine levels can be distinguished, formed mainly by sand-clayey-marls and separated by erosional discontinuities; four levels contain the remains of large and small mammals (Angelone et al., 2010). Rodents are very abundant: murids are represented by at least five species, glirids by three taxa, cricetids and sciurids at least by one. Besides these, there are other small mammals such as insectivores (very abundant) and lagomorphs. The rodent assemblage of Moncucco shows affinity with those collected in other coeval sites of the Italian peninsula, in particular with Brisighella (Emilia Romagna) due to the presence of the murid *Centralomys benericetti* which is reported only in the Italian peninsula (De Giuli, 1989).

In Verduno, where some remains of large mammals were found (Sardella, 2008; Damiani, 2009), the highest part of the studied section is represented by conglomeratic and sandy sediments divided into two levels. The underlying deposits are separated from the former by an erosional surface and consists of three levels of clayey and sandy sediments. All levels above and below the erosional surface are fossiliferous. The assemblages are particularly rich in small mammals and even in this case, rodents are very abundant. The presence of *Centralomys benericettii* is an important element that the site of Verduno shares with Moncucco and Brisighella. However, some differences occur. In particular, glirids as well as murids of the genus *Apodemus* are absent in the three lower levels of Verduno, whereas they are present, though rare, in the upper deposit. On the contrary, these taxa are quite abundant in Moncucco. These differences may be related to paleoecological constraints.

Moncucco and Verduno are important:

1) as they are two new fossil sites to be added to the very few latest Miocene continental fossil sites of the Italian peninsula (Rook et al., 2006; 2008)

2) due to the abundance of remains;

3) due to their geographical position, pathway of immigration towards the Italian peninsula from Eastern and Western Europe during the latest Messinian.

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FOSSIL CROCODYLIDS FROM SCONTRONE (EARLY TORTONIAN, ITALY) AND THE LATE MIOCENE MEDITERRANEAN CROCODYLID BIOGEOGRAPHY

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The origin of *Crocodylus* and its early biogeographic history is still unclear. According to palaeontological and molecular data, the divergence among living species goes back to the Neogene, but it is not clear if the only African species, *C. niloticus*, is an ancient inhabitant of the Old World or if it is a relatively recent immigrant (Brochu 2000, 2001, 2003; Brochu et al., 2010). The three extant African crocodylids are currently referred to three different genera: *Mecistops*, *Osteolaemus*, and *Crocodylus*. Their fossil record is rather abundant and it is being revised so that an updated taxonomic identification of a large part of the remains, as well as the proper phylogenetic position of some taxa, are still pending. Nonetheless, it seems likely that *Crocodylus* originated in Africa during the Early Miocene (McAliley et al., 2006).

The only European crocodylian remains that have been referred to *Crocodylus* on a phylogenetic basis come from the Late Miocene-Early Pliocene of the Gargano region (Apulia), at the western edge of the Abruzzo-Apulian palaeobioprovince (Delfino et al., 2007). On the eastern side of the same palaeobioprovince, at Scontrone (Early Tortonian, Late Miocene; Mazza & Rustioni, 2008), crocodylian remains are represented by isolated teeth that were originally referred to genus *Crocodylus* sp. by Rustioni et al. (1992). Due to the fact that isolated teeth are nearly uninformative for crocodylian taxonomy, the identification of this material has been questioned (Kotsakis et al., 2004; Delfino et al., 2007) or cautiously accepted (Delfino & Rook, 2008) by crocodylian scholars.

A recently prepared skeletal element from Scontrone, SCT 276 (currently exposed at the "Centro di Documentazione Paleontologico *Hoplitomeryx*, Scontrone), significantly improves the knowledge of the crocodylians of this locality. SCT 276 is a nearly complete right dentary, 21 cm long, preserving 13 alveoli, none of which hosts a complete tooth. The third and fourth alveoli are clearly separated by a bony septum (approximately 2.1 mm wide) and are markedly different in size, being the fourth (11.9 mm) much larger than the third (6.1 mm). The eighth interalveolar space is the largest. The dentary symphysis reaches the posterior half of the fifth alveolus.

The characters described above match with the morphology of *Crocodylus*, already identified in same palaeobioprovince, and allow us to exclude the presence of alligatoroid *Diplocynodon*, the only other short snouted crocodylian that was present in Europe during the Late Miocene according to the present knowledge of crocodylian biogeography. The dentary of *Diplocynodon* is characterized, among others, by subequal and confluent third and fourth alveoli, and, usually, by a large seventh interalveolar space. Even if the material so far known from Scontrone does not allow to detect the autapomorphies of *Crocodylus* (see Brochu, 2000, but consider that in that paper *Mecistops cataphractus* was still considered to belong to *Crocodylus*), for both morphological and biogeographic reasons the dentary from Scontrone can be referred to cf. *Crocodylus* sp.

At the moment, the only European fossils referable to *Crocodylus* are the ones coming from the Late Miocene-Early Pliocene of the Gargano region (*Crocodylus* sp.; Delfino et al., 2007), from the Tortonian of Monte Bamboli (cf. *Crocodylus* sp.; note that *Crocodylus bambolii* is a *nomen dubium*; Delfino & Rook, 2008), and from the Tortonian of Scontrone (cf. *Crocodylus* sp.; this paper).

In conclusion, SCT 276 confirms the original identification by Rustioni et al. (1992), and currently represents the oldest European evidence of the presence of *Crocodylus*. From a biogeographic perspective, it proves that this taxon could have reached Europe "during the Tortonian and therefore well before the Messinian Salinity Crisis, traditionally considered as the event that caused several trans-Mediterranean dispersals" (Delfino et al., 2007: 303).

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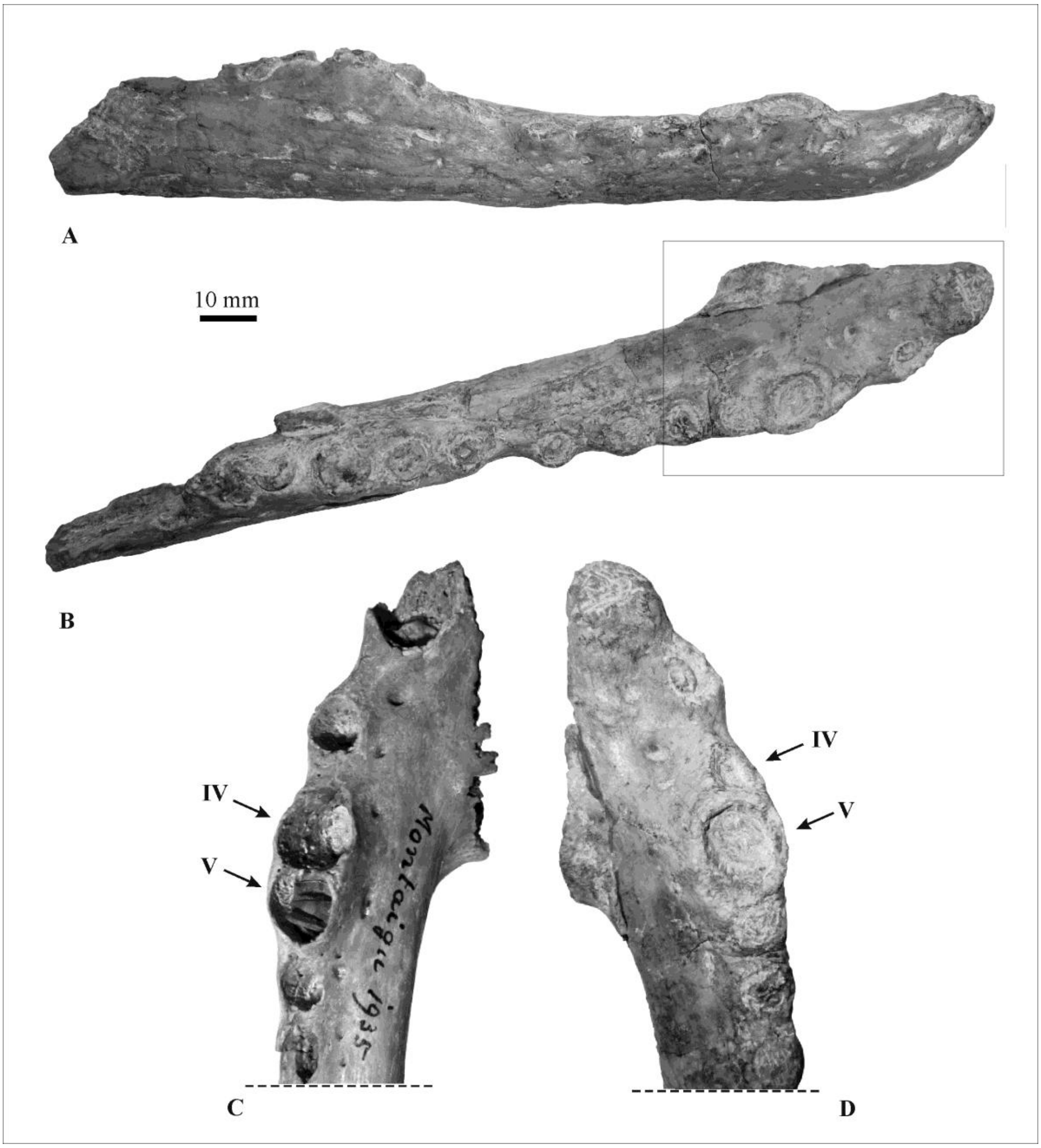

Figure 1: **A**, **B** – cf. *Crocodylus* sp. (SCT 276), Late Miocene (Early Tortonian), Scontrone (Italy); right dentary in right lateral and dorsal views. **C** – *Diplocynodon* sp., unnumbered specimen in the collections of Naturhistorisches Museum, Basel (Switzerland), Early Miocene, Montaigu (France); dorsal view of the anterior region of a left dentary showing that alveoli IV and V are confluent and subequal in size. **D** – detail of **B** clearly showing that alveoli IV and V are well separated and different in size. **C** and **D** not to scale.

THE LATE MIOCENE COLONIZATION OF GARGANO AND SCONTRONE

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Introduction: The mammal faunas of the fissure fillings of Gargano (Apulia, Italy) were discovered in 1969 and published for the first time by Freudenthal, 1971, who dated the colonization as not later than Early Turolian. The fauna is unbalanced, important groups like Carnivora and Perissodactyla are missing, and gigantism in rodents indicates that we are dealing with island faunas. Two of the characteristic components of the Gargano faunas, the peculiar artiodactyl *Hoplitomeryx* Leinders, 1984 and the giant insectivore *Deinogalerix* Freudenthal, 1972 were reported from coastal sediments at Scontrone (Abruzzo, Italy) by Mazza & Rustioni (1996, 2008).

The latter authors concluded that these genera colonized the Abruzzo-Gargano area in the Late Oligocene or in the Miocene, but before the end of the Langhian (before approx. 15 My ago).

The 2008 paper led to a reaction by van den Hoek Ostende et al. (2009), who disagreed with Mazza & Rustioni on the ancestry of *Hoplitomeryx* and concluded a 10 Ma age for the colonization of Scontrone/Gargano. Freudenthal & Martín Suárez (2010) analyzed the arguments and proposed an alternative age of 7.5 - 7.0 Ma.

Colonization of the Scontrone area: Rustioni et al. (1992) attributed a Turolian (Tortonian or Messinian) age to the Scontrone fauna and Mazza & 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 the Serravallian. It would be younger than the First Regular Occurrence of *Neogloboquadrina acostaensis*, astronomically dated to 10.554 Ma.

But, *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. On that basis they conclude that the migration must have taken place earlier than that age.

However, a landbridge is not a necessary element for the colonization of an island. Other mechanisms, like the sweepstake model (see 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 landbridge reappeared during the Messinian, about 6 Ma ago, leading to the conclusion that their arguments for an Oligocene migration are mainly of a paleontological nature and above all based on their interpretation of the -uncertain- taxonomic position of the Hoplitomerycidae. Subsequently, we will show that paleontological evidence derived from the different groups present in the Gargano faunas does not support their interpretation.

Analysis of the Gargano fauna: Subsequently, we will analyze all components of the Gargano fauna and their implication for the age of the colonization:

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) made it clear that in fact we do not know the phylogenetic position of this group. Mazza & 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 endemized, 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 colonization of the area.

Amphimoschus is known from MN4-5. If that is the ancestor, the colonization cannot be younger than about 14 Ma ago. *Micromeryx* is known from MN5 to MN11 and maybe the first part of MN12; it might account for an Early to Middle Turolian immigration.

Deinogalerix - Van den Hoek Ostende (2001) mentioned the close relationship between this genus and *Parasorex*. The latter genus is represented in many localities of Gargano (cited as *Pseudogalerix* by Freudenthal, 1971) 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. *Deinogalerix* is probably not older. The only thing Mazza & Rustioni say, without further arguments, is 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*.

Muridae - Two genera of murids are present in the Gargano faunas: *Mikrotia* and *Apodemus*. *Mikrotia* is characterized by an increasing number of crests in the first lower molar 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), but the *Apodemus* from Gargano is fairly advanced, resembling Late Turolian and Ruscinian species.

Cricetidae - Freudenthal (1985) recognized 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. The *Cricetulodon* material is better classified as *Neocricetodon*. The *Cricetus* material should be transferred to *Apocricetus* Freudenthal et al, 1998, and *Hattomys* may well be derived from *Apocricetus*. The latter genus is typically Turolian/Ruscinian and *Neocricetodon* is known from the Vallesian, Turolian and Ruscinian. Freudenthal (1985) found the Turolian Crevillente faunas (MN11/MN12) to present the best possible ancestors for the Gargano Cricetidae, but maybe Central or Eastern European cricetids are a better source.

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 (MN13) of Spain, France and Germany. Possible ancestors of *Stertomys*, like *Myomimus dehmi* and *M. maritsensis* were reported from Chomateres and Pikermi (MN12, Greece) and Messinian (MN13) deposits in Spain and Greece. For sources of information see Freudenthal & Martín-Suárez.

Lagomorpha - *Prolagus apricenicus* Mazza, 1987 from Gargano may be derived from the *P. michauxi* lineage, which is documented in Rema Marmara (MN12, Greece), El Arquillo (MN13, Spain) and Maramena (MN13, Greece); possibly related forms have been reported from Monte Castellaro, Capo di Fiume and Brisighella (MN13, Italy).

Aves - The only thing that can be said is that the ancestors of the Gargano birds are not older than La Grive (MN8).

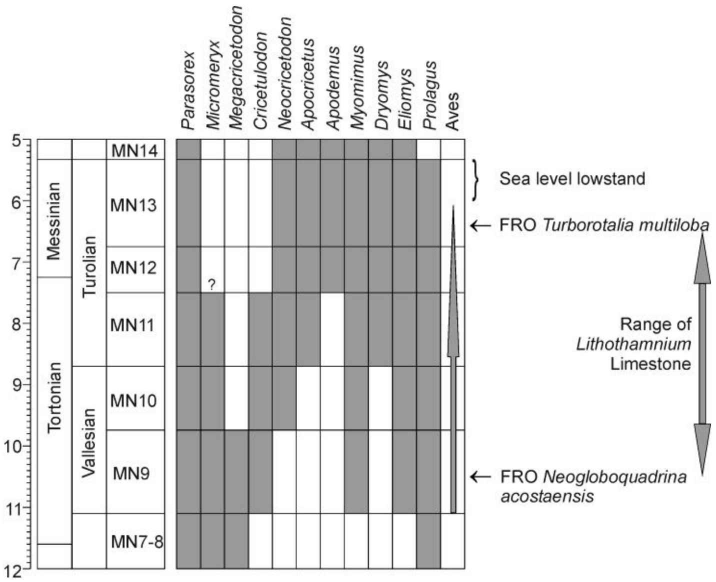

Fig. 1. Distribution of the potential ancestors of the Gargano faunal components.

<u>The age of immigration</u>: Fig. 1 shows that potential ancestors for all of the Gargano faunal components are present in MN unit 12, equivalent to Latest Tortonian/Early Messinian. Apparently an age of 7.5 - 7.0 Ma is the best estimate for the colonization of Gargano and this is compatible with the age of the *Lithothamnium* Limestone at Scontrone. At that time the Balkan-Gargano landbridge did not yet exist and the colonization must have taken place through a sweepstake model, crossing the Adriatic seaway; this explains the unbalanced composition of the fauna.

A later moment, during the sea level lowstand of the Late Messinian (6.0 to 5.3 Ma ago), cannot be excluded, but in that case one would expect a more complete fauna, including e.g. Carnivora. Such a normal fauna may have reached Gargano, but has left no record. If it did reach Gargano, it certainly caused the extinction of the endemic fauna.

<u>Conclusion</u>: Our conclusion is that the "terre rosse" fauna arrived on the Gargano island about 7.5 - 7.0 million years ago. Its evolution may have lasted one million years or more, and it probably became extinct some 6 million years ago, when Gargano got connected to the mainland due to the Messinian sea level lowstand.

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THE MIOCENE VERTEBRATE FAUNA OF CALVERT CLIFF, MARYLAND, U.S.A.

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In 1904, the Maryland Geological Survey published a two-volume summary, edited by W. B. Clark, G. B. Shattuck, and W. H. Dall, of the Miocene fossil fauna then known from the State of Maryland, U.S.A. Although their focus was the Miocene deposits of Maryland, the vast majority of the fossils originated from Calvert Cliffs. In the one hundred years since their seminal work, a large body of original research has been published. An effort has now begun to compile an exhaustive update reflecting our much greater understanding of both the geology and vertebrate paleontology of the Miocene biota recovered from along Calvert Cliffs and adjacent tributaries to the Chesapeake Bay. This large and diverse shallow marine biota needs to be documented for its own sake, for the benefit of an interested public audience, and to further and foster a better understanding of the Miocene epoch by encouraging similar efforts by researchers worldwide. As the price of water-front real estate continues to escalate along Calvert Cliffs, increasingly, efforts are being made to stabilize the cliffs to slow or prevent further erosion. In addition to the many negative ecological consequences, cliff stabilization also has the unfortunate effect of rendering the Miocene exposures inaccessible thus precluding the study of their geology and the recovery of important fossils that would otherwise erode naturally from the cliffs. It is important to retain this portal to the Miocene by preserving the cliffs in their natural state.

Calvert Cliffs extend for approximately 50 km along the western shore of Chesapeake Bay. They are the best-exposed onshore record, and the most complete sequence of marine Miocene siliciclastic sediments exposed on the East Coast of North America (Ward, 1992; Kidwell, 1997; Ward and Andrews, 2008). The most impressive cliffs extend south from southern-most Anne Arundel County along most of the length of Calvert County, Maryland. A series of cliffs, 25 to 35 m high, consist almost entirely of unlithified strata that dip at about two meters per kilometre toward the southeast. Calvert Cliffs are comprised of strata from three Miocene formations, in ascending order – Calvert, Choptank, and St. Marys of Shattuck (1904) – and an additional 20 m of coarse channel-formed deposits of fluvial and tidal origin of younger but uncertain age (Kidwell, 1997; Ward and Andrews, 2008).

The Early, Middle, and Late Miocene strata preserve a biostratigraphically complete record of approximately ten million years in only about 70 m of sediment (Kidwell, 1997). Gernant et al., (1971), Ward (1992), Shideler (1994), Kidwell (1997), and Ward and Andrews (2008) concur that the Miocene sequence along Calvert Cliffs records multiple transgression/regression cycles in an overall shallowing succession within the Salisbury Embayment. The Calvert Formation is characterized by muddy inner to middle shelf deposits. Maximum water depth within the embayment was attained during deposition of Beds 11 and 12 of the Plum Point Member (Calvert Formation) as indicated by high planktonic foraminiferal diversity (Kidwell, 1997). Sandy shoreface deposits predominate in the Choptank Formation, whereas muddy marginal marine and intertidal deposits typify the St. Marys Formation. The cyclic deposits of the Calvert through Choptank interval are not as evident in St. Marys strata, in addition to which, they are muddier, less shelly, and preserve more brackish-water taxa (Kidwell, 1997).

Of the more than 600 species described from fossils from Calvert Cliffs, the large majority is of marine organisms. The rich fossil assemblage includes trace fossils (burrows and coprolites), palynomorphs and terrestrial plants, foraminiferans, radiolarians, dinoflagellates, diatoms, poriferans, cnidarians, annelid worms, ostracod and decapod crustaceans, abundant and diverse mollusks, barnacles, an inarticulate brachiopod, echinoderms, sharks and rays, bony fishes, turtles, crocodiles, pelagic birds, phocid seals, dugongid sea cows, isolated and fragmentary remains of mostly large terrestrial mammals (dog, bear-dog, peccary, protoceratid, camel, horse, tapir, rhino, and gomphothere), and a great diversity of smaller odontocetes, sperm whales, and baleen whales (De Verteuil & Norris , 1992; Gottfried et al., 1994; Eshelman et al., 2007; Fuller & Godfrey, 2007; Godfrey & Barnes, 2008; Barnes et al., 2010; Gerholdt & Godfrey, 2010; Godfrey & Smith, 2010; Lambert et al., 2010; Visaggi & Godfrey, 2010). Work to describe new vertebrate taxa continues.

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GEOGRAPHICAL DISTRIBUTION AND 3D RECONSTRUCTION OF THE LATE MIOCENE SABERTOOTHED CAT *AMPHIMACHAIRODUS* EX GR. *KABIR* (FELIDAE, MAMMALIA)

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Large sabertoothed cats characterized the Late Miocene terrestrial mammal carnivore guilds in Africa and Eurasia.

Amphimachairodus giganteus had a wide geographical distribution in Eurasia, from China to western Europe. The African Late Miocene sabertoothed cats are not so well documented as the Eurasian taxa, even if an increasing amount of data has been recently collected and published providing new information on the evolution and diffusion of these felids (Werdelin, 2003; Peigné et al., 2005; Werdelin & Sardella, 2006; Sardella & Werdelin, 2007; Rook & Sardella, 2008; De Bonis et al., 2010).

Werdelin (2003) studied sabertoothed cat fossils from Lothagam Nawata Formation (Kenya) and instituted a new genus and a new species *Lokotunjailurus emageritus*. In 2005 Peigné et al. described a mandible and a humerus from Toros Menalla - Anthracotherid unit - (Chad) and referred them to the new species *Machairodus kabir*.

The affinities between the Toros Menalla sabertoothed cat and the felid (partial skull and mandible collected by Petrocchi in 1930s) from the Late Miocene site of Sahabi (Libya), was evidenced by Sardella & Werdelin (2006) who referred the Lybian fossils to *Amphimachairodus* aff. *A. kabir*. Rook & Sardella (2007) described new fossils from Sahabi putting in evidence the occurrence of different taxa (possibly including a *Dinofelis*).

Recently De Bonis et al. (2010) described the new species *Lokotunjailurus fanonei* and cf. *Megantereon* sp. from Toros Menalla. The large sabertoothed cats from the Late Miocene-earliest Pliocene African sites (Toros Menalla, Sahabi, Wembere Manonga Fm. and Langebaanweg) show peculiar cranio-dental features and a direct phyletic relationships between these species and the Plio-Pleistocene *Homotherium* cannot be supported (Werdelin & Sardella, 2006). A large sabertoothed cat referable to *Amphimachairodus* ex gr. *kabir* is one of the top predators of the Chado-Libyan paleobioprovince (Lihoreau et al., 2006).

Sardella (2008) suggests that also an upper canine and a mandible recorded in the Late Miocene Spanish site of Venta del Moro (Valencia) (Montoya et al., 2006) could be referred to *Amphimachairoduds* ex gr. *kabir,* thus supporting the evidence for the presence of an African element in Europe at the Mio-Pliocene transition.

A comparative analysis of the Miocene and Plio-Pleistocene sabertoothed cats is in progress. In this study also 3D virtual imaging techniques are used and the skull and mandible of *Amphimachairodus* aff. *A. kabir* from Sahabi have been considered for biometrical and morpho-functional studies in order to provide a 3D reconstruction of the specimen.

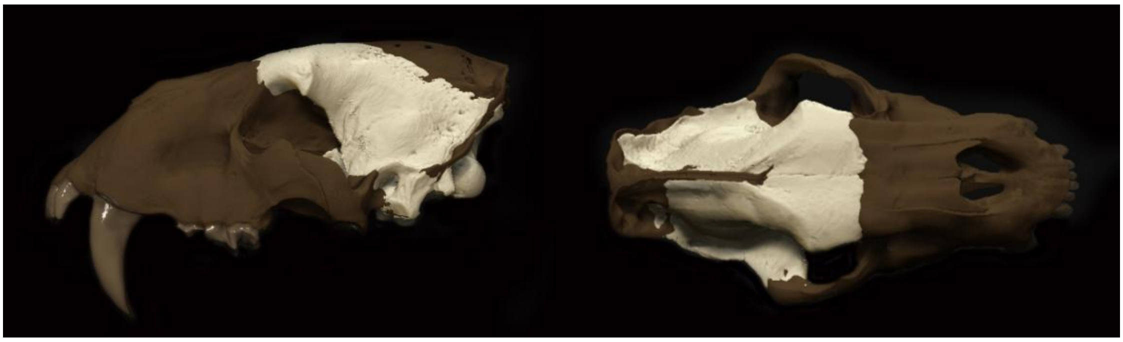

Fig. 1 - 3D virtual reconstruction of the skull of *Amphimachairodus* aff. *A. kabir* from the Late Miocene of Sahabi (Lybia).

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BIOSTRATIGRAPHICAL INTERPRETATION OF TUĞLU FORMATION IN ÇANKIRI BASIN (CENTRAL ANATOLIA, TURKEY) BASED ON NEWLY COLLECTED SMALL MAMMALS ASSEMBLAGES

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Located in the northern part of the Central Anatolian Plateau (CAP), the Çankiri Basin represents one of the largest intermontane Tertiary basins of the CAP. Mesozoic to Tertiary tectonic units form the backbones of the plateau and are unconformably covered by thick Miocene to Quaternary continental sediments separated by basement highs. Tectonic evolution of the Çankiri Basin has been studied and discussed by several authors (e.g. Kaymacki, 2000).

Within the framework of the EU VAMP (Vertical Anatolian Movements Project), an international and interdisciplinary research team has started detailed sampling and study of key stratigraphic sections in the Çankiri Basin (Kováčová et al., 2010). The current investigations focus on the low-energy fluvio-lacustrine Tuğlu Formation. The section of Tuğlu, located around 200 km from the Black Sea coast, is characterized by a succession of clays, silty and sandy clays, with patchy sand bodies. The age was stated as Tortonian-Messinian (MN10-12) by Kaymacki (2000) on the basis of micro-mammal assemblages (*Parapodemus, Cricetinae* gen. indet., *Byzantinia* sp., *Zapodidea* gen. indet, *Myomimus* sp., *Schizogalerix* sp., *Erinaceid* indet.). During 2008-2010 fieldworks the samples from selected layers were collected for micromammal analyses. Rodent microfauna collected from two different layers shows some discrepancy from previously published fauna and point to older age of the section. New data will be presented and discussed.

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NEOGENE MEDITERRANEAN INSULAR VERTEBRATE ASSEMBLAGES

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"...it is too much to say that when we have mastered the difficulties presented by the peculiarities of island life we shall find it comparatively easy to deal with the more complex and less clearly defined problems of continental distribution..."

This sentence by Alfred Russel Wallace published in 1902, reported by Whittaker & Fernández-Palacios (2007), summarizes the interest by naturalists for evolutionary as well as for biogeographic investigations of insular domains. Actually, insular faunas peculiarities, such as the high endemic degree, the local radiations by sibling species, the high oligotypy of vertebrate communities, and body mass modifications (especially in mammals), were well known phenomena since the second half of the 19th century.

It was also known that Quaternary outcrops in Mediterranean islands bear fossil vertebrates characterized by "dwarfism" of large mammals (mainly Elephantidae and Hippopotamidae) and "gigantism" of small mammals (Falconer, 1868; Adams, 1874). The intense palaeontological work by Falconer, Adams, Busk, De Gregorio, Gemellaro, Major and especially by Miss Dorothy Bate between the second half of the 19th century and World War II, decisively improved both systematic collections and basic knowledge about several fossil assemblages of Mediterranean islands (Cyprus, Crete, Sicily, Malta, Sardinia, Corsica, Majorca, Minorca and many other smaller islands). As researches were expanded outside the Mediterranean area, a constant pattern, successively named "Island Rule", was unveiled in many other insular domains even out of Mediterranean (e.g. Caribbean, Indonesia, etc.) irrespective of taxonomic differences. Living mammal communities with dwarf and gigantic forms were discovered in Indonesia and Philippines in the same years and different explanations were then suggested for such a pattern (mainly "dwarfism" and "gigantism"). The first temporal ordination of fossil assemblages in the Sicily-Malta area was based on different "dwarfism" degree of elephants, evolved from the well known European species *Elephas antiquus* (cf. Vaufrey, 1929).

After World War II, and especially since the 60's, analytical investigations about single lineages evolution in insular environment began, without the typical noise of greatly diverse mainland assemblages. On the other hand both "dwarfism" and "gigantism" became object of theoretical explanations and faunal turnovers modality in insular domain (MacArthur & Wilson, 1967) began to be investigated.

In some extant islands the fossil record attests the presence of typical insular faunas alternating with assemblages showing continental features (Sondaar, 1977; Azzaroli, 1982, 1996; Alcover, 1987), thus suggesting alternating connections with the continent. Per contrast, fossil assemblages with clear insular characters, were discovered in present continental areas. Miocene fossil mammal associations in the Gargano peninsula are a good example representing evidence of a lost archipelago of palaeoislands (Freudenthal, 1971; Abbazzi et al., 1996). The occurrence of mammals on islands can be explained by: 1) a residual of previous colonisations or vicariance events; 2) dispersive events allowed by temporal continental connections or by limited sea straits; 3) passive transportation on occasional natural raft (sweepstake crawl; mainly for small vertebrates; Sondaar, 1977, 1986; Dermitzakis & Sondaar, 1978; Azzaroli, 1982, 1996; Whittaker & Fernández-Palacios, 2007). Polyphasic colonisations represent an interesting phenomenon: they are characterized by the temporal overlapping of species pertaining to different colonisation events (for ex. the Early Miocene Oschiri (Sardinia) assemblage - Bruijn & Rümke, 1974; Van der Made, 2008).

Our knowledge on Quaternary insular vertebrate assemblages of the Mediterranean area is relatively good. For the 2.5 Ma of the Quaternary we know 84 endemic species of mammals described until now and, with a few exceptions of taxa under discussion, accepted by the great majority of the students (Van Der Geer et al., 2010). A small number of endemic birds, reptiles and amphibians must be added to the mammalian species. Another good number of not yet described mammalian taxa (often based unfortunately on insufficient remains for a good diagnosis) is also known.

The situation is worse for the Neogene insular assemblages. Abundant remains of Neogene vertebrates are known from many Aegean Islands (Lemnos, Lesbos, Psara, Chios, Samos, Evia, Rhodos, Karpathos and others) and from Crete but all belong to “normal” non-insular faunas, a datum confirmed by the Miocene palaeogeography of the Aegean area (Kotsakis, 1990; Koufos, 2006). During the Pliocene, Crete was divided into four islands at least, but no continental fossil vertebrates have been discovered for this time span (Van der Geer et al., 2010).

Western Mediterranean has a complex geological history, characterized by orogenic processes and extensive tectonic phases that caused an alternation of connections and separation of microplates, of isolation or connection of insular districts and produced a fragmentation in geochemical provinces while favouring the renewal and the evolution of insular faunas (Kotsakis et al., 1997; Rook et al., 1999, 2006; Masini et al., 2008; Palombo, 2009).

On the contrary, a combination of tectonics and eustatic oscillations was the main factor that drove colonization events during late Pliocene and Quaternary (Masini et al., 2001, 2002). Glacial eustatism seems to be the main driving force for insular faunal evolution during Middle and Late Pleistocene.

Neogene remains of insular vertebrate assemblages are reported from the extant islands of Sardinia (Early Miocene, Late Miocene, Late Pliocene), Majorca (early Middle Miocene, Late Miocene, Early Pliocene, Late Pliocene), Minorca (Middle Miocene, Early Pliocene), Ibiza (Late Miocene/Early Pliocene) and from the "fossil islands" of Gargano-Scontrone (Apulian–Abruzzi palaeobioprovince; Late Miocene/?Early Pliocene), southern Tuscany (Tusco-Sardinian palaeobioprovince; Late Miocene) and Las Murchas (Middle Miocene). Vertebrate remains of Late Miocene age have been collected also in Sicily but they belong to a non-insular faunal assemblage. Problematic isolated remains from marine sediments are collected in Sicily, Malta and Cyprus. Moreover, the ancestors of some species known from Early Pleistocene insular assemblages, colonized the islands during the Neogene. (Kotsakis et al., 1997; Rook et al., 1999, 2006; Bover et al., 2008; Masini et al., 2008; Mazza & Rustioni, 2008; Palombo, 2009; Van den Hoek Ostende et al., 2009; Freudenthal & Martín-Suárez, 2010; Van der Geer et al., 2010).

The number of endemic species erected for mammals belonging to insular Neogene assemblages of the Mediterranean area (that is for a time span of 20.5 Ma) is 65. The number of endemic species of birds, reptiles, and amphibians is higher than the Quaternary endemic species.

For many of these assemblages there is an agreement among palaeontologists about the area of origin of the immigrants, and for a good number of species the researchers agree about the possible ancestral stock. For some others different opinions have been advanced and stimulating debates are under way. However several systematic, phylogenetic and palaeobiogeographic problems are still open.

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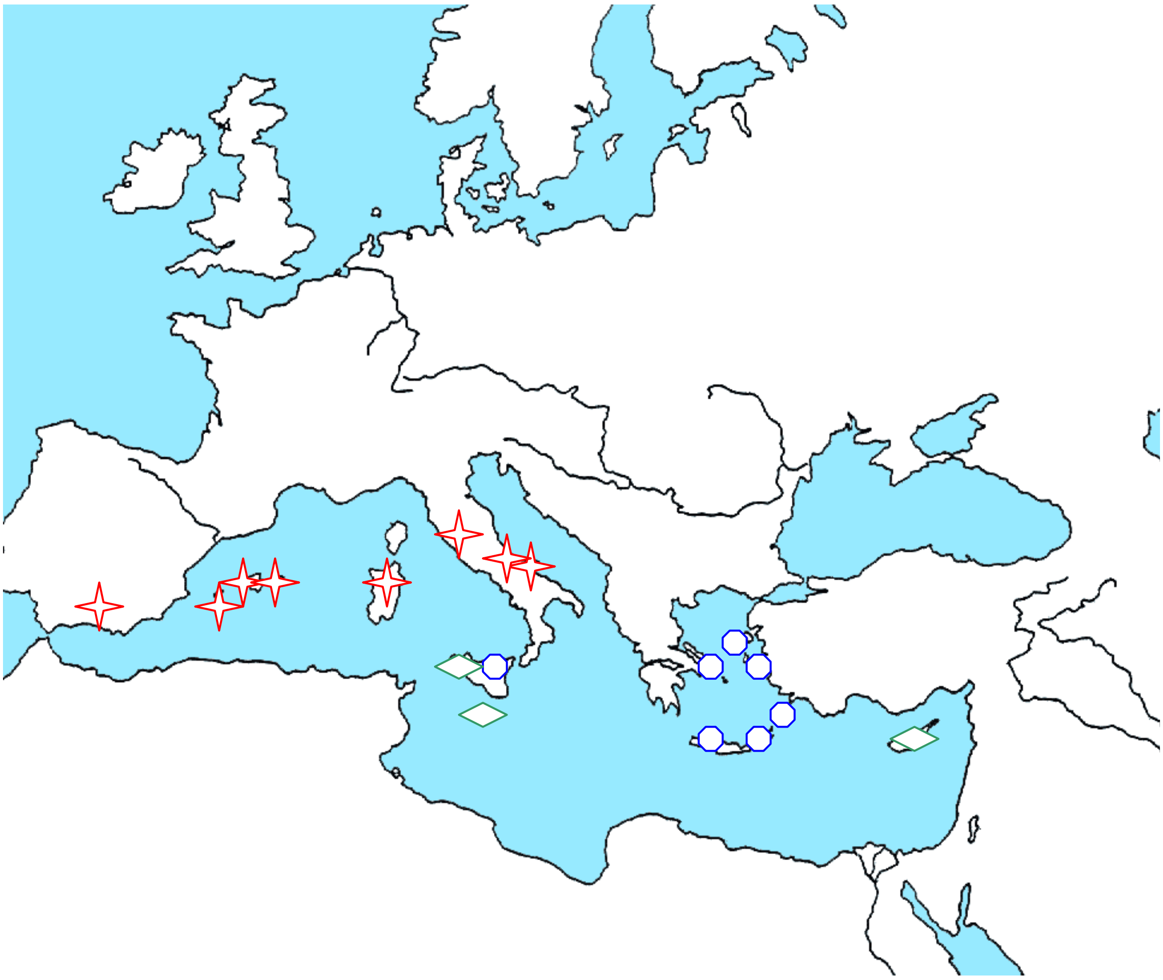

Fig. 1 – Diamonds (insular vertebrate assemblages) from west to east: Las Murchas, Ibiza, Majorca, Minorca, Sardinia, Tuscany, Scontrone, Gargano. Polygons (non insular vertebrate assemblages on extant islands) from west to east: Sicily, Evia, Crete, Lesbos, Chios, Karpathos, Rhodos. Rhombi (uncertain isolated remains): from west to east Sicily, Malta, Cyprus.

PIKERMIAN "GUESTS" IN THE LATE MIOCENE OF CALABRIA, SOUTHERN ITALY

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The existence of a land connection between the Monte Poro – Capo Vaticano area (Southern Italy) and North Africa has been firstly suggested by the occurrence of *Stegotetrabelodon syrticus* at Cessaniti (Ferretti et al., 2003). The newly recorded occurrence of the giraffids *Bohlinia* cf. *attica* and *Samotherium* cf. *boissieri* (Marra et al., in press) represents the first record of the species out of the Greco-Iranian bioprovince and is coherent with the land-connection of the Monte Poro – Capo Vaticano area with North Africa. The spreading of *Bohlinia* and *Samotherium* out of the eastern domain is one of the evidence of the expansion in Africa of the so-called "Pikermian" biome, whose paleogeographical range and paleocological character are going to be revised (Kostopoulos, 2009a; Solounias et al., 2010). However, in North Africa the presence of *Samotherium* is rare, while *Bohlinia* is absent, maybe for a short persistence or for ecological reasons. The association of *Bohlinia* and *Samotherium* is a peculiar character of the area of Cessaniti–Zungri making it similar to Samos. The record of Cessaniti-Zungri can represent one of the latest occurrences of the species *Samotherium boissieri*, which in the Greco-Iranian bioprovince is replaced by the derived species *Samotherium major* at MN11/MN12 transition (Kostopoulos, 2009b; Geraads, 1994). Moreover, according to Solounias et al. (2010) Samos – where *Samotherium* and *Bohlinia* co-occur – is slightly younger (7.8 - 6.9 Ma) than Pikermi (estimated around 8 Ma).

The vicinity in space and the comparable chronology between Cessaniti and As Sahabi, give to Cessaniti an intriguing potential. Like As Sahabi, positioned as a Late Miocene biogeographic crossroad, the fossiliferous

succession at Cessaniti could provide new evidence for the faunal evolution of this portion of circum Mediterranean area in very late Miocene times, a crucial time period in the evolution of African vertebrate assemblages.

The record of Cessaniti-Zungri invites to reconsider times and ways of expansion of the Pikermian biome, in particular its diffusion in North Africa.

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THE SMALL SIZED GALERICINI FROM F32 "TERRE ROSSE" FISSURE FILLING (GARGANO, SOUTHEASTERN ITALY) AND ITS BIOCHRONOLOGICAL IMPLICATIONS

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Deinogalerix is by far the better known Galericinae (Galericini according toVan den Hoek Ostende, 2001) from the Gargano fissure filling thanks to very careful description of Butler 1980. However, another moon rat, very small sized, belonging to the Galericini tribe, is virtually present in all the assemblages from the "terre rosse" fissure filling of the Gargano. It was first mentioned in the pioneering report of Freudenthal (1971) and by Butler (1980) in his study of the "gigantic" *Deinogaleri* and it has been quoted in several faunal lists. It has been ascribed to *Parasorex* by Van den Hoek Ostende (2001), and to *Galerix* (*Apulogalerix*) by Fanfani (1999). Van den Hoek Ostende (2001) considered it and the large *Deinogalerix* as derived from a common ancestor. Up to date, however, a detailed description of the characters of this gymnure has never been presented to the scientific community. Indeed, only De Giuli et al. (1987) used the size of the mandible in six selected samples to describe the variation along their proposed biochonology of the terre rosse.

We present here the morphological description of a sample from Fissure Filling F32, that is considered to represent the youngest phase of population of the Gargano Paleoarchipelago. This sample has been chosen since it is very rich and is not affected by taphonomic biases. The philogenetic relationships of the Gargano Galericini are discussed. The description of a new very primitive species of *Deingalerix* from Pirro 12 fissure filling (Villier, 2011) opens new perspectives to investigate the relationships between the small and the gigantic Galericine of the Gargano.

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A NEW SMALL MAMMAL ASSEMBLAGE FROM THE PIRRO 12 "TERRE ROSSE" FISSURE FILLING (GARGANO, SOUTHEASTERN ITALY)

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The Pirro 12 fissure filling has been discovered and sampled by a team of the University of Torino during the 2005 field survey in the Dell'Erba Quarry (Apricena, Foggia). The occurrence of a very small *Deinogalerix* and of a very simple *Mikrotia* supported, at a first glance, the very old position of Pirro 12 in the biochronological succession of endemic faunal settlements of Gargano (Villier, 2011). In this communication the preliminary result of taxonomic studies of the small mammal assemblage of the Pirro 12 filling is presented.

The Gliridae is by far the most common family in this site. Two species of the endemic genus *Stertomys* have been identified: the small-sized *Stertomys* cf *simplex*, and the larger-sized *Stertomys* cf *lyrifer*. The possible occurrence of *Stertomy daamsi* still needs to be ascertained. These Myomiminae closely resemble those of fissure Rinascita 1 reported in the literature[1].

Murids are represented by two species of *Mikrotia*: one is very small, with very brachyodont crown and simple morphology of M/1, while the other is somewhat larger and hyspsodont, and has a slightly more complex occlusal pattern. Another Murinae species is rather common and although it is still being analyzed, it is the first new taxon reported from Pirro 12. A second one is a very large-sized and rather hypsodont cricetid (latu sensu) genus, which cannot be associated with any other cricetid so far reported from the Gargano Terre Rosse. Insectivores are represented by three mandibles without teeth of a small-sized Galericinae, as well as by a single remain of Crocidurinae. The sample is rather poor, and therefore the absence of characterizing taxa should be considered with caution. The occurrence of a new murine and of a new large cricetid distinguishes the Pirro 12 assemblages from all other fissure fillings. The shrew is present also in some old fissure fillings reported in the literature of the 1980's (Martín-Suárez & Freudenthal, 2007). *Stertomys lyrifer* and S. *symplex* are found only in the fissure Rinascita 1, which is the second oldest fissure mentioned in the literature of the late 1970's (De Giuli et al., 1987). The absence of *Apodemus* and *Prolagus*, two genera which are virtually present in all known fissure fillings from the Gargano, the absence of *Hattomys*, the endemic resident cricetidae, the absence of *Apocricetus*, *Neocricetodon* and *Democriceton* which are instead found in older fissures (i.e., Rinascita 1 and Biancone), together with the extreme primitiveness of *Microtia*, prove the ancient biochronological age of this fissure, changing the scenario of the oldest faunal settlements of the Abruzzo- Apulian paleo-bioprovince.

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PRIMATE TURNOVER IN THE BACCINELLO-CINIGIANO BASIN: STABLE ISOTOPE ANALYSES AND FAUNAL TURNOVER OF A LATE MIOCENE VERTEBRATE-BEARING SUCCESSION IN SOUTHERN TUSCANY (ITALY)

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The latest Miocene succession of the Baccinello-Cinigiano Basin (BCB) in southern Tuscany (Italy) records a faunal turnover documenting the extinction of the faunal complex characterised by the Late Miocene ape *Oreopithecus bambolii* and the setting of a new faunal complex, including the colobine monkey *Mesopithecus* (Benvenuti et al., 2001; Rook et al., 2000, in press).

A similar turnover pattern (Late Miocene ape/latest Miocene Cercopithecidae) is generally observed in Late Miocene continental successions of Eurasia, from Spain to Central Europe, Southwest Europe, near East, and Southwest Asia (Andrews et al., 1996). An abundant literature reports that Late Miocene Eurasian Hominoid primate distribution closely tracks climatic/environmental changes during the 12–9Ma interval (Agusti et al., 1996) until their extinction in western Europe. In the primate record the dispersion of Cercopithecidae and contraction of hominids is interpreted as an event depicting a pattern of ''continentalization'' in the Old World (Eronen & Rook, 2004).

In order to contribute to the debate on this hypothesis, we have performed a study of stable carbon isotopes in soil organic matter along the entire sedimentary succession of the Baccinello-Cinigiano basin (Matson, 2010). The isotopic data exhibit very low temporal and spatial variability (<4.5‰ VPDB), and provide no evidence for ecologically significant changes in floral composition spanning the *Oreopithecus* extinction event. These results indicate plant ecosystem stability through time and suggest that the extinction of *Oreopithecus* and its associated fauna was likely due to competition with the new faunal complex immigrant from Europe more than to climatic, environmental, or ecosystem changes. The carbon isotope values fall entirely within the range of isotopic variability for modern plants following the C_3 photosynthetic pathway (trees, shrubs, cool-season grasses), indicating that C_4 vegetation (warm-season grasses) was not an important component of biomass. When corrected for temporal variation in the carbon isotopic composition of atmospheric carbon dioxide, the paleosol carbon isotope values are consistent with predicted values based on modern plants and the Baccinello palynoflora, confirming the reliability of paleosol isotopic records as paleoecological proxies.

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THE SYSTEMATIC POSITION OF HOPLITOMERYCIDAE REVISITED

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Hoplitomeryx was originally described only on cranial characters. The type specimens were found in Gargano (Apulia, southeastern Italy), during the 1970's, in karstic fissure fillings, most likely of Messinian age. During the 1990's a rich amount of *Hoplitomeryx* remains were discovered in Lower Tortonian layered calcarenites outcropping near Scontrone (Abruzzo, central Italy). The skull fragments, teeth, and jawbones from both localities have been recently examined. The dental characters had never before been described, and also part of the maxillaries and jawbones were not part of the original sample that had been analyzed to establish the genus. Hoplitomerycids were originally linked more closely with Cervids, and thus accommodated in the Cervoidea, only because of their possessing two lacrimal orifices and closed metatarsal gulleys. The many new lines of evidence prompted a revision of the standing classification of hoplitomeryids. A character-taxon matrix of 121 features (48 cranial, 51 dental and 22 postcranial characters) was set up based on direct observation and the literature, to infer the interrelationships between Hoplitomerycidae and an ingroup of twelve past and six living ruminant taxa. The dataset was analyzed by using the heuristic search algorithms in PAST 1.99. All searches used 100 reorderings, 1000 bootstrap replicates, tree-bisection and reconnection (TBR) branch-swapping, random addition sequence, exclusion of uninformative characters. Ficht optimization was performed. The cladistic analysis shows that hoplitomerycids stem either between antilocaprids and bovids, or between antilocaprids and giraffids. It was also found that hoplitomerycids can be the sister group of two clades, one formed by Bovidae, Cervidae, Moschidae, and Palaeomerycidae, the other by Antilocapridae, Giraffidae, and Climacoceridae. They were not found to be linked directly with cervids. Because the family shares a mixture of characters with many other ruminants, it is here believed to be descendant of a primitive ruminant stock that should be placed somewhere at the basal divergence of Pecora. Geological evidence from Abruzzo-Apulia to deep into the Adriatic offshore shows that 29 Ma the Abruzzo-Apulia platform was connected with the Balkans by a stripe of land across the Adriatic Sea, approximately where the Tremiti islands are today. This connection is supposed

to have allowed the ancestors of *Hoplitomeryx* to spread in Abruzzo-Apulia. The stripe of land then sank and the ruminants remained isolated thereafter for a few million years. Living in insularity led them to radiate, giving birth to new species of a range of sizes, either brachyodont or mesodont. Hoplitomerycids hence developed autapomorphic homoplasies masquerade as homologies that near them to antilocaprids and bovids, or even to giraffids, rather than to cervids, as previously believed. For this reason they cannot be easily accommodated in any of the superfamilies of higher ruminants.

LAND MAMMAL COLONIZATION OF ISLANDS IS A MULTIFACTORIAL PRODUCT: A CRITIC TO THE UNWISE USE OF MODELS

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The colonization of islands by terrestrial mammals has been the topic of a flurry of studies. Contributions normally tend to oversimplify the subject, focusing on specific key factors which are allegedly considered the best to explain why, how and when non volant terrestrial mammals reached islands and which are used to devise models. The subjectivity in the choice of key factors understandably leads to controversy and debate. Insular faunas are the multifactorial result of complex combinations of facts, conditions and processes. Hence, the faunal assemblages of each island should be inquired individually, on a case-by-case basis. Models, by definition, are simplified representations of reality, which turn into oversimplifications when reality is so overly complex as it is in islands; yet models are usually considered the unavoidable starting point of investigations. An *evidence-based, multidisciplinary* approach, instead, is *highly* recommended. Besides obvious paleontological evidence, we need to carefully inspect geological and stratigraphical information, climatological factors, sea-level evolution, paleogeographic characteristics, ecological, physiological and environmental factors, behavioral characters and ecological preferences, genetics and densities of colonizing populations, as well as taphonomic, sampling and analytical biases. The lack of some of this indispensable information seriously affects the reliability of interpretations and reconstructions.

SIZE CHANGE IN INSULAR MAMMALS: SCRUTINIZING ASSUMPTIONS OF A HOTLY DEBATED QUESTION

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Islands have been regarded by scientists as living laboratories of evolution and an optimal context for the study of forces influencing evolution and diversification. In response to the special characteristics of island environments, plants and animals often undergo evolutionary changes that could be observed on islands varying in surface area, primary productivity and available resources, in the diversity and intensity of ecological interactions, and in time and magnitude of their isolation. Since Darwin's (1859) and Wallace's (1876) pioneering contributions to evolutionary biology and biogeography, the unusual nature and composition of island faunas, as well as the causes underlying these peculiarities, the pathways of island colonisation, and patterns of evolution of insular species have been a matter of thorough scrutiny and debate for biologists, palaeontologists, ecologists, and biogeographers. Two main issues have been attentively considered and discussed: 1) the loss of biodiversity and 2) the peculiar changes undergone by island settlers, above all changes in size of insular mammals, birds, and some reptiles, including dinosaurs (see e.g. Sondaar, 1977; Clegg & Owens, 2002; Boback, 2003; Lomolino, 2005; de Vos et al., 2007; Bromham and Cardillo, 2007; Benton et al., 2010; van der Geer et al., 2010 and references in those papers). For instance, occurrences of unbalanced faunas, including "dwarfed" or "giant" species, enable us to identify "fossil" islands, sometimes thought to be predator-free, "lost paradises" such as, in the Mediterranean basin, the archipelagos of the Abruzzi–Apulia palaeobioprovince inhabited, during the Late Neogene, by the intriguing *Hoplitomeryx* fauna (see e.g. Mazza et al., 2008; van der Geer, 2008; Freudenthal and Martín Suárez, 2010 and references in those papers).

Differences in the body size of closely related insular and continental species of mammals were first described by Foster (1964) as a tendency for rodents (and possibly marsupials) to increase and for artiodactyls, carnivores, and possibly lagomorphs (rabbits and hares) to decrease in body size on islands. Foster (1964), considering factors separately for each mammalian order, was more respective of evidence from extant and extinct insular taxa in comparison with Van Valen (1973), who regarded the tendency as a "rule", which postulates gigantism in smaller and dwarfism in larger species of insular mammals. Indeed, a number of exceptions and departures from the predictions can be found among both extinct and extant endemic mammals of different body size, trophic habits, and phylogenetic affinities. As a result, the "island rule" is still a hotly debated issue among evolutionary biologists. Even recent overviews have presented conflicting points of view, confirming or rejecting the soundness of the "rule". Some authors maintain that it is quite a general principle (e.g. Lomolino et al., 2006; Köhler et al., 2008; Palombo, 2009; Welch, 2009 and references in those papers), others reject the generality of the "rule", saying it would be an artifact of comparing distantly related groups showing clade-specific responses to insularity (Meiri et al., 2008).

Body size of insular mammals results from a combination of biotic and abiotic factors (geographic, climatic and ecological characteristics of the islands, structure of insular communities, biology of the species in question), whose importance could vary on spatial and temporal scales, giving rise to a different body size evolution even in species originated from the same ancestor (e.g. the dwarfed straight-tusked elephants from the Mediterranean islands, Palombo, 2007, 2009).

Evolutionary trends shown by fossils taxa can help us explain causal mechanism of body size modification at a wider temporal scale. The Mediterranean islands and palaeo-archipelagoes - with different phyletic lineages colonizing islands of different size, climate and ecological diversity, as well as multiple populations of the same lineage inhabiting the same islands during different time periods when climatic and ecological conditions (and, in some cases, island area and isolation) substantially differed - provide a noteworthy opportunity to study the causality of body size variation in insular mammals over space and time.

The results obtained provide evidence that, as regards large species and pachiderms (e.g. proboscideans, hippopotamuses and deer), the most dwarfed taxa occur in faunas where no other large herbivores lived, whilst the less miniaturized taxa appeared in more diversified faunas, including or not including predators. Therefore, we could suppose that large species and pachiderms were mostly influenced by ecological release (the more the diversity of competitors and maybe larger predators decreases, the more the body size reduces), and the same can be said for small mammals, as their body size increases in the absence of species larger than the species in question. On the other hand, the body size evolution of the Mediterranean insular mammal seems to have only marginally been affected by the area of the island, while evolution and size of endemic species might be indirectly affected by island physiography and isolation, the latter constraining colonization from mainland. Consequently, we could assume that the body size of non carnivorous insular species mainly results from the nature of competing species, therefore from the peculiar biological dynamics that characterize unbalanced, impoverished insular communities.

Interspecific competition via coevolution, prevents the coexistence of species with overlapping body sizes (see inter alios Brown and Wilson, 1956; Schoener, 1989; Dayan and Simberloff, 1998 and references there in), sometimes triggering adaptive radiation. In a "ideal" mainland community, niches would scale in a predictable way. Since just a few species from these communities can cross a more or less severe barrier to enter islands, the ecological structure of communities might be rebuilt, and newcomers on islands might develop new adaptations that depend on the nature, trophic habit, and size of vacant species. Since body size influences all physiological and ecological processes (e.g. reproductive rate, geographic and home ranges, populations interact ion, evolution and extinction) and, selective pressures vary with body size, we could assume that for each functional body plan and trophic strategy, there is a body size that is optimal/critical for the environmental conditions each species/population is living in (see e.g. Lomolino, 2005 and references there in). Therefore, body size evolution of insular taxa could result from a predictable response to competing differences and the availability of niches between insular and mainland environments. Evolutionary trends in endemic taxa also involved the occupation or creation of novel niches, possibly producing morphologies different from those of their ancestral forms.

On the whole, the ecological interaction could be regarded as a major driver of evolution in unbalanced insular communities, allowing to the optimization of energy balance by means of changes in size. Removing biotic and abiotic environmental constraints, the body size of non carnivorous insular species could converge towards a taxon-specific size allowing the best energetic equilibrium, depending on the intrinsic characteristics connected with their bauplän and trophic strategy. Conversely, body size of carnivorous species mainly depends on the size of the most available prey as well as on the adaptive strategy for a more efficient energy use under the special environmental conditions of insular ecosystems.

Body size evolution of insular mammals is, however, a highly complex phenomenon and the significance of some exceptions cannot be neglected. Further study is certainly required to provide evidence for the causal mechanism driving body size changes of insular mammals, and perhaps support this assumption, but it should be a promising area for future studies on body-size evolution in insular vertebrates.

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THE ENDEMIC BOVIDS FROM SARDINIA AND THE BALEARIC ISLANDS: THE STATE OF ART

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Bovids are unusual components of endemic insular faunas and are only recorded in some Mediterranean and Asian islands (South East Asia and Japan). During the late Miocene, endemic bovids have been reported in the Mediterranean basin from the Tusco – Sardinian palaeobioprovince. In the South of Tuscany, endemic bovids are known in the Tortonian V0-V2 levels of the sedimentary succession cropping out at a number of localities in the Baccinello-Cinigiano basin (Hürzeler & Engesser, 1976; Rook et al., 2006, and references therein), while in Sardinia they were discovered at Fiume Santo (North-Western Sardinia). In Sardinia, at least five Bovidae have been collected in late Tortonian deposits at Fiume Santo, bearing a quite diversified, but notably endemic "*Oreopithecus*" fauna, similar to that known from Southern Tuscany. Bovidae from Fiume Santo possibly belong to at least three tribes: Alcelaphini (*Maremmia* cf. *M. lorenzi*), Neotragini *(Tyrrhenotragus* cf. *T. gracillimus,* Neotragini gen. et sp. indet.), Antilopini? (*Etruria viallii*), plus the small bovid *Turritragus casteanensis*, already identified at Casteani (Baccinello-Cinigiano basin, Southern Tuscany) as *Maremmia haupti* (see Abbazzi et al., 2008a for a discussion), whose systematic affiliation is uncertain due to the absence of skulls and horn-cores, while it shares a few dental features with *Aragoral mudejar* (Upper Vallesian, Spain; see Abbazzi et al., 2008a and references within), a primitive representative of Caprinae (*sensu* Bibi et al., 2009).

Among mammals present in both Fiume Santo and Baccinello-Cinigiano LFAs, the suid *"Eumaiochoerus"* and the alcelaphine *M. lorenzi* are not present in the V0-V1 levels and first appear in V2 (Hürzeler & Engesser 1976), thereby it is rational to suppose that the connection between Sardinia and Tuscany was active during the MN12. This evidence that during the Late Miocene the Tusco-

Sardinian palaeobioprovince came into existence as an isolated region (Rook et al. 2006), possibly an archipelago or a single large island. By the Messinian, an intense tectonic activity caused the uplift of the Apennine mountain chain and led to the dispersal along the emerging chain of European mammalian taxa. Since no new immigrant from Europe, which colonized the southern Tuscany and the temporary emerged lands of Romagna during the MN13, has been found to date in Sardinia, it is rational to suppose that the Sardo-Corsican massif was definitely isolated from Tuscany by the Messinian due to the opening of the Tyrrhenian Sea. A question arises about temporary connections between Sardinia and the European mainland during the Messinian. Indeed, the ancestors of the endemic bovids *Nesogoral* and *Asoletragus,* documented in Late Pliocene-Early Pleistocene Sardinian deposits, possibly entered the island sometime during the Messinian Salinity Crisis (MSC) (5.6–5.32 Ma), because they are not apparently related to the bovids retrieved at Fiume Santo (Palombo, 2009 and references therein).

In the late Neogene and Quaternary, bovids showing highly endemic features were restricted, in the Mediterranean region, to the Balearic Islands and Sardinia (Palombo, 2009; Bover et al., 2010 and references in those papers), whilst bovids relatively reduced in size have also been reported in Late Pleistocene deposits in Sicily (*Bos primigenius siciliae* and *Bison priscus siciliae*) (Masini et al., 2008) and have been claimed on Pianosa (*Bos primigenius bubaloides;* Azzaroli, 1978).

In Sardinia endemic bovids ascribed to the so called "*Nesogoral* group" have been first reported in Capo Figari (northeastern Sardinia) (see Gliozzi & Malatesta, 1980 and references therein) and in breccias deposits dated at about 1.807.500 ± 20% years B. P (van der Made, 1999; Palombo, 2009). Bovid remains have then been reported from other Late Pliocene - Early Pleistocene sites on the island, such as Mandriola (*Nesogoral* sp., Van der Made, 1999) and Capo Mannu (*Nesogoral* sp. and bovid remains of small size which do not fully conform to the morphology of *Nesogoral* spp., Abbazzi et al., 2008b) (central-western Sardinia), Monte Tuttavista (eastern Sardinia) (at least two genus and three species, Palombo et al., 2008 and references therein) and from a unknown locality in the Campidano area (southwestern Sardinia) (*Nesogoral cenisae,* Van der Made, 2005).

The richest sample comes from Monte Tuttavista where more than 1500 bovid specimens have been collected from 9 karstic fissures. The preliminary analysis of cranial specimens from three fissures ("VI-3; X-ghiro; XI-antilope") shows the presence of different morphotypes and demonstrates that more than one taxon occur in the same fossiliferous deposits (Abbazzi et al., 2004). A partial skull from fissure "VI-3" was assigned to the new genus and species *Asoletragus gentry* (Palombo et al., 2006a). This bovid differs from other genera thus far known in the Mediterranean region in having straight, almost conical, horn-cores, closely inserted, slightly divergent and strongly inclined backwards (about parallel to the glenoid surface of the temporal bone). The peculiar shape and position of horn-cores make phylogenetic relationships with Neogene European bovids difficult to ascertain. Among the other skulls, two morphotypes could be ascribed to as many species within the genus *Nesogoral* (morphotype A = *Nesogoral* sp. 1 aff. *N. melonii* and morphotype B = *Nesogoral* sp. 2 in Abbazzi et al., 2004). Different morphotypes have also been recognised in teeth, mandibles and postcranial bones, but relating them to the respective skull morphotypes is extremely difficult (Palombo, unpublished data). Attributig the material more recently discovered at Monte Tuttavista and the revision of other Sardinian fossil bovids, systematics and phylogeny of the bovids previously ascribed to the genus *Nesogoral* will remain hypothetical.

On the Balearic islands six chronospecies belonging to the *Myotragus* phylogenetic lineage have been described, spreading from the Early Pliocene to the Holocene (Bover et al., 2010 and references therein): *Myotragus palomboi* (earlier Early Pliocene), *M. pepgonellae* (Early/Middle Pliocene), *M. antiquus* (latest Middle Pliocene), *M. kopperi* (latest Pliocene/Early Pleistocene), *M. batei* (Early/Middle Pleistocene) and *M. balearicus* (Middle Pleistocene to Holocene). *M. balearicus*, the terminal species of the lineage, survived on Mallorca and Menorca presumably until the first human arrival, i.e. 4300–4200 years ago (Alcover, 2008). Two species are recorded on Menorca, *Myotragus balearicus* and a second one from an Early Pleistocene deposit described as *M. binigausensis* (see Bover & Alcover, 2000and Moyà- Solà et al., 2007 for a discussion). On the island of Eivissa ('Ibiza'), two bovids (a very hypsodont and small-sized Antilopini, and "Caprinae" with short metapodials) have been identified in the Late Miocene/Early Pliocene deposit of Ses Fontanelles, (Moyà-Solà et al., 1999).

Myotragus palomboi, recently described on remains found at the Early Pliocene site of Caló den Rafelino (Mallorca) (Bover et al., 2010), represents the earliest record of the genus and the first representative of the *Myotragus* phylogenetic lineage. Since no bovid remains are known from the Middle Miocene of the Balearic Islands, the ancestor of Balearic lineage presumably reached the Mallorca island thanks to a temporary and selective connection during the MSC (see Bover et al., 2010 and references therein).

Some remarkable similarities can be traced not only between the metatarsal of *M. palomboi* and the metacarpal of a unidentified bovid from Baccinello figured in Abbazzi et al., 2008a, but also between *Myotragus* and both *Aragoral* (Upper Vallesian, MN10) and *Norbertia* (Turolian–Ruscinian boundary, MN13/14) , displaying robust metapodials, weak upper premolar styles and reduced p2, and so eligible as putative ancestors of the Balearic genus (see Bover et al., 2010 for a discussion).

For decades, a close phylogenetic relationship between *Nesogoral* and *Myotragus* has been widely accepted by scholars (see e.g. Gliozzi & Malatesta, 1980; Palombo et al., 2006b). Nonetheless, differences in the proportion and in the features of limb bones (especially metapodials; see Rozzi, 2010 unpublished dissertation) make the hypothesis that bovids from Balearics and Sardinia do not derive from the same ancestor reasonable.

Despite their morphological and dimensional variability, metapodials of Sardinian bovids were more or less elongated, sometimes also quite slender with respect to continental caprines, especially *Myotragus*. Moreover Sardinian bovids seem to have had long limbs as in animals having speedy gait. Accordingly, Balearic and Sardinian bovids optimized costs of their peculiar locomotion by way of opposite limb proportion: *Myotragus* acquired a slow, powerful walking gait by reducing limb length, while Sardinian bovids possibly preserved (if not developed) long leg bones and a cursorial aptitude. Therefore, the focal point to interpret the patterns of bovid evolution in Sardinia and Balearic Islands seems to have been the occurrence in Sardinia of a top predator, *Chasmaporthetes melei*, found in the Early Pleistocene deposits of Monte Tuttavista (Rook et al., 2004), that must have conditioned the biotic dynamics of Sardinian faunas as well as bovid evolution. Since hyaenids and bovids cannot either swim or float easily, it is rational to suppose that both the ancestors of hyaena and bovids did not colonise Sardinia overseas or by sweepstake dispersal but, most likely, reached the islands sometime during the MSC (see Palombo 2009 and reference therein).

It is challenging to evaluate the actual meaning of the morphological resemblances between the skulls and the horn-cores of *Myotragus* and *Nesogoral* (Palombo et al., 2006b), as the distinction between synplesiomorphic features and homoplasies remains ambiguous. Similar difficulties have been faced when trying to investigate the phylogenetic relationships of *Asoletragus* (see Palombo et al., 2006a), whose horn-cores are notably different from those of *Nesogoral* specimens.

Further findings and work are necessary in order to understand the systematics of insular Mediterranean bovids and the evolutionary patterns on Sardinia and the Balearic islands.

All in all, available data indicate that the peculiar features of Balearic and Sardinian bovids are the result of evolution, which took place in two different island ecological systems, characterized by different inter and intra-guild selection pressures: on the one hand, the more diversified environment of Sardinia, as well as the presence of other large mammals (similar-sized competitors belonging to the same guild and a carnivore), increased the interspecific competition, forcing Sardinian bovids to exploit different resources and to occupy different niches; on the other hand, *Myotragus* exploited the supply of resources available for large herbivores on the Eastern Balearic Islands under a monopoly regime (see e.g. Palombo et al., 2006b; Bover et al., 2010).

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TERTIARY EVOLUTION OF THE APULIA PALEOGEOGRAPHIC DOMAIN

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Apulia is a carbonate platform domain which during the Mesozoic was part of a complex platform-and-basin system a palinspastic reconstruction of which is provided in Figure 1.

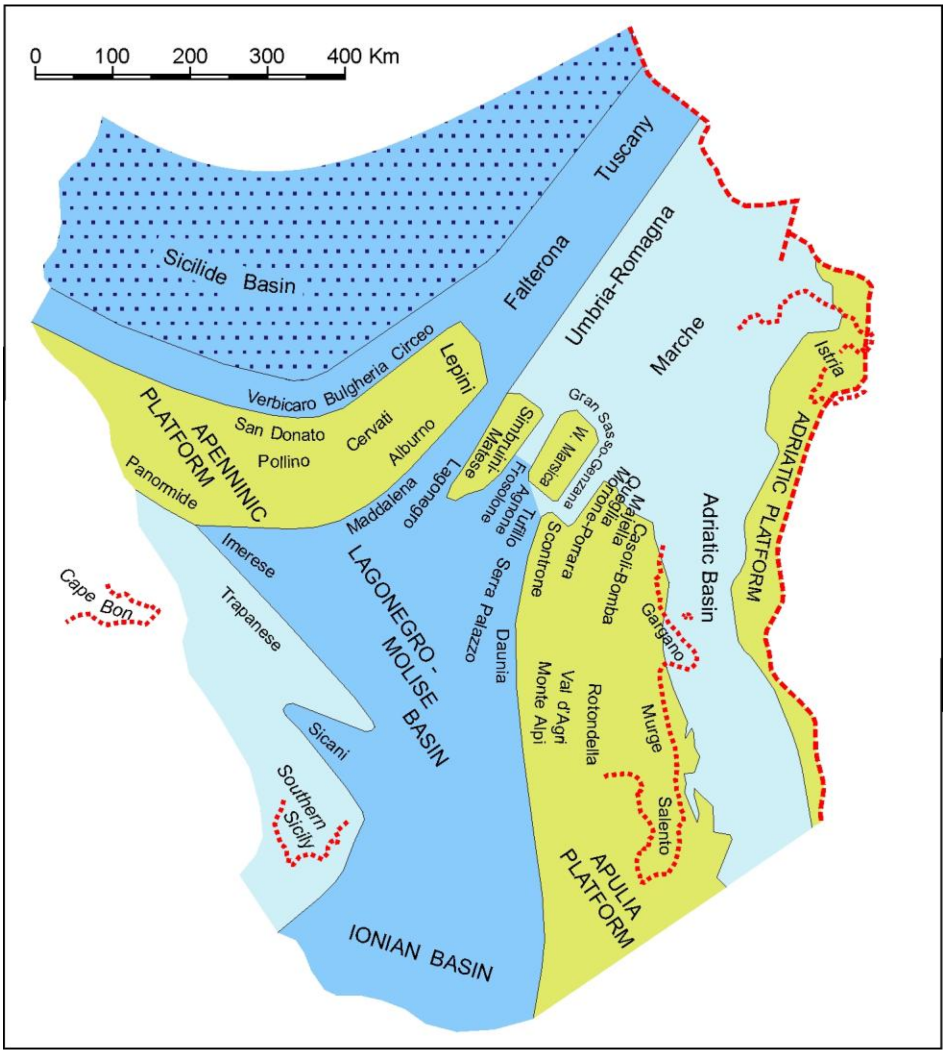

Figure 1. Palinspastic restoration of the Apulia Platform and surrounding platform-and-basin system in late Jurassic times (about 150 Ma). Green areas are Bahamian-type carbonate platforms separated by more or less deep basins (dark blue and light blue, respectively). The Sicilide and Lagonegro basins are supposed to have been floored, at least in part, by oceanic crust.

Apart from the deep-marine seaways of Lagonegro in the Apennines and of Budva-Pindos in the Dinarides-Hellenides (the latter out of the represented region), which are both related to middle Triassic tectonic events, the bulk of the platform-and-basin system in the peri-Adriatic region set up as a consequence of a lower Jurassic extensional tectonics that dissected an original upper Triassic-lower Liassic shallow epeiric area. During the Jurassic and during the greatest part of the Cretaceous, the peri-Adriatic platforms grew as isolated Bahamian-type carbonate platforms surrounded by basinal realms. Around the end of the Cretaceous the platform edge turned into a carbonate ramp characterized by overall prograding internal geometries. The new physiographic configuration of the platform-and-basin system brought to a paleogeography more articulated than the previous one, strongly influenced by global sea level changes. During sea-level drops widespread seaward progradation of shallow-water carbonates over deeper-marine deposits determined an enlargement of the shallow-marine/subaerial areas and favoured connections between the previously isolated platforms.

Starting from the early Miocene, the platform-and-basin depositional system underwent severe compressional deformation and was progressively incorporated into the Apennine and Dinaride-Hellenide thrust belts. Figure 2 shows the spatial distribution of the platform and basins in the undeformed (or slightly deformed) foreland areas, as well as the distribution of the platform-derived and basin-derived tectonic units in the Apennines, Dinarides and Hellenides.

The portion of the Apulia Platform that has escaped tectonic shortening forms today a segment of the foreland of the peri-Adriatic mountain chains about 700 kilometres long and up to 250 kilometres wide. The original transition between the Apulia Platform and the adjacent Adriatic Basin is preserved in offshore for about 450 kilometres between Central Italy and Southern Albania. The geology of this area is well known thanks to the extensive petroleum exploration. A short segment of this platform-to-basin transition crops out in the Gargano Promontory. In addition, the transition from the platform to the basin in its northern portion is preserved, in some cases with spectacular expositions (Scontrone, Morrone, Majella) in the Central Apennines. In the Southern Apennines, the deformed Apulia carbonates form a buried duplex system that extends toward the west as far as the Tyrrhenian coast beneath a stack of rootless nappes.

From the latemost Cretaceous to the Miocene until the early Messinian, the Apulia Platform was not significantly influenced by tectonics and its paleogeographic evolution was entirely controlled by climate conditions and by global sea-level changes. The sedimentary record evidences several disconformities separating different depositional sequences. In the most continuous sections (e.g. northern Majella), major gaps fall in the Paleocene (Danian and great part of the Selandian), early Eocene (Ypresian), middle Eocene

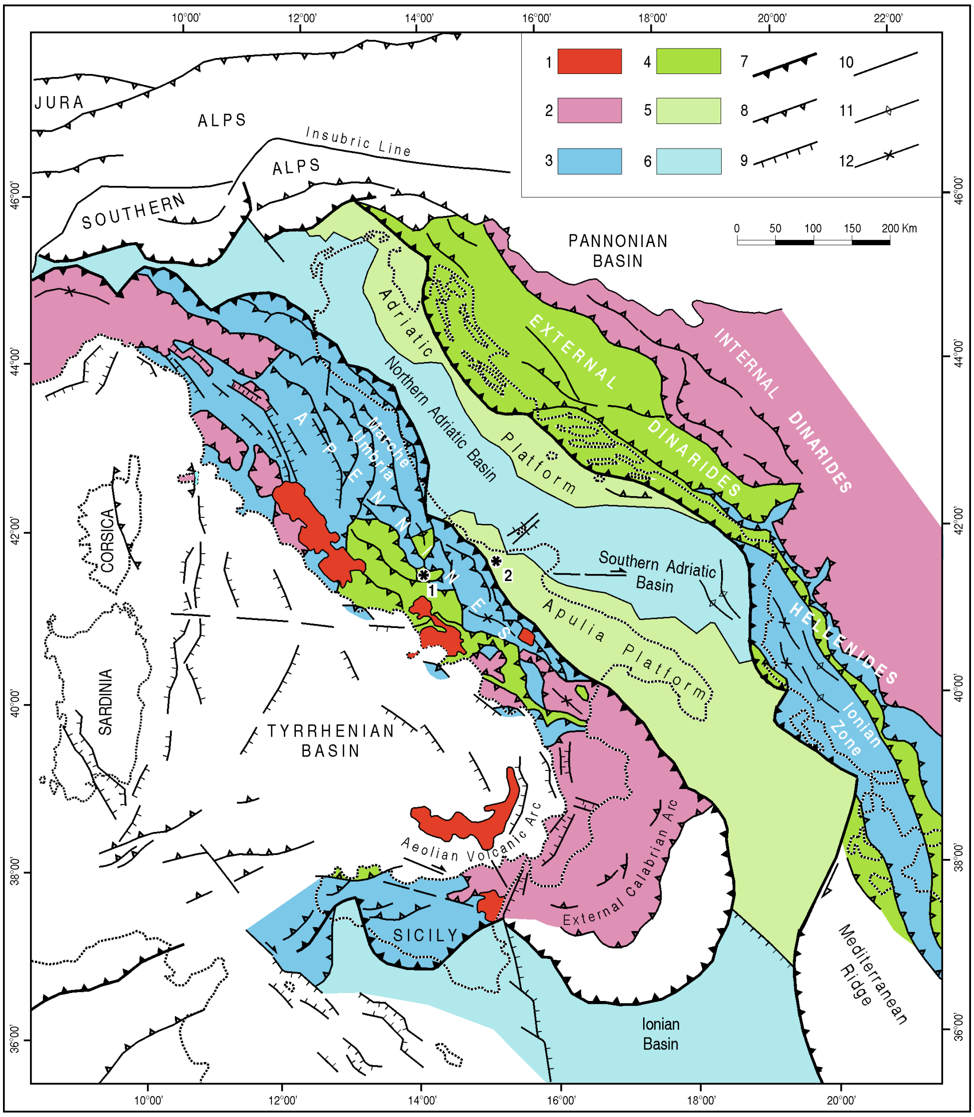

Figure 2. Tectonic lineaments of the peri-Adriatic region with the distribution of the platforms and basins in the foreland areas and the distinction between platform-derived and basin-derived tectonic units in the Apennines and Dinarides. Asterisks indicate the Scontrone (1) and Gargano (2) fossil sites. 1 Major subaerial Quaternary volcanoes. 2 Undifferentiated internal units of the Apennines, Calabrian Arc and Dinarides-Hellenides. 3 External units of the Apennines, Sicilian Maghrebides and Dinarides-Hellenides chiefly represented by Mesozoic-Tertiary basinal and pelagic carbonate sequences. 4 External units of the Apennines-Sicilian Maghrebides and Dinarides-Hellenides chiefly represented by Mesozoic-Tertiary shallow-water carbonate sequences. 5 Foreland areas characterized by Mesozoic-Tertiary basinal and pelagic carbonate sequences. 6 Foreland areas characterized by thick Mesozoic-Tertiary shallow-water carbonate sequences. 7 Front of the Sicilian Maghrebides, Apennines, Alps, Southern Alps and Dinarides-Hellenides. 8 Major thrusts. 9 Normal faults. 10 High-angle faults, mostly strike-slip faults. 11 Anticline axis. 12 Syncline axis.

(top Lutetian and Bartonian *p.p.*), Oligocene around the Rupelian-Chattian boundary (29 Ma "Mid-Oligocene" unconformity), early Miocene around the Aquitanian-Burdigalian boundary and finally in the Tortonian. In the westernmost areas of the Apulia Platform, where the hiatus reaches the maximum amplitude, lower Messinian shallow-ramp limestones directly overlie deeply karstified lower Cretaceous carbonates. In some places, a horizon of "terra rossa" deposits is present at the base of middle-upper Miocene limestones which unconformably overlie uppermost Cretaceous or Paleocene-Eocene ramp carbonates.

In the early Messinian the western margin of the Apulia Platform underwent flexural subsidence and became part of the Apennine foredeep basin. This tectonic evolution is documented by the flysch deposits of Scontrone that conformably cover hemipelagic marls with *Turborotalia multiloba* lying on top of the Tortonian-Messinian *Lithothamnium* Limestone Formation. Starting from this moment, the Apulia Platform was progressively involved in the time-space migration of the thrust belt-foredeep-foreland system and huge volumes of Mesozoic-Tertiary carbonates referable to several paleogeographic realms from Scontrone to Majella were scraped off from their original substratum and were incorporated in the mountain chain. The forward migration of the compression front, which lasted from the early Messinian to the early Pleistocene, is very well documented in the Abruzzi region by surface sections exposed between Scontrone and Majella (Apulia-derived thrust sheets) and in the other Central-Southern Apennine regions by numerous commercial wells that have reached the Apulia Platform beneath the allochthonous sheets.

FOSSIL BIRDS FROM THE NEOGENE OF THE GARGANO (APULIA, SE ITALY)

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The Gargano area (Apulia, SE Italy) has been known for a long time for its vertebrate assemblages found in fissure fillings in the numerous limestone quarries of the Apricena area, on the West edge of the Gargano promontory. The vertebrate assemblages, particularly the mammals, are well studied (Abbazzi et al., 1996), as also the geology of the quarry district (Pavia et al., 2010). The fossil remains can be separated in two different associations, one of the Neogene (MN 13-15) (Freudenthal, 1971) and the other one of the Early Pleistocene (De Giuli et al., 1986). In the latter one some lithic artefacts testifying the early human presence into Europe have been found (Arzarello et al., 2007). Fossil bird remains have been found in both associations. The present analysis deals with that found in the Neogene fissure fillings. It has already been studied by Ballmann (1973, 1976). Here we present the revision of the material, already presented by Ballmann, but also new and unpublished bird material. The new material comes from the collections of the Nationaal Naturhistorische Museum of Leiden (The Nederlands), the Dipartimento di Scienze della Terra of the University of Firenze (Italy), the Museo di Geologia e Paleontologia of the University of Torino (Italy) and the Naturmuseum Augsburg (Germany).

The new unpublished material almost doubles that previously seen by Ballmann and now the fossil bird remains from the various fissure fillings of Gargano are more than 1100. Following Ballmann, (1973, 1976), the bird association of the Neogene of Gargano contains 16 taxa, in particular *Garganoaetus freudenthali*, *G. murivorus*, *Palaeortyx grivensis*, *Tyto sanctialbani*, *T. robusta*, *T. gigantea*, *Strix*? *perpasta*, *Columba omnisanctorum*, *Apus wetmorei* and a few other taxa not determined at specific level. These analyses of Ballmann revealed the presence of several new endemic extinct species, testifying the high degree of isolation of the Gargano area during the Late Miocene and Early Pliocene. The present analysis of the new material confirms the species described by Ballmann, but in some cases, the new material allows an amelioration of the description of their osteological characteristics and new taxa can be added to the bird association.

The final results of the analysis reveals 12 new taxa, here presented in a preliminary way: Treskiornithidae indet., *Anas* cf. *A. velox*, a small sized Accipitridae, two species of Rallidae, Otitidae n. gen. et n. sp., two species of Charadriiformes, *Athene* sp., *Strix* n. sp., Coliidae indet. and Corvidae indet.; some of these taxa have already been found, but not determined at specific level, by Ballmann. At this point the faunal list of the Gargano fossil complex comprises at least 26 avian taxa. Our study also changes some of his determinations, in particular, the remains formerly attributed to *Palaeortyx grivensis* actually represent the new species *Palaeortyx volans* (Goelich & Pavia, 2009 VER), and *Tyto sanctialbani*, later on attributed to *Tyto balearica* (Mlíkovský, 1998), actually belongs to another undescribed taxon (Pavia & Mourer-Chauvirè, in press). The new material also gives the opportunity to improve the osteological description of both *Tyto robusta* and *Tyto gigantea* and to confirm their taxonomic validity as separate species, and not as a single one under *T. gigantea*, as suggested by Mlíkovský (1998). Some of the newly detected avian taxa are not strictly endemic and they allow to better correlate the Gargano with other European localities from a chronological and biogeographical point of view.

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CHANGING MIOCENE FAUNAL COMPOSITION AS INDICATOR FOR MARINE MIGRATION PATHWAYS BETWEEN THE CENTRAL PARATETHYS AND THE MEDITERRANEAN

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The reconstruction of terrestrial (palaeo)biogeography and related vertebrate migration pathways is intimately connected with the distribution of larger aquatic areas. Oceans, inland seas and vast lakes significantly influence and limit migration of land organisms. This very general aspect also applies for the Central European Miocene where the early Mediterranean Sea as well as the Paratethys Sea and its relict, Lake Pannon, represent vast water bodies. These basins show a complex sequence of interconnection and isolation creating various aquatic pathways on one hand and landbridges on the other.

The Paratethys is a northern appendage of the early Mediterranean Sea and spanned a north-south gradient of at least 4° latitude. It is considered to represent some kind of "palaeothermometer" reflecting slight expansions or restrictions of climatic belts. Due to its vulnerable marine connections it was also highly susceptible to major (global) sea-level fluctuations which are reflected in phases of endemism. Hence, a fairly continuous record of marine nearshore assemblages throughout the Miocene reflects an extraordinary interplay of sea-level fluctuations, changes in climate, immigrations, and blooms in autochthonous elements. Some of these changes enabled a biostratigraphic application of the faunal patterns and led to the establishment of a Paratethyan chronostratigraphy differing from those of the Mediterranean. This marine biostratigraphy of the Central Paratethys serves as stratigraphic backbone and control for continental stratigraphy. The frequently changing seaways between the Paratethys and the Mediterranean and the resulting high degree of endemism make, however, correlation between the two basins arguable. More recently, the integration of additional stratigraphic methods such as magnetostratigraphy, sequence stratigraphy and cyclostratigraphy allow a more precise correlation.

While biostratigraphic implications of faunal patterns were recognised early in Paratethyan research, a biogeographic model has been developed only more recently. The intermingling of palaeogeographic terms with those restricted to biogeography is still commonly used - a situation which can be overcome by integrating data from different biota into a consistent palaeobiogeographic scheme. A dataset of 1809 species-level taxa (Gastropoda and Foraminifera) serves as the base for interpretations. Gastropods in particular turned out to be of greatest value for the differentiation of palaeobiogeographic units due to sensitive reactions to all environmental parameters and occupying a wide range of ecological niches. Based on the excellent gastropod record the Proto-Danubian Province, Early Danubian P., Danubian P., Balatonian P. and a Proto-Caspian Subprovince have been defined. These biogeographic units are the result of five major biotic events within the gastropod faunas. These "big five" comprise four extinctions – the late Ottnangian extinction event (LOEE), the mid-Badenian-extinction-event (MBEE), the Badenian–Sarmatian-extinction event (BSEE), the Sarmatian–Pannonian-extinction event (SPEE) – and one exceptional immigration/origination event termed the early Badenian Build-up event (EBBE). Foraminifera are less valuable for palaeobiogeographic purposes. Endemisms are generally lower and turn-over rates less dramatic. They are, however, very useful for stratigraphic correlations with the Mediterranean and Atlantic areas.

PHYLOGENETIC RELATIONSHIPS OF GENUS *STERTOMYS* (GLIRIDAE) FROM THE "TERRE ROSSE" FISSURE FILLINGS (GARGANO, APULIA)

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Stertomys is an endemic genus of Gliridae commonly found in the Late Miocene "Terre Rosse" fissure fillings from Gargano (southern Italy). The taxonomy of this genus have been recently reconsidered and, up to date, five new species have been described beside the giant *Stertomys laticrestatus* Daams & Freudenthal 1985. The species have different biochronological range and may be assigned to two groups according to their size and complexity of the dental pattern. The smaller and morphologically simpler group includes *Stertomys simplex* Martín-Suárez & Freudenthal 2007, *Stertomys daamsi* Freudenthal & Martín-Suárez 2006 (occurring in the older fissures) and *Stertomys degiulii* Rinaldi & Masini 2009, while the larger and more complex one takes *Stertomys lyrifer* Martín-Suárez & Freudenthal 2007, *Stertomys daunius* Freudenthal & Martín-Suárez 2006 (occurring in the older fissures) and *S. laticrestatus*. These two informal groups have been considered also as representing two distinct phylogenetic branches deriving from a common ancestor. Phylogenetic relationships among those species and their possible continental ancestor, however, have never been investigated in detail.

In this contribution we presents the results of a parsimony phylogenetic analysis performed using PAUP software. The six *Stertomys* species have been considered together with several other related glirid taxa, distributed over a rather wide geographical and stratigraphical range, with the aim to verify if *Stertomys* is a monophyletic taxon and to identify its possible relationships with continental taxa, thus bringing some new contribution to the still open question of the ancestry of this endemic taxon.

NEW DATA ON THE GARGANO (APULIA) CRICETIDS FROM THE MIOCENE "TERRE ROSSE"

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The Gargano "Terre Rosse" deposits are paleokarst fissure fillings in Mesozoic limestone in quarries in the area Apricena-Poggio Imperiale (Apulia, southeastern Italy). They yielded Late Miocene-Early Pliocene faunal remains which depict a complex history of endemic faunal distribution and development, possibly in a paleoarchipelago. These fossils contributed substantial evolutionary and paleogeographic information.

Terre Rosse cricetids had been studied originally in the 1980s. Three endemic species were then described: the small-sized *Hattomys beetsi*, the dimensionally intermediate *Hattomys nazarii*, and the large-sized *Hattomys gargantua*.

The results of a detailed morphological and odontometric analysis of cricetid teeth stored in the Department of Earth Sciences of the University of Florence are presented and discussed. Five fissures (F15, F21a, F21b, F21c, F1, F9) were selected from the available biochronological schemes, and an unpublished fissure "Nazario Bivio Sinistra" has been added for a more comprehensive view of the Gargano cricetid evolution.

In line with previous reconstructions, the endemic cricetids show a remarkable increase in size through time. Specimens from fissures F15 and F21a, b and c have been attributed to the small *H. beetsi*, those from Nazario Bivio Sinistra to *H. nazarii*, and those from fissures F1 and F9 to the larger *H. gargantua*. The morphological variations include the tendency of the teeth to increase the thickness of the enamel, whereas the cusps assume a carved-in aspect. Morphologically, the three species likely belong to the same lineage.

AFRICAN NEOGENE MAMMALS IN THE MIDDLE EAST: WAYS AND WHYS

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The Middle East has a particular geography being situated in the cross-roads between the three continents of the Old World. In paleogeographic evolution of the Old World, this region underwent important changes because of northeastern drift of the Afro-Arabian plate towards Eurasia, and the consequent progressive closure of the Neotethyan Ocean. Thus, the Middle East became situated on the suture zones between these landmasses, playing the function of bridge for terrestrial faunal exchanges between the southern and northern continents. In this contribution, only the occurrence of land mammals originated from the Afro-Arabian plate in the Middle East will be discussed. We are aware that the migration of some mammals from Eurasia to Africa is also a key point contributing to the understanding of the time and modalities of the terrestrial exchanges and the related tectonic, paleogeographic and climatic events. This second question is out of the scope of the present contribution.

The Afro-Arabian landmass became isolated from Albian up to the Aquitanian (Tabuce & Marivaux, 2005; Gheerbrant & Rage, 2006). This is proved by the great endemic character of African vertebrate faunas dated to this interval of time. However, it is now well accepted that some sporadic exchanges occurred in early Paleogene, in particular during Late Paleocene and Early-Middle Eocene between these two continents, rather from Eurasia to Africa than on the other side. In this context, the occurrence of rodents and primates in the Eocene of Africa is explained as a consequence of Late Paleocene – Early Eocene migration of these groups from Asia (Marivaux et al., 2002; Jaeger & Marivaux, 2005). On the other hand, some apparently African taxa migrated to Eurasia, at least an Embrithopoda to Turkey and to Romania (Sen & Heintz, 1979; Radulescu & Sudre, 1985; Maas et al., 1998).

Up to today no Oligocene "African" mammal has been discovered in the Midlle East. However, Antoine et al. (2003) discovered a primitive proboscidian tusk fragment in the Early Oligocene of Pakistan. It is to be noted that despite five years of paleontological research and excavation in Oligocene deposits of Anatolia, no mammal with African affinities was recorded. The available data led to conclude that a major physical and/or climatic barrier existed during

Oligocene separating mammalian communities of Afro-Arabian plate from these of Eurasia.

In late Early Miocene, the settlement of a terrestrial connection between the Afro-Arabian and Eurasian landmasses across the Middle East considerably modified the composition of mammalian communities on both sides of the "bridge". In this playground, the Middle East was the first terrain where the impact of this event is recorded with the occurrence of mammals originated from Africa (proboscideans and rodents). It is important to note that during the Early Miocene, the Eurasian distribution of these mammals remains limited to this area.

From the Early Miocene upwards, mammalian faunas from the Middle East include some elements of African affinities. The number of these "African" species and their abundance in the fossil record vary in time and space. Such fluctuations are usually related to some climatic and paleogeographic parameters and it is necessary to determine and measure their degree of impact on the occurrence of these "foreigner components" of mammalian faunas in the Middle East. It is obvious that their occurrence as well as their abundance in this region were controlled by some external physical factors rather than by paleocommunity competitions (Pickford & Morales, 1994; Pickford, 1997). Paleogeography of the Middle East as well as the latitude and the width of climatic belts underwent important changes during the whole Cenozoic. How can we measure their relative impact on mammalian migration and the occurrence of "African" mammal in the Middle East?

In this presentation, firstly, the status of supposedly « African » species is discussed under the light of the recent discoveries of related taxa in Eurasia and Africa. Secondly, the number of species with African affinities in the territories from the Balkans to Afghanistan is calculated per MN unit, and presented as a graph. Thirdly, their abundance per MN unit is calculated by using their occurrence in localities of the same territories. In conclusion, and this is the main aim of the present study, the relationships between the occurrence and the frequency of mammalian taxa exhibiting African affinities with the paleogeographic evolution of the region and with the north-south fluctuation of climatic belts during the Neogene times are discussed.

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AMONG OTHER ISLANDS: GARGANO!

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The fissure fillings of the Gargano Peninsula have yielded collections of peculiar animals, testament to the period in which Gargano was an island. Not only does the fauna exhibit the typical characteristics of insular evolution, but the presence of so many localities of different ages allows us to follow the development of the fauna, such as the divergence of the different lineage of the giant rat *Mikrotia*. The unique situation of having richly fossiliferous localities of various ages on a Miocene palaeoisland makes Gargano unique.

At the same time, the evolutionary processes that we witness on Gargano are part of a familiar picture. The same processes can be observed in fossil island vertebrate faunas all over the world, though these are generally known from only a few localities. In order to understand these processes we need to compare the different insular faunas.

Starting at Gargano, this lecture will take you on a trip across the globe, in an attempt to link the observations from the Italian palaeo-island to the phenomena observed on Crete, Flores, the Baleares and many other islands.

LATE PALEOGENE AND NEOGENE FOSSIL FISHES OF ARMENIA

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Armenia is situated in the Lesser Caucasus, between Europe and Asia, in central part of Alpine-Himalayan belt. The territory of Armenia is rich on fossil remains of vertebrate fauna of Paleogene and Neogene ages. In spite of abundant vertebrate, specially fish fauna remains from these localities, the palaeontological studies were very sporadic and rare. Several new taxa were either described (Bogachev, 1936; 1962; Vladimirov, 1946; Pipoyan & Gabrielyan, 2003; Pipoyan, 2003) or the presence of "some fish/vertebrate remains" was only mentioned (Bogachev, 1938; Gabrielyan, 1964; Gabrielyan et al., 1958; Rukhkyan, 1989; Melik-Adamyan, 2003; etc.).

The study on Late Paleogene and Neogene fish fauna of Armenia is of special interest, because starting from this time the territory of the Republic began its continental development (Alsanyan, 1958; Sayadyan, 2009). During this time, the territory of Armenia both subsided and uplifted. The former caused sea expending and the latter sea retreating. These movements continued repeatedly, however there were also some land parts on the territory of Armenia. Later in the Late Miocene, the brackish influenced inland water body completely disappeared. After a short period of erosion, freshwater sedimentation started (Aslanyan, 1958; Sayadyan, 2009; Steininger et al., 1985; Popov et al., 2004).

Development of Late Paleogene and Neogene fish fauna is closely related to the orogenesis of the Caucasus in the Pre-Oligocene time, which caused the uplift of the earth's crust and emergence of a landmass in the southern part of Armenia, as a part of Balkanian-Anatolian-Iranian archipelago, connecting Asia with Europe. In this landmass during the Oligocene (till early Miocene?) existed a freshwater lake. *Palaeoleuciscus macrocephalus, Enoplophthalmus* cf. *alsaticus, Prolebias armeniacus* and Perciformes gen. et sp. indet. are found from the sediments (Dilijan suite) of this lake. Occurrence of anadromous – *Enoplophthalmus* cf. *alsaticus,* brackish water species *Prolebias armeniacus* and ? Perciformes gen. et sp. indet. shows presence of connection between this lake and the Maikopian marine basin of the Kura depression.

During the Early and Middle Miocene the tectonic movements in Armenia were continuing, as a result in the central and southern parts of Armenia a landmass arose and the marine basin desalinated. From the sediments of this desalinated palaeoreservoir (Hoktemberyan Suite) on the south-western part of Armenia *Chondrostoma* sp., Percidae gen. et sp. indet., as well as Gobiidae gen. et sp. indet. are revealed. Discovery of *Chondrostoma* from the Early and Middle Miocene of Armenia is the oldest record of the genus. Gobiidae gen. et sp. indet. probably reached this reservoir from the East, from the marine basin of the Kura depression and formed here "freshwater" forms.

During the Sarmatian s.l. the Central Armenia subsided, which caused sea expending and formation of Yerevan marine basin (Hrazdan suite). The fish fauna in the clay and limestone sediments from localities of Hrazdan suite (late Middle and early Late Miocene (Sarmatian s.l./Bessarabian)) contains "herrings" similar to *Clupea ventricosa* and *C. lanceolata* (Bogachev, 1938), *Prolebias mutilus*, *Prolebias* sp., *Atherina schelkovnikovi* (Bogachev, 1936), *Alosa* sp. and *Aphanius yerevanicus*. It is significant, that the beds with *A. yerevanicus*, *Prolebias* sp., *P. mutilus* and *Atherina schelkovnikovi*, do not contain *Alosa* sp., and contrariwise. The first four taxa are recognized in coastal and brackish/euryhaline habitats, as well as in lagoons and in land-locked bodies of freshwater. *Alosa* inhabit, generally, in the pelagiac zone. Based on the above mentioned, we can conclude that during Bessarabian the coastline and/or the depth of Yerevan marine-brackish basin changed.

From the latest Miocene, when the final uplifting stages of modern territory of Armenia occurred, freshwater bodies in the North-Western Armenia appeared. From here (Voghjaberd suit?) *Chondrostoma* sp. (Mays), *Pseudophoxinus* vel *Delminichthys* sp. and Leuciscinae gen. et sp. indet. (Mays) are known. These fishes are significant for permanent water body – lake with the system of slow flowing rivers with marshland banks. *Pseudophoxinus* vel *Delminichthys* sp. is an interesting species considering its palaeobiogeography of the Eastern Anatolia and the Lesser Caucasus. The species of these genera are not documented from the basin of the Kura and Arax Rivers, to which the modern hydrological network of Armenia belongs.

In the eariest Pliocene (Nurnus locality), in the Central Armenia *Barbus* sp. and *Alburnus* sp., as well as for the first time marsh frog *Pelophylax* cf. *ridibundus* (Melik-Adamyan, 2003) appeared. These are the first genera of recent fauna of Armenia appearing in the fossil record.

There are other fossil localities Koturvan, Dzorakhbyur, Jradzor (ex. Gelaysor) of Pliocene age, where fish fossil remains are present. In Koturvan locality a single taxon, Leuciscinae gen. et sp. indet. is found, while in Dzorakhbyur *Alburnus gambariani* and *Leuciscus oswaldi* are known. The palaeofauna from Jradzor consists of cyprinids including four taxa *Leuciscus* sp., *Leuciscus* cf. *souffia*, *Capoeta* sp., *Garra* cf. *rufa* and a marsh frog *Pelophylax* cf. *ridibundus*. *Garra* cf. *rufa* from Jradzor is the first fossil records of this recent genus.

The Pleistocene (Quarternary) of Armenia is significant for the high volcanic activity. During this time in the Southern Armenia a Palaeovorotan lake system formed (Sisian suite) with an area of 80 km^2. The fossil fauna of the Sisian suite consists of *Salmo* cf. *trutta*, *Alburnus sisianensis* and *Pelophylax* cf. *ridibundus*. From the oldest sediments of this suite (< 1.3 mln) a single skeleton on *A. sisianensis* is found, in the overlying sediments (1.3-0.9 mln, pers.com. A. Bruch) large amount of *Salmo* cf. *trutta* and a complete skeleton of *Pelophylax* cf. *ridibundus* are found. The majority of *S*. cf. *trutta* remains are represented by a disarticulated skeleton and isolated vertebrae and scales. These records of *S*. cf. *trutta* indicate the presence of lakes and fast flowing (mountainous) rivers, where they could be inhabited during their whole life. *Salmo* cf. *trutta* from Sisian suite is the oldest fossil record of this species.

There are several ideas on the origin of salmonid fishes (Berg, 1949; Rukhkyan, 1989). Rukhkyan (1989) considered Ponto-Caspian basin as one of the speciation centre for salmonid species, namely brown trout (*Salmo trutta*) and its subspecies. Evidence from the present study greatly supports this idea.

From the clay sediments of Pleistocene age locality from Northern Armenia a pharyngeal tooth of *Capoeta* sp. has been found.

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PALAEOBIOGEOGRAPHY AND PALAEOCLIMATIC SIGNIFICANCE OF EURASIAN CENOZOIC GIANT SALAMANDERS – CRYPTOBRANCHIDAE (CAUDATA: AMPHIBIA)

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Cryptobranchids are the largest living amphibians (up to 2 m). These paedomorphic basal salamanders are known since the Middle Jurassic (Gao & Shubin, 2003, Frost et al., 2006). The two living genera with 3 species from North-America (*Cryptobranchus alleganiensis*) and East-Asia (*Andrias davidianus, Andrias japonicus*), can be regarded as living fossils, as extinct cryptobranchids show little morphologic change over the last 160 myrs (Gao & Shubin, 2003).

Both living Asian species are strictly aquatic amphibians and confined to clear, well-oxygenated, cold mountain streams and rivers. However, it seems probable that the original Holocene distribution include also lowland rivers (Thenius 1954) from which these animals today are missing probably due to increased human hunting pressure.

Palaeobiogeography: Cenozoic fossil giant salamanders are known from Eurasia with four or five genera and five or six species from 60 localities, ranging from the Late Paleocene to the Late Pleistocene (Böhme & Ilg, 2003). The first Cenozoic cryptobranchids appeared in the latest Paleocene of S-Mongolia (*Aviturus exsecratus* and *Ulanurus fractus*). Then, they are present in the Middle-Late Eocene of the Central Asian Zaissan Basin (SE-Kazakhstan, *Zaissanurus beliajevae*), whereas the Late Oligocene to Early Pliocene species *Andrias scheuchzeri* is distributed from Central Europe (first penetrate in the Late Oligocene) to Western Siberia and the Zaissan Basin.

In all regions the fossil distribution is stratigraphically patchy. In Asia cryptobranchids occurred mainly during five periods; the latest Paleocene, the late Middle to Late Eocene, the latest Oligocene, the late Early to early Middle Miocene and the earliest Pliocene. All fossils are found in lowland habitats, in deposits of distal meandric rivers as well as in lakes. The occurrence in basinal lacustrine deposits stands in contrast to their recent habitats (Thenius, 1954; Westphal, 1958). However, juvenile individuals are found so far only in fluvial sediments suggesting a habitat shift in ontogeny.

(Palaeo)climatic significance of cryptobranchids: To investigate the palaeoclimatic significance of giant salamanders we analyzed the climate within the present-day distribution area and at selected fossil localities with independent palaeoclimatic record. The recent *Andrias* species occur in humid areas, where the mean annual precipitation (MAP) reach over 1.000 mm (1.000-2.000 mm) (Müller & Hennings, 2000; www.weather.com; www.wunderground.com). The palaeoclimatic data from *Andrias* bearing localities derive from palaeobotanical methods (Coexistence Approach, Mosbrugger et al., 2005) as well from estimations based on herpertofaunal assemblages (Böhme et al., 2006) showed MAP 900-1.650 mm. So the fossil cryprobranchids are a useful proxy for significantly elevated levels of past humidity.

Our analysis indicates that temperature parameters are of less importance in defining the climate space for cryptobranchids since fossil and recent taxa live from warm-subtropical to temperate regions.

We denote this concordance of ancient and extant humidity requirement as environmental stasis, which is remarkable, because recent investigation shows that unlike cryptobranchid salamanders, other ectothermic vertebrates display a broad environmental plasticity during their evolution (e.g. the anguine lizard *Pseudopus*, Klembera et al., 2010).

Implications for Cenozoic palaeoclimatology of Central Asia: Applying the relationship between giant salamander occurrences and humidity it is showed that the five cryptobranchid intervals are characterized by humid to very humid climates in Asia, with MAP above 900 mm. Interestingly all five intervals represent global warm periods. Cryptobranchids from the oldest interval derive from the top of the Naran Member of the Naran Bulak Formation (Badamgarav & Tolstikova, 1976), which can be correlated to the late Gashatan Asian Land Mammal Age and the late Clarkforkian North American Land Mammal Age (Meng & McKenna, 1998; Secord et al., 2006), very near or contemporary with the Paleocene–Eocene Thermal Maximum. For both the Naran Member and the contemporary nearby Chinese Nomogen Formation humid environments have been already suggested (Badamgarav & Tolstikova, 1976; Van Itterbeck et al., 2007).

Significant is their last appearance, which occured at the Mio-Pliocene transition in the Western Eurasia (Eastern Paratethys), directly after the Messinian salinity crisis (Early Pliocene warming). This time is characterised by more humid and warm climate (Böhme et al., 2010, Krijsman et al., 2010).

As a working hypothesis (assuming a similar ecology of *Andrias, Aviturus, Ulanurus* and *Zaissanurus*) we interpret occurrences of both fossil Eurasian giant salamanders as indicative for humid palaeoclimatic conditions. Based on this assumption the Late Eocene, the latest Oligocene (late Oligocene warming), the late Early to early Middle Miocene (Miocene Climatic Optimum) and the Early Pliocene (Early Pliocene warm period) of Central Asia are periods of elevated humidity, suggesting a direct (positive) relationship between global climate and Central Asian humidity evolution.

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NEW DISCOVERIES FROM GARGANO (APULIA, ITALY) ABOUT THE GIANT HEDGEHOG *DEINOGALERIX*

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During the Miocene the Abruzzo/Apulia region (Italy), isolated from the continent, was the theatre of the evolution of a vertebrate ecosystem in insular context (Rook et al., 2006). At the late Miocene the protagonists of this ecosystem called "*Mikrotia fauna*" show a high endemic speciation level with spectacular giant and dwarf species of mammals and birds. Most of the remains of this peculiar fauna are found exclusively in the "Terre rosse" of Gargano, except for the oldest genus: *Deinogalerix* and *Hoplitomeryx*, also found at Scontrone (Mazza & Rustioni, 2008). *Deinogalerix* is one of the most uncommon forms of the "*Mikrotia fauna*". It's the largest Galericinae ever lived. *Deinogalerix* was first described by Freudenthal (1972) then by Butler (1980). We report here the new data about this enigmatic genus from the revision of the old collections (1970's, Rijksmuseum van Geologie en Mineralogie, Leiden; 1980's, Università degli Studi di Firenze) and the study of the new material from the recent excavation lead by the Università degli Studi di Torino.

Five species of *Deinogalerix* have been described. However, the variation has never been studied in detail, even though we know extralimital evolution occurs in island. The revision of the old collections allowed us to identify ontogenetic variations, extrapolate ecological behaviors and we suspect sexual dimorphism in *Deinogalerix*.

In 2005 the excavation lead by the Università degli studi di Torino at Cava Dell'Erba, in the Gargano area put the light on a new Miocene fissure, Pirro 12. The preliminary studies attest the presence of new taxa of mammals: a carnivore (see Villier & Rook, 2011) and an unidentified large mammal, of birds and of archaic forms of *Deinogalerix* and *Mikrotia*, which attest that Pirro 12 is among the oldest fissures (see Masini et al., 2011). All the *Deinogalerix* remains belong to the smallest species ever found and differ from the other representative of the genus by their mandibular and teeth features and by their wearing patterns.

This new remains allowed us to update the knowledge about *Deinogalerix* still unstudied since Butler (1980) and to have an overview on an almost unknown part of the story of the "*Mikrotia* fauna".

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CARNIVORES IN ISLAND FOSSIL RECORD: NEW DATA FROM GARGANO TERRE ROSSE FAUNAS

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Fossil insular faunas in paleontological literature are generally referred to as unbalanced impoverished faunas (MacArthur & Wilson, 1963; Sondaar, 1977). Even if insular faunas may contain relatively large numbers of endemic taxa, the term impoverished indicates that taxonomic diversity is poor at the higher levels with many major groups absent. Insular faunas are usually referred to as unbalanced because of the absence of large carnivores.

We report here new data from recent excavations (leaded by the Università degli Studi di Torino) and revision of old collections (1980's, Università degli Studi di Firenze).

The revision of Florence material allowed identifying, within the material from fissure labelled "F9", the occurrence of *Paralutra garganensis* (Willemsen 1983). The type specimen of this lutrine mustelid was the only carnivore remain known from the Gargano Terre Rosse fissure filling record (cfr. De Giuli et al., 1990).

The excavation of a new fissure, Pirro 12, carried out in 2005 in the Dell'Erba quarry revealed the occurrence of a faunal assemblage characterised by the occurrence of very primitive morphotypes among the typical endemic taxa (e.g. *Mikrotia*, *Deinogalerix* etc.) thus representing a probably very early stage of this endemic faunal complex (see Villier, 2011; Masini et al, 2011). Among the abundant material from this fissure filling, we report the occurrence of carnivora remains, a humerus and a tooth fragment, preliminarily attributable to a viverridae.

Although very rare, these findings allow expanding our knowledge of an almost unknown part of the ecological structure of the so-called "*Mikrotia* faunal complexes".

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DENTITION AND DIET: NEW 3D-METHODS HELP TO DISCOVER DENTAL ADAPTATIONS IN THE EXTINCT BOVID *MYOTRAGUS*

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Mammalian teeth are an excellent study object when questions of energy efficiency in foraging strategies and questions of functional optimisation are considered. They can either be highly specialised, or highly generalistic in their functional traits, in order to meet demands of forage and environment. When it comes to reconstructing diets of extinct species, the immediate tooth/food interface (the occlusal surface) allows inference of dietary information at a variety of scales and resolutions. A fascinating extinct artiodactyl endemic to Mallorca and Minorca Islands is the dwarf goat *Myotragus*. The genus has long been in the focus of attention, as it has developed peculiar cranial and post-cranial adaptations to meet the specific demands of its insular habitat. This study aims at applying 3D methods of dental morphometry and microtexture analysis to a) infer palaeodiet of four of the four successive *Myotragus* species (*M. pepgonellae*, *M. kopperi*, *M. batei*, *M. balearicus*), b) detect small scale morphological adaptations on their molariform teeth and c) test for dietary differences in two geographically separated populations of the youngest species, *M. balearicus*. An optical topometric digitisation system (smartSCAN3D, Breuckmann, Meersburg, Germany) is used to generate 3D occlusal surface models. Furthermore, a high resolution 3D-topometer (µsurf Custom, NanoFocus AG, Oberhausen, Germany) is applied to generate microtexture scans of dental facets. Microtexture analysis is performed according to scale-sensitive fractal analysis (SSFA) and industrial areal surface texture standards (ISO/DIS 25178-2). The older *Myotragus* species, *M. pepgonellae*, *M. kopperi* and *M. batei* have significantly higher enamel/dentine ratios than the younger *M. balearicus*, whose teeth are composed of more dentin. This suggests a gradual evolutionary decrease of the dentin/enamel ratio. Also the length and surface of inner enamel ridges decreases within the *Myotragus* lineage. In a two-factorial PCA, ISO/DIS microtexture parameters allowed to successfully characterise the four *Myotragus* species in terms of their dietary strategy. SSFA revealed decreasing surface complexity (*Asfc*) and increasing heterogeneity of area-scale fractal complexity (*HAsfc*) between *M. pepgonellae, M. kopperi and M. batei* and the younger *M. balearicus*. The ISO/DIS *Sz*-Parameter (maximum height of the scale limited surface) decreases within the succession of species, which implies that tooth-to-tooth contact was prevalent in *M. balearicus* which would produce more flattened textures. This signature is indicating a dominance of soft and tough food items like browse, while brittle and hard forage maintains a more elevated profile. Another indicative parameter is the ISO/DIS *Sda*-Parameter (closed dale area), as it is likely to reflect what is referred to as a 'pits' in classical microwear. *M. balearicus* has larger *Sda*-values than the three older *Myotragus* species. More frequent pits are characteristic of browsers, while microwear of grazers is dominated by scratches. Within the two tested populations of *M. balearicus*, however, no difference in tooth morphology or microtexture was found. Both, 3D dental morphometry and microtexture analyses place *M. balearicus* among extant browser which have a source of abrasives in their diet, while its ancestors show characteristics similar to extant grazer. Our results are interpreted as to reflect an adaptation to energetic restrictions of an isolated, insular environment and reveal that either a dietary shift took place in the *Myotragus* lineage or *Myotragus* successively adapted to increased intraspecific competition and expanded its dietary range. Finally, the question becomes evident, if a general trend in dental adaptations of large, herbivorous insular mammals is detected here, that may apply to insular conditions in general.

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