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PLEISTOCENE FAUNAS OF SICILY: A REVIEW

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INTRODUCTION

Sicily has a rich palaeontological heritage of Pleistocene continental vertebrates, that indicates different faunal complexes inhabited the island through time.

Most of the older studies on Quaternary vertebrates in Sicily have focused on evolutionary and taxonomic aspects (e.g. Pohlig 1893; Pohlig 1909; Vaufrej 1929; Accordi & Colacicchi 1962; Ambrosetti 1968; Aguirre 1968-69; Gliozzi & Malatesta 1984; Brugal 1987) with the aim to identify the continental species from which the Sicilian ones derived. Most of the known vertebrate remains came from cave deposits and little was known about the palaeoenvironmental conditions of the vertebrate-bearing deposits.

Chronological arrangements of the various Pleistocene mammal assemblages of Sicily were based on the assumption of the phyletic derivation of the dwarf elephant *Elephas falconeri* from the middle sized *Elephas mnaidriensis*, which was in turn considered a direct descendent of *Elephas antiquus* (Accordi 1963; Accordi 1965; Accordi & Colacicchi 1962; Ambrosetti et al. 1980). Vaufrej (1929) was inclined to assume a post-Tyrrhenian age for all the vertebrate faunas. Since the studies of Accordi (1957; 1963; 1965) it was thought that most of the size reduction of elephants in Sicily took place during the period preceding the Tyrrhenian. The smallest species (*Elephas falconeri*) was considered to be limited to the early Würm period and to have evolved as a consequence of environmental stress linked to the Würmian climatic cooling (Ambrosetti 1968; Kotsakis 1979). Stratigraphic and taphonomic features have

been generally disregarded although the first valuable scientific paper dealing with the excavations of the Hippopotamus pentlandi bearing deposits of the S. Ciro cave (Palermo), carried out by the abbot Scinà (Scinà 1831), contains many interesting remarks concerning the relationship between the vertebrate-bearing deposits and the underlying marine sands which extend inside and outside the cave.

Vaufrej (1929), Accordi & Colacicchi (1962) and Accordi (1963; 1965) provide also interesting observations concerning the relationship between vertebrate-bearing deposits and littoral marine deposits.

Since 1985, a new synthesis has incorporated new stratigraphic and aminostratigraphic data (Belluomini & Bada 1985; Bada et al. 1991; Burgio & Cani 1988; Bonfiglio 1987; Bonfiglio 1991; Bonfiglio 1992 a; Bonfiglio 1992 b; Bonfiglio & Burgio, 1992; Bonfiglio & Insacco 1992).

These data concern essentially the following aspects:

- (1) Number and composition of the Pleistocene faunal complexes
- (2) Stratigraphic, environmental and taphonomic data
- (3) Chronological data
- (4) Geographic distribution of vertebrate bearing deposits and palaeogeography.

NUMBER AND COMPOSITION OF PLEISTOCENE FAUNAL COMPLEXES (Table. 1)

On the basis of extensive new evidence, the Pleistocene vertebrate assemblages of Sicily can be arranged into 5 phases or Faunal Complexes (F.C.), spanning from the Early Pleistocene to the Late Glacial (Bonfiglio et al. 2000;

Bonfiglio et al. 2001; Bonfiglio et al. in press).
MONTE PELLEGRINO FAUNAL COMPLEX.

This is the oldest Quaternary fossil record so far known (late Villafranchian, Burgio & Fiore 1997) and it is documented only in the very restricted geographic area of Monte Pellegrino, close to the town of Palermo. The poorly diversified fauna includes species of the genera Hypolagus, Pannonictis, Leithia, Asoriculus, Pellegrinia, Apodemus.

Hypolagus and Pannonictis are moderately endemic taxa and the potential ancestors appear to be typical European forms, not found so far in northern Africa (Burgio & Fiore

teristics of the African stock of Ctenodactilids, thus indicating a dispersal from that region.

The composition of the Monte Pellegrino fauna - unique for the Mediterranean islands - suggests it may have been derived in part from an older, not locally known, population phase (Messinian age ? Azzaroli 1974; Azzaroli & Guazzone 1979) and partially from younger dispersals from Europe. The different degree of endemism and the different geographical affinity of the taxa, indicate a polyphasic origin (Masini et al. in press). After the first report by Thaler (1972) some of the taxa have been revised more recently

"Monte Pellegrino" F.C.	"Elephas falconeri" F.C.	"Elephas mnaidriensis" F.C.	"Grotta S. Teodoro - Pianetti" F.C.	"Castello" F.C.	Holocene fauna
<i>Testudo graeca</i> <i>Asoriculus</i> sp. <i>Pannonictis arzilla</i> <i>Apodemus maximus</i> <i>Leithia</i> sp. <i>Maltamys</i> cf. <i>gollcheri</i> <i>Pellegrinia</i> <i>panormensis</i> <i>Hypolagus</i> sp.	<i>Discoglossus</i> cf. <i>pictus</i> <i>Bufo</i> cf. <i>viridis</i> <i>Hyla</i> sp. <i>Emys orbicularis</i> <i>Testudo hermanni</i> <i>Geochelone</i> sp. <i>Lacerta</i> <i>siculomelitensis</i> <i>Lacerta viridis</i> <i>Lacerta</i> sp. <i>Coluber</i> cf. <i>viridiflavus</i> <i>Natrix</i> sp. Several species of bats <i>Crociodura esuae</i> <i>Vulpes</i> sp. <i>Nesolutra trinacriae</i> <i>Elephas falconeri</i> <i>Leithia cartei</i> <i>Leithia melitensis</i> <i>Maltamys gollcheri</i>	<i>Discoglossus</i> cf. <i>pictus</i> <i>Emys orbicularis</i> <i>Testudo hermanni</i> <i>Lacerta</i> <i>siculomelitensis</i> Birds <i>Erinaceus europaeus</i> <i>Crociodura</i> aff. <i>esuae</i> <i>Crocota crocuta</i> cf. <i>spelaea</i> <i>Panthera leo</i> <i>Canis lupus</i> <i>Nesolutra trinacriae</i> <i>Ursus</i> cf. <i>arctos</i> <i>Elephas mnaidriensis</i> <i>Sus scrofa</i> <i>Hippopotamus pentlandi</i> <i>Cervus elaphus siciliae</i> <i>Dama</i> <i>carburangelensis</i> <i>Bos primigenius siciliae</i> <i>Bison priscus siciliae</i> <i>Leithia</i> cf. <i>melitensis</i> <i>Maltamys</i> cf. <i>wiendincitensis</i>	Reptiles <i>Testudo</i> sp. Birds Chiroptera <i>Crocota crocuta</i> cf. <i>spelaea</i> <i>Ursus</i> cf. <i>arctos</i> <i>Canis</i> cf. <i>lupus</i> <i>Vulpes vulpes</i> <i>Elephas mnaidriensis</i> <i>Sus scrofa</i> <i>Equus hydruntinus</i> <i>Cervus elaphus siciliae</i> <i>Bos primigenius siciliae</i> <i>Apodemus</i> cf. <i>silvaticus</i> <i>Microtus (Terricola)</i> ex gr. <i>savii</i> <i>Crociodura</i> cf. <i>sicula</i>	Birds <i>Erinaceus europaeus</i> <i>Crociodura</i> cf. <i>sicula</i> <i>Canis lupus</i> <i>Vulpes vulpes</i> <i>Equus caballus</i> <i>Equus hydruntinus</i> <i>Sus scrofa</i> <i>Cervus elaphus</i> <i>Bos primigenius</i> <i>Microtus (Terricola)</i> ex gr. <i>savii</i> <i>Apodemus</i> sp. <i>Lepus europaeus</i>	<i>Bufo bufo</i> <i>Bufo</i> cf. <i>viridis</i> Turtle indet. <i>Emys orbicularis</i> <i>Lacerta viridis</i> Birds Chiroptera indet. <i>Erinaceus europaeus</i> <i>Crociodura</i> sp. <i>Canis</i> cf. <i>lupus</i> <i>Vulpes vulpes</i> <i>Felis silvestris</i> <i>Martes</i> sp. <i>Mustela</i> cf. <i>nivalis</i> <i>Ursus</i> sp. <i>Sus scrofa</i> <i>Cervus</i> sp. <i>Bos primigenius</i> , <i>Microtus (Terricola)</i> cf. <i>savii</i> <i>Apodemus</i> sp. <i>Arvicola terrestris</i> <i>Mioxus glis</i> <i>Monachus monachus</i>

TABLE 1. FAUNAL COMPLEXES OF SICILY (AFTER BONFIGLIO et al., 2001)

1997); the endemic shrew *Asoriculus burgioi* is of uncertain provenance (Masini & Sarà 1998); *Asoriculus* is well documented in Europe from the Early Pliocene, and it has also been found recently in northern Africa, in Late Pliocene - Early Pleistocene deposits (Geraads 1995; Rzebik-Kowalska 1988).

The endemic dormouse *Leithia* (Thaler 1972), is regarded as one of the direct ancestor of the better known and better described *Leithia* and *Maltamys* from the Middle and Late Pleistocene of Sicily and Malta (Zammit Maempel & De Bruijn 1982). *Leithia* and *Maltamys* are considered by Daams & De Bruijn (1995) as relics of a scarcely known older (Messinian) population phase and these elements have remained isolated in the Sicilian Maltese archipelago for the entire Pliocene and most of the Quaternary.

According to Thaler (1972) *Pellegrinia* has derived charac-

but our knowledge of this very peculiar and intriguing faunal assemblage is still not exhaustive.

ELEPHAS FALCONERI FAUNAL COMPLEX. This Faunal Complex is even poorer than the preceding one in mammalian biodiversity. The poorly diversified fauna includes, besides the pigmy elephant, members of the genera *Crociodura*, *Lutra*, *Leithia*, *Maltamys*, a giant tortoise, and a rich typical endemic avifauna (Pavia 1999; Pavia 2000).

The shrew *Crociodura esuae* is an endemic species, of uncertain bio-geographic affinity (Kotsakis 1986). The genus *Crociodura* occurs widely in the Quaternary of Europe (Reumer 1984; Rzebik-Kowalska 1995) and in northern Africa (Butler 1980). Large mammals include the pigmy elephant *Elephas falconeri*, strongly reduced in size, and a member of the Lutrinae (genus *Lutra*).

Neither the ancestor nor the geographic provenance of *E. falconeri* has been determined unequivocally. Even though its derivation from a Paleoloxodontine elephant is accepted by several authors, its possible origin from European *Elephas antiquus* stock, or from a north African species is still a matter for discussion.

Moreover, also the composition of this faunal complex reveals a polyphasic origin; some taxa are relics from the preceding phase and others are 'newcomers' that probably entered the island through a strongly filtering barrier (Masini et al. in press).

ELEPHAS MNAIDRIENSIS FAUNAL COMPLEX: This Faunal Complex is almost completely renewed with respect to the preceding F. C. The pigmy *E. falconeri* is extinct, while the faunal composition is more balanced and includes top predators such as the lion and the spotted 'cave' hyena. The faunal composition is quite similar to that found in the southern Italian peninsula, and the continental forerunner of most of these taxa has been fairly accurately identified. The only significant absence is that of perissodactyls (rhinos and horses). The herbivorous taxa (bison, auroch, fallow deer, red deer, hippo) are moderately modified with respect to the congeneric or conspecific taxa from the Italian mainland and the endemic nature of the fauna is apparent mainly from the modest reduction in size. *E. mnaidriensis* is a smaller, but not extremely modified, descendant of *Elephas antiquus*. The red deer *Cervus elaphus siciliae* is slightly reduced in size (about 20%). *Dama carburangelensis* (previously identified as *Megaceroides carburangelensis*) is probably derived from fallow deer populations (*Dama dama tiberina*) widespread in central and southern Italy during the late Middle Pleistocene (Abbazzi et al. 2001).

A peculiarity of this fauna is the very low diversity of small mammals, which are represented only by survivors from the *E. falconeri* F. C. (*Leithia*, *Maltamys* and *Crocidura esuae*; Petruso 2001; Petruso in progress; Masini et al. in press). The knowledge of the composition of the avifauna is still incomplete (Pavia 2000; Pavia 2001). One endemic species of birds, *Cygnus falconeri* occurs, while the endemic species of the previous F. C. became extinct, except *Grus melitensis* whose persistence is, however, questionable. Typical continental taxa (i. e. Galliforms) are still lacking. On the whole the avifauna assemblages are partially renewed alike the mammal fauna.

THE PIANETTI - SAN TEODORO CAVE FAUNAL COMPLEX

The Pianetti - San Teodoro Cave Faunal Complex dates to the last glacial cycle. The faunal history of this period is characterised by extinction events (hippopotamus, endemic dormice and *Crocidura esuae*), and by the dispersal of equids (*Equus hydruntinus*) and of mainland small mammals, which are represented by taxa still occurring in Sicily (*Microtus* (*Terricola*), *Crocidura cf. sicula*, *Apodemus cf. sylvaticus*, *Erinaceus europaeus*) (Bonfiglio et al. 1997; Bonfiglio et al. 2001). Almost all of the large mammals belonging to this F. C. seem to be inherited from *Elephas mnaidriensis* F. C. endemic species of avifauna are lacking

(Pavia 2000).

The faunal composition of this F. C. is probably not completely known, since only a few sites have been discovered so far and one of them (S. Teodoro cave) has not yet been completely investigated.

Castello Faunal Complex. Finally, the Late Glacial associations show a dramatic decrease in diversity, missing all endemic large mammals still occurring in the Pianetti-S. Teodoro F. C. Late glacial faunas, which are similar to continental ones, are associated to lithic artifacts and cultural evidences of late Upper Palaeolithic and, following some authors (Kotsakis 1979), include taxa present in one (*Equus hydruntinus*) or both (*Sus scrofa*) previous faunal complexes.

STRATIGRAPHIC, ENVIRONMENTAL AND TAPHONOMIC DATA

Taphonomic data show that Pleistocene vertebrates were distributed in both cave environments and broad, open environment (Bonfiglio 1987; Bonfiglio 1992 b; Bonfiglio 1995; Bonfiglio et al. 1993; Bonfiglio et al. 1996; Bonfiglio et al. 1997; Chilardi & Gilotti 1996) and numerous relationships have been found between the vertebrate bearing deposits and terraced marine deposits, which can be correlated with the $\delta^{18}O$ isotopic record and the main palaeogeographic events in Sicily (Agnesi et al. 1997; Bonfiglio 1991; Bonfiglio et al. 2000; Bonfiglio et al. in press; Di Maggio et al. 1999).

Actually most of the mammalian fossils of Sicily are found in caves and fissures - rather common in the carbonate mountain ranges of Northern Sicily and in the Hyblean plateau. Another important category of deposits is represented by ancient shorelines, beach deposits and marine terraces, frequently associated with a lagoon or swamp. Limnic deposits related to small freshwater basins also occur, often in relation to coastal and fully marine deposits.

The assemblages of the Monte Pellegrino F.C. and those of S. Teodoro Cave - Pianetti and Castello F.C.'s are contained in caves and fissure-filling deposits and they have not relationships with marine deposits. The assemblages of the *Elephas falconeri* and of the *Elephas mnaidriensis* F.C.'s are contained in cave deposits as well as in coastal plain and/or in marine littoral deposits.

The biodiversity, the preservation conditions and the concentration of the skeletal remains are very diverse in the different environments (see FIGURE 1).

Littoral marine sands - In the late Middle Pleistocene sandy gravel outside the S. Ciro cave, the rare hippopotamus and elephant remains (molars, limbs) are disarticulated, encrusted by serpulid polychaetes worms and associated with a rich marine fauna containing gastropods, bivalves, ostracods, foraminifera, of littoral a euryhaline environment (Galletti & Scaletta 1991).

An isolated scapula of *Elephas mnaidriensis* comes from Thyrrenian marine deposits at Maddalena peninsula (Siracusa) (Accordi 1963; Di Grande & Scamarda 1973).

Deltaic marine clay sands - At Contrada Cacaladritta (south eastern Sicily) rare skeletal remains of *Hippopotamus pentlandi*, *Elephas cf. mnaidriensis* and *Bos primigenius siciliae*

are concentrated in deltaic Middle Pleistocene clay sands with *Ostrea edulis* (Roda 1965; Ruggieri 1973; Lentini 1984; Bonfiglio et al. 1997).

Deltaic marine gravels and sands - Disarticulated, fragmented, worn and mechanically selected remains of elephant (*Elephas mnaidriensis*), hippopotamus (*Hippopotamus pentlandi*), red deer (*Cervus elaphus siciliae*), bear (*Ursus cf. arctos*), tortoise (*Testudo cf. hermanni*) are contained in the deltaic marine gravel and sandy deposits underlying Tyrrhenian sands with *Strombus bubonius* at Cape Peloro. Serpulids encrust some skeletal elements (Bonfiglio & Berdar 1979; Bonfiglio & Violanti 1986; Marra 2001).

FLUVIAL AND LACUSTRINE COASTAL PLAIN DEPOSITS

At Comiso a regressive marine sequence begins with Early Pleistocene marine deposits and ends at the top with sands of brackish environment which, in turn, pass to deposits of limnic environment underlying Middle Pleistocene marine sands (Conti et al. 1980; Carbone et al. 1982). In the different levels of the limnic deposits skeletal elements of *Elephas falconeri*, *Leithia melitensis*, bats, fish, birds, reptiles (*Lacerta sp.*, *Testudo sp.*, *Emys orbicularis*, *Geochelone sp.*) are contained (Bonfiglio & Insacco 1992).

At Contrada Fusco, near Siracusa, gravel, sandy and silty deposits of coastal plain environment contain a rich vertebrate fauna (an elephant of little reduced size, *Elephas mnaidriensis*, *Hippopotamus pentlandi*, *Ursus cf. arctos*, *Crocota crocuta spelaea*, *Lutra trinacriae*, *Leithia melitensis*, *Maltamys wiedincitensis*, *Crocidura esuae*, *Emys orbicularis*, *Testudo cfr. hermanni*, *Lacerta siculomelitensis*, *Natrix sp.*) (Chilardi 1996; Kotsakis 1996 a; Kotsakis 1996 b; Cassoli & Tagliacozzo 1996 a; Cassoli & Tagliacozzo 1996 b). The coastal plain deposits overlie Early Pleistocene bathyal clays and underlie Tyrrhenian calcarenites (Chilardi & Gilotti 1996).

To the coastal plain environment belong the silty, laminated lacustrine deposits at Acquadolci (north eastern Sicily) containing very abundant skeletal elements of the endemic hippo *Hippopotamus pentlandi* associated with scarce remains of *Cervus elaphus siciliae*, *Ursus cfr. arctos*, *Canis lupus*, *Elephas cfr. mnaidriensis*, *Testudo cfr. hermanni*, birds (Bonfiglio 1992a; Bonfiglio 1995).

CAVE DEPOSITS CORRELATED WITH MARINE DEPOSITS

The vertebrate assemblage containing abundant remains of *Hippopotamus pentlandi* associated with rare remains of *Elephas mnaidriensis*, *Cervus siciliae*, *Dama carburangelensis*, *Bos primigenius siciliae*, *Canis lupus*, *Ursus cfr. arctos*, *Crocota spelaea* of the S. Ciro cave overlie middle Pleistocene marine sands (Scinà 1831; Fabiani 1928a; Fabiani 1928b).

At Spinagallo cave the lower vertebrate deposits containing abundant remains of *Elephas falconeri* associated with *Leithia melitensis*, *Maltamys gr. gollcheri-wiedincitensis*, *Crocidura esuae*, *Testudo hermanni* overlie Middle Pleistocene littoral calcarenites (Accordi & Colacicchi 1962; Pet-

ronio 1970; Kotsakis 1977; 1986; Kotsakis & Petronio 1981; Di Grande & Raimondo 1984; Bonfiglio 1992 b; Petruso in progress).

Vertebrate bearing deposits overlying marine terraces - At San Vito Lo Capo peninsula mammal remains of the *Elephas falconeri* F.C. and of the *Elephas mnaidriensis* F.C. overlie marine terraces correlated with the IOS 11-15 and with the IOS 5a or 5c respectively. (Di Maggio et al. 1999). In eastern Sicily vertebrate bearing deposits with prevalent hippo overlie late Middle Pleistocene (Coste di Gigia; Bonfiglio 1992 b) or Tyrrhenian (Scodoni, Bonfiglio 1987) abrasion platforms.

KARST FISSURE AND CAVE DEPOSITS

Fossil vertebrates contained in fissure-filling deposits were accumulated by different ways. At Contrada Pianetti remains of *Bos primigenius siciliae*, *Cervus elaphus siciliae*, *Canis cf. lupus*, *Ursus cf. arctos*, have been recovered in a small karst cavity (Bonfiglio et al. 1997; Marra & Bonfiglio, 2000). The taphomic features (fragmentary and disarticulated skeletal elements belonging to different species) suggest that detritus and bones scattered on surface filled the cavity by the action of gravity and/or washing. At Contrada Cimilla, abundant remains of *Dama carburangelensis* were associated to scarce remains of *Cervus elaphus siciliae*, *Elephas mnaidriensis*, *Ursus cf. arctos* (Bonfiglio et al., 1993; Abbazzi et al., 2001). The skeletal element representation shows that surface opening of the fissure may act as a trap for living fallow deers, which were abundant at the site by ethological and/or ecological reasons.

In the bone assemblage of the San Teodoro cave large mammals skeletal elements were accumulated by *Crocota crocuta spelaea* which damaged the main part of bones. A so impressing accumulation by hyena in a large cave (floor area: more than 1000 square meters) is an absolutely novelty for insular environments (Bonfiglio et al. 2001; Marra & Bonfiglio 2002).

CHRONOLOGICAL DATA

The record of fossil vertebrate faunas from Sicilian Pleistocene deposits allowed the reconstruction of a detailed biochronological scale, based on geochemical and radiometric dating also (Bada et al. 1991; Rhodes 1996).

Where correlated with marine sediments, the assemblages of the *Elephas falconeri* Faunal Complex are associated with deposits dated early Middle Pleistocene; amino-acid racemization dating yielded an age of 455 ± 90 Ky for *Elephas falconeri* from the Spinagallo and Luparello cave deposits (Bada et al. 1991).

Where correlated with sediment of littoral environments, the assemblages of the *E. mnaidriensis* Faunal Complex are associated with deposits dated as late Middle Pleistocene and / or Late Pleistocene (Bonfiglio & Burgio 1992; Bonfiglio et al. 1996).

Bada et al. (1991) assigned an age of 200 ± 40 Ky to this faunal complex. ESR dating for teeth enamel of *Elephas mnaidriensis* and *Hippopotamus pentlandi* from Contrada Fusco (Rhodes 1996) provided an age ranging between 146.8 ± 28.7 and 88.2 ± 19.5 Ky.

of an African provenance for both *E. falconeri* and human populations through the Sicilian-Tunisian isthmus, as a result of tectonic controlled changes of sea bottom depth during the Early Pleistocene (see Alimen 1975; Kelling & Stanley 1972; Vaufreij 1929), should at least merit a fresh and more detailed re-consideration.

From the beginning of the Middle Pleistocene onward, the evolution of Southern Calabria and Sicily was characterised by an uplifting tendency which led, in the late Middle Pleistocene, to the establishment of a palaeogeography very similar to the present one (Barrier et al. 1990; Barrier et al. 1993; Fabbri et al. 1980; Bonfiglio et al. in press). In the late Pleistocene the interaction of neotectonic with eustatic marine cycles probably led to the establishment of an intermittent filter barrier in the area of Messina Straits, which controlled the processes and timing of the Late Pleistocene-Late Glacial vertebrate faunal dispersion in Sicily. In fact the composition of the two younger F. C.'es denotes that temporary connections with southern Italy occurred.

DISCUSSION AND CONCLUSION

Changes in faunal associations of islands are controlled by climatic and environmental factors, but mainly by geographical barriers (Azzaroli 1982; Azzaroli 1996; Dermitzakis & Sondaar 1978).

Biochronologic, taphonomic and palaeogeographic evidence regarding Pleistocene vertebrate faunas of Sicily leads to the following considerations:

The two oldest Faunal complexes (Monte Pellegrino and *E. falconeri* F.C.) characterised by strongly endemic faunal assemblages, denote the occurrence of an insular system made up of geographically isolated small islands, with very difficult and sporadic connections with the mainland. Palaeogeographic data do not provide more precise information on the route followed by dispersals for these complexes.

The three dispersals documented in Sicily from the late Middle Pleistocene to the Late Pleistocene prove the possibilities of connection between the island and the continent through the Strait of Messina area. However, these conditions do not fully explain the modifications recorded in the transition between faunal complexes.

As a matter of fact, variations in the three faunal complexes depend on three components:

(1) Dispersal events. Dispersals (or new occurrences) change obviously the faunal composition and are easier during low-stand episodes.

(2) Extinctions. It seems that most of the extinction events recorded in insular complexes corresponds to those occurring in Italian peninsula and in Western Europe (*Elephas antiquus* become globally extinct; lion and hyena disappear from Western Europe; the European bison is now present only in few residual populations living in Middle-Eastern Europe; *Equus hydruntinus* disappear from Italian peninsula at the beginning of the Holocene and became totally extinct; etc.) It is still unclear, however, if extinctions took place at the same time in the Southern Italian peninsula as in the island. Observations from S. Teodoro cave suggest that at least elephant survived in Sicily longer than elsewhere in Europe. A remarkable exception is, however, represented by the extinction of the endemic dormice

(*Leithia* and *Maltamys*) and of the shrew *Crocidura esuae*. These endemics became extinct during the last glacial cycle, prior then the extinction of *Elephas mnaidriensis*, possibly owing to the interaction of several factors, such as dispersal of new small mammals and predators from the mainland, concomitant to a severe climatic deterioration (see Masini et al. this volume, for a discussion).

(3) Environmental changes related to climatic and physical variations. These changes (connection between the island and the mainland during the Glacial maximum, disappearance of coastal plains subsequent to deglaciation; rearrangement of vegetation in response to climatic changes; etc.) represent very probably direct and indirect causes of dispersals and extinctions.

Components 1 and 2 are basic parameters to define trends in faunal changes; component 3 refers to explanatory models of the variations themselves. The entity of impact in extinction directly linked to these changes is still unclear.

Many taxa identified in different sites and attributed to the considered faunal complexes are still little known. Exhaustive morphological and biometrical data are lacking and relationships with continental ancestors have not still been investigated in the details. In particular, data about the degree of endemism of some taxa (bear, spotted cave hyena, wolf, wild boar) have not still been collected and elaborated. Direct comparisons between the best known taxa of *Elephas mnaidriensis* F.C. (ox, deer) and those of Pianetti-S. Teodoro F.C. have not been done; *Equus hydruntinus* from the latter F. C. is still to be described. Detailed descriptions of micromammals from the three faunal complexes, in particular voles and dormice, are also partially lacking. The relationship between micromammals from Sicily and Malta has never been studied in the details (Petrucci in progress), and can bring a new sight on dispersal dynamics internal to the Sicily-Malta archipelago, given that the latter island likely was a promontory of Sicily during low stand phases.

Careful taxonomic investigations on the recorded taxa, whose spreading on the island has been controlled by geographical barriers of different entity, and a correct evaluation of changes in faunal composition can also emerge from the recognition of differences between mainland and island taxa and a comparison with data from the continent (Italy).

These studies, still in progress, could enhance our knowledge on how and to what extent "discontinuous" insularity conditions interact with climatic and environmental changes in determining the faunal changes of Sicily during last phases of Pleistocene.

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