ARTICLES

HOLOCENE ENDEMIC AND ANTHROPOCHOROUS WILD MAMMALS OF THE MEDITERRANEAN ISLANDS

Marco MASSETI*

Summary

In the Quaternary period, the mammalian fauna found on Mediterranean islands differed considerably from contemporary continental wildlife. The insular assemblages were characterized by species, which evolved in a rather peculiar way, of which significant examples can be found on the Balearics, Corsica, Sardinia, the Tuscan archipelago, Sicily, Malta, Crete, several Aegean islands, and Cyprus.

Apart from certain native taxa being identified from a few islands like Sicily, Crete and (perhaps) Cyprus, the almost complete absence of endemic species from the actual mammal fauna on the Mediterranean islands is quite surprising. Today the existing populations of non-flying, terrestrial mammals, are almost exclusively dominated by continental taxa whose appearance on the islands seems to be directly related to human intervention. Thus, the exploitation of natural resources on Mediterranean islands was a long-lasting process, beginning before the Neolithic period and lasting until historical times. Islands often represented natural enclosures where allochthonous species had been kept and bred since prehistory in a free-ranging state, while man exerted his control on the animal numbers through hunting being justified as occasionally demanded.

Résumé

Mammifères sauvages endémiques et antropochores des îles méditerranéennes à l'Holocène.

Au Pléistocene, les mammifères des îles de la Méditerranée différaient considérablement de leurs contemporains du continent. Les ensembles fauniques insulaires étaient caractérisés par la présence d'espèces ayant subi une évolution particulière : les îles Baléares, la Corse, la Sardaigne, l'Archipel Toscan, la Sicile, Malte, la Crète, les îles Égéennes et Chypre en offrent des exemples particulièrement illustratifs.

Il est assez surprenant de constater que toutes ces espèces endémiques autochtones sont absentes de la faune actuelle des îles méditerranéennes, à l'exception de quelques très rares taxons limités à la Sicile, à la Crète et peut-être à Chypre. À présent, ces peuplements de mammifères terrestres non volants sont largement dominés par des taxons continentaux, dont l'apparition sur les îles semble résulter directement de l'intervention humaine. Il apparaît donc que l'exploitation des ressources naturelles des îles méditerranéennes, initiée durant les phases pré-néolithiques et poursuivie jusqu'aux périodes historiques, s'est déroulée sur la longue durée. Les îles constituent souvent des territoires naturels à l'intérieur desquels les espèces allochtones sont préservées.

Key Words

Mediterranean islands, Holocene, Endemic and anthropochorous mammals.

Mots clés

Îles méditerranéennes, Holocène, Mammifères endémiques et anthropochores.

* *Istituto di Antropologia dell'Università di Firenze, via del Proconsolo 12, 50122 Firenze, Italia.*

Introduction

According to paleontological evidence, several of the late Pleistocene mammalian faunas of the Mediterranean islands differed considerably from contemporary continental faunas (Azzaroli, 1971, 1977; Sondaar, 1971, 1977). The insular mammalian assemblages were characterized by a very low taxonomic diversity. The most common trends of endemisation are the decrease in the size of macromammals, such as proboscideans and artiodactyls, and the increase in the size of micromammals, such as insectivores and rodents. These modifications are generally supposed to be above all a consequence of a genetic isolation from continental populations, a quantitative and qualitative reduction in food supply, an alteration of intraspecific competition, the lack of large carnivores, and concerning the micromammals, also endothermic adaptations. Among the fossil Mediterranean island faunas, examples from Balearics, Corsica and Sardinia, the Tuscan archipelago, Sicily, Malta, Crete, several Aegean islands, and Cyprus are significant. Each of these mammalian compositions, even though they were represented by few taxa, were repeated monotonously on most of the islands. They displayed peculiar endemic elements which differed extremely from one island to the other (Masseti, 1993). However, if we look at the present non-flying terrestrial mammals of these islands, we can hardly find any of the endemic elements that characterized the Pleistocene faunal structures. Although with few exceptions -constituted mainly by certain edemic taxa, such as few micromammals still reported from Sicily, Crete and, perhaps, Cyprus -, the island faunas display virtually the same species composition. It can be stressed that neither the repertoire of the modern species in Pleistocene deposits is traced, nor, all things considered, does it seem likely that they have reached the islands by swimming, jumping onto floating logs or other so-called sweepstake routes (Groves, 1989). Today the terrestrial non-flying mammalian wild fauna of most of the Mediterranean islands displays an undoubtely homogeneous composition of elements. Its structure is balanced by the presence of carnivores. It mainly consists of species that are more or less common to the present fauna of all the Mediterranean islands, and shows a generic continental origin (Alcover, 1980; Sanders and Reumer, 1984; Blondel and Vigne, 1993; Masseti, 1993) influenced by the faunistic composition of the nearest mainland.

Three out of eight Mediterranean islands studied here are still reputed to be inhabited by endemic mammalian species (37.5%) (tab. 1). This corresponds to 10.25% of the total of all the species occurring on the eight islands. The percentage decreases, however, up to 5.12% if one considers the representatives of the genus *Acomys* from Crete and Cyprus as subspecific forms.

Endemic and non-endemic insular mammals

Regarding Corsica and Sardinia, Azzaroli, as early as 1962, noted the inconsistency of the island fauna structures between Late Pleistocene and Holocene, observing that the arrival of the species occurring at present on the two islands has been most probably related mainly to the appearance of man. Baccetti (1964) expressed a similar opinion about the origin of the modern Sardinian mammals. On the basis of the lack of fossil evidence for sheep and goats on the islands, Payne (1968) and Poplin (1979) suggested that the mouflons and wild goats, still occurring on some Mediterranean islands, are ancient feral animals descending from captive specimens taken there since early Neolithic times. Although there is some evidence recorded from Sicily (Ambrosetti, 1968), Cyprus (Simmons, 1988, 1991; Swiny, 1988), Corsica (Vigne and Desse-Berset, 1995), and perhaps Sardinia (Sondaar *et al.*, 1984, 1986) of pre-Neolithic human colonization which possibly (Vigne, 1996) overlaps with the existence of endemic mammals, it was especially from Early Neolithic periods onwards that most of the Mediterranean island faunas began to show evidence of human exploitation, enhancing a gradual extinction of the endemic species (Vigne, 1987; Vigne and Valladas, 1996). A certain amount of the Pleistocene species persisted beyond the end of the Pleistocene to become extinct during the Holocene. As far as is known today, the data available for the Mediterranean islands point to faunal extinction being the result of the human activities of land clearance and the introduction of allochthonous animals. Since the 1970s, many zooarchaeological studies have been carried out on the poor and unbalanced island faunas. Especially due to the research by Alcover (1980) and Alcover *et al.* (1981) on the Balearics, Vigne (1987, 1988a, 1988b, 1990, 1992) on Corsica and Sardinia (Vigne and Alcover, 1985), and Davis (1984, 1987, 1989, 1993) on Cyprus, a reconstruction of their ancient variations became possible. In fact, it is above all on the islands that the impact of extraneous elements on the unspoilt ecological system can be identified and its chronology specified with sufficient precision, due to the evidence it left and the relative rapidity of the consequences it produced (cf. Elton, 1958; Azzaroli, 1977; Watson *et al.*, 1977; Davis, 1984). Archaeological evidences hint to the appearance of allochthonous species extraneous to the Pleistocene fauna, such as the hare, the fox, the cat, the boar, the deer, the ox, the sheep, the goat, and several micromammals in Neolithic periods. All these mammals can be considered to be imported by man, except those

Table 1: Non-flying terrestrial mammals occurring at present on some Mediterranean islands: n, species of continental origin; o, endemic species. (1) (2) Alcover, 1988; Castells and Mayo, 1993; Gisbert, 1996; (3) Cassola and Monni, 1989; Salotti 1992; Vigne, 1992; (4) Schenk, 1976; Casu *et al.*, 1989; Bonhomme *et al.*, 1986; (5) Catalisano *et al.*, 1991; (6) Zimmermann, 1952; Ragni *et al.*, in press; (7) Wettstein, 1941; Zimmermann, 1952; Ondrias, 1965, 1966; Pieper, 1965-66; Niethammer, 1989; Adamakopoulos *et al.*, 1991; (8) Spitzenberger, 1978, 1979.

SPECIES	Mallorca (1)	Menorca (2)	Corsica (3)	Sardinia (4)	Sicily (5)	Crete (6)	Rhodes (7)	Cyprus (8)
Erinaceus europaeus			n	n	n			
Erinaceus concolor						n	n	
Atelerix algirus	n	n						
Hemiechinus auritus								n
Crocidura russula				n				
Crocidura suaveolens		n	n			n	n	n
Crocidura zimmermanni						o		
Crocidura sicula					o			
Suncus etruscus			n	n	n	n	n	n
Lepus granatensis	n			n				
Lepus corsicanus			n		n			
Lepus capensis				n				
Lepus europaeus						n	n	n
Oryctolagus cuniculus	n	n	n	n	n			
Hystrix cristata					n			
Myoxus glis			n	n	n	n		
Eliomys quercinus	n	n	n	n	n			
Muscardinus avellanarius					n			
Microtus savii					n			
Rattus rattus	n	n	n	n	n	n	n	n
Rattus norvegicus	n	n	n	n	n	n	?	?
Apodemus mystacinus						n	n	
Apodemus sylvaticus	n	n	n	n	n	n	n	
Mus domesticus	n	n	n	n	n	n	n	n
Mus spretus	n	n						
Acomys minous						o		
Acomys nesiotes								o
Vulpes vulpes			n	n	n		n	n
Mustela nivalis	n	n	n	n	n	n		
Martes martes	n	n	?	n	n			
Martes foina						n	n	
Meles meles						n	n	
Genetta genetta	n							
Felis silvestris	?		n	n	n	n	?	
Sus scrofa			n	n				
Dama dama				† 1968			n	
Cervus elaphus			† 1969	n				
Ovis gmelini			n	n				n
Capra aegagrus						n		
TOTAL 39	12	11	16	19	18	17	12	9

which reached those islands that were joined to the nearest land-masses during the Late Pleistocene. Through this introduction of continental terrestrial mammals, the autochtonous faunal elements, represented mainly by endemic forms, were gradually replaced. As far as is known today, less than one-fourth of the mammalian species found in the continental Mediterranean region have been described as endemic to the area (Cheylan, 1990), including very peculiar elements, such as *Macaca sylvanus* L., 1758, and *Oryctolagus cuniculus* (L., 1758). The number of the endemisms drastically decreases if we consider the composition of the extant mammalian fauna on islands. Recent genetic and morphometric analyses show that only a few endemic micromammals still survive on the Mediterranean islands, and that these can be referred to a few species of shrews and, perhaps, of spiny mice.

The Sicilian white-toothed shrew (fig. 1)

From a cytogenetic analysis of shrews found on Sicily and the island of Gozo (Maltese archipelago), it became evident that all the members of the *Crocidura* genus from the Siculo-Maltese archipelago actually belong to the same species *Crocidura sicula* Miller, 1912 (Vogel *et al.*, 1989). This *taxon* is a Sicilian-Maltese endemic, distributed on Sicily, Levanzo, Favignana, Marettimo, Ustica and Gozo, and it is considered being extinct on Malta and Lampedusa (Vogel *et al.*, 1990; Sarà, 1995, 1996). Much evidence convincingly indicate that this is a probable survivor from the Pleistocene, but perhaps not related to the endemic *C. esuae* Kotsakis, 1986, living in the Middle Pleistocene of Sicily (Kotsakis, 1986; Hutterer, 1990; Sarà, 1995), and apparently replaced by *C. sicula* since the terminal Pleistocene (Bonfiglio *et al.*, 1997). Further investigations are however needed to define better the phylogenetic relations between these two Sicilian shrews. Recently, *C. sicula* has been identified as a conspecific form of *C. canariensis* (Hutterer *et al.*, 1987), endemic to the Canary islands (Sarà, 1995).

The Cretan white-toothed shrew

Crocidura zimmermanni Wettstein (1953) has been recognized by Reumer (1986) as a relic of the Early and Middle Pleistocene group of European *Crocidura* species, and of the Pleistocene Mediterranean fauna. Fossils of this species have probably been present since the Early Pleistocene. *Crocidura* has been found in association with those endemic mammals that lived on Crete during the Pleistocene. It regressed after the man-made introduction of those species which characterize the current fauna (Reumer and Payne, 1986). Today this shrew is not known anywhere outside of Crete (Reumer, 1996) and it is therefore considered endemic to this island (Vogel *et al.*, 1990; Reumer, 1996).

It can be assumed that these two shrews are the last remnants of a vanished world. As observed by Reumer (1986, 1996) for the Cretan shrew, both of them are relics in two senses: firstly, they are the direct descendants of the Pleistocene group of *Crocidura* species that have disappeared from Europe and have been replaced by the present living species; secondly, they are the only known survivors of the wealth of endemic species that were found in most of the Mediterranean islands during the Pleistocene.

Spiny mice on Mediterranean islands

The Cretan spiny mouse, *Acomys minous* (Bate, 1906) (fig. 2), and the Cypriot spiny mouse, *Acomys nesiotes* (Bate, 1903) have also been described by some authors as endemic to the islands (Dieterlein, 1963; Matthey, 1963; Spitzenberger, 1979; Macholán *et al.*, 1995). But against

Fig. 1: The small island of Ustica, off the north-western Sicilian shores, is inhabited by a melanistic population of the Sicilian white-toothed shrew, *Crocidura sicula* (Photograph by M. Sarà).

Fig. 2: The Cretan spiny-mouse, *Acomys minous* (Photograph by A. Trichas).

their supposed endemicity, however, there is the lack of any Pleistocene fossil of the genus recorded so far from the islands. Genetic analyses demonstrate the vicinity of the Cretan and of the Cypriot spiny mice to the *A. cahirinus-dimitiadus* group, distributed in Sinai, the Near East, and southwestern Asia (Macholán *et al.*, 1995). Except for *A. russatus* Wagner, 1840, which occurs from Egypt to eastern Arabia, the members of this group are the only spiny mouse taxa distributed outside the African continent. The assumption of an occasional importation on Crete and Cyprus of *Acomys* carried out by man from the nearest mainland has been also recently strenghtened by the results of cytochrome b (non coding region of mtDNA) analyses. These suggest that the two island spyny mice possibly belong to the species *A. cahirinus* (Desmarest, 1819) *sensu stricto* (Barome *et al.*, 1998). In fact, the low divergence between the sequences from *Acomys* from Cairo, Crete, Cyprus and Turkey suggests that the colonization of the islands is likely to be recent, and this could be explained as a dispersion due to humans (Barome *et al.*, 1998). It is also convenient to note that in the Mediterranean region the spyny mouse has been found within human settlements, where it is as a rule sympatric with *Mus musculus* L., 1758, and *Rattus rattus* (L., 1758), often behaving as a true commensal with man (Tchernov, 1991). In the Levant, according to Tchernov (1984, 1991), the abrupt increase in the frequency of *Acomys cahirinus* since the Natufian culture layers may be explained as a rapid adaptation of the species to commensal life around human settlements.

On the areas of provenance of the allochthonous mammals of Cyprus

Interdisciplinary research, based on zoological, archaeological, paleontological, zoo-archaeological, biogeographical, paleoethnological, ethnological and ethnozoological evidence, provide important clues as to where a species was originally distributed. Thus, in some cases it is possible to ascertain the probable area of the original continental distribution of the allochthonous species occurring today on the Mediterranean islands. One striking example is the introduction of the modern white-toothed shrew, *C. suaveolens praecypria* (Reumer and Oberli, 1988) to Cyprus which

Table 2: Distribution-types of the non-flying terrestrial wild mammals reported from Cyprus since Neolithic times (data from: Storrs and O'Brien, 1930; King, 1952; Harrison, 1964; Atallah, 1978; Spitzenberger, 1978, 1979; Lehmann and Nobis, 1979; Nobis and Lehmann, 1979; Davis, 1984, 1989; Harrison and Bates, 1991; Held, 1993; Hadjisterkotis and Masala, 1995; Macholán *et al.*, 1995). * This includes all the species common to the boreal Euroasiatic region, the Mediterranean region and the Saharo-Sindian region.

	Endemic species	Palaearctic pluriregional species*	Irano-Turanian and Indo-Asiatic species	Human commensal species
Hemiechinus auritus			u	
Crocidura suaveolens		u		
Suncus etruscus		u		
Felis silvestris		u		
Mustela nivalis		u		
Vulpes vulpes		u		
Sus scrofa		u		
Dama dama mesopotamica			u	
Cervus elaphus		u		
Ovis gmelini			u	
Capra aegagrus			u	
Lepus europaeus		u		
Mus domesticus				u
Rattus rattus				u
Rattus norvegicus				u
Acomys nesiotes*	u			
TOTAL 16	1	8	4	3

**Recent genetic analyses indicate the vicinity of the Cypriot *A. nesiotes* to the *A. cahirinus-dimitiadus* group, distributed in Sinai, the Near East, and southwestern Asia (Macholán *et al.*,1995).

took place long before the arrival of the species on Crete. The origin of the extant Cypriot shrew might not lie in Anatolia, but elsewhere in the Eastern Mediterranean region (Reumer and Oberli, 1988). This ancient Levantine origin of the Cypriot shrew reinforces the hypothesis made by King (1952), Zeuner (1958) and Ducos (1965), and followed by Davis (1984), about the Near-Eastern origin of another mammalian species, the Mesopotamian fallow deer, *Dama dama mesopotamica* (Brooke, 1875), documented since the Pre-Pottery Neolithic (Guilaine *et al.*, 1996) and Aceramic Neolithic (Davis, 1984) throughout the Chalcolithic and Bronze Age contexts of the island (Croft, 1991). The lack of any archaeological evidence on Cyprus for the origin of its Neolithic human settlers (cf. Le Brun, 1989) allows their origin to be referred to the closest area of the "natural" Early Holocene distribution of the Mesopotamian fallow deer, which is reported to be confined to the Levant and Mesopotamia, excluding Anatolia (Uerpmann, 1981).

Apart from the white-toothed shrew, the present-day mammalian fauna of Cyprus includes another species characteristic of the Levantine region, the long-eared hedgehog (*Hemiechinus auritus* Gmelin, 1778), the only species of hedgehog occurring on the island (Spitzenberger, 1978), and which is not recorded from Anatolia (Harrison and Bates, 1991) (tab. 2). The extant Cypriot mammalian fauna also comprises another species of eastern origin, the Asiatic mouflon (*Ovis gmelini* Blyth, 1841), also introduced by man to the island since the Pre-Pottery Neolithic (Guilaine *et al.*, 1996). The origin of *C. suaveolens* and *D. d. mesopotamica* seems to be the Eastern Mediterranean region, and probably the Levant area, whence they must have been imported since prehistorical times by the ancient human settlers of Cyprus. On the basis of current evidence, the present non-flying terrestrial mammalian fauna of Cyprus seems to have more elements in common with the extant fauna of the Levant than with that of southern Anatolia.

The prehistorical artificial diffusion of wild goats and mouflons in the Mediterranean region

Free-ranging populations of wild sheep and goats now inhabit several of the Mediterranean islands (fig. 3). They featured more or less the same morphological patterns, respectively, of the Asiatic moufflon and the bezoar goat (*Capra aegagrus* Erxleben, 1777) (Zimmermann, 1952; Toschi, 1953; De Beaux, 1955; Couturier, 1959; Kahmann, 1965; Payne, 1968; Poplin, 1979; Clutton-Brock, 1981; Masseti, 1981; Poplin and Vigne, 1983; Davis,

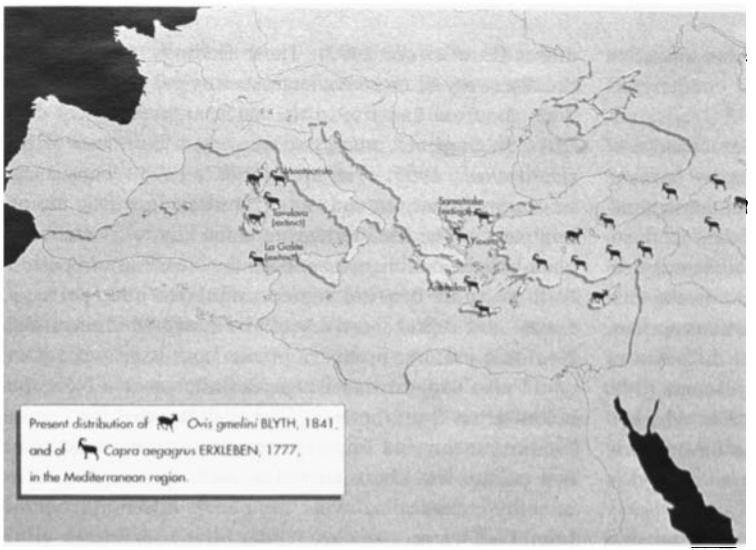

Fig. 3: Present distribution of the Asiatic mouflon and of the wild goat in the Mediterranean region (Drawing by A. Sacchetti).

1984; Geddes, 1985; Vigne, 1988a, 1988b, 1993a; Groves, 1989; Ciani and Masseti, 1991). These island ungulates were thought to be autochthonous forms. But it is now realized that they are ancient feral breeds preferably imported by man (Azzaroli, 1962, 1971; Payne, 1968; Poplin, 1977, 1979; Masseti, 1981; Poplin and Vigne, 1983; Davis, 1984, 1987; Geddes, 1985; Clutton-Brock *et al.*, 1990; Ciani and Masseti, 1991; Helmer, 1992; Vigne, 1992, 1993a). Of the various species of ungulates affected by Neolithic domestication, a local taming in certain areas outside the Near East must necessarily be excluded for sheep and goats, because their diffusion in the wild in southern Europe and the Mediterranean islands cannot be evidenced by any fossil record (Schultze-Westrum, 1963; Payne, 1968; Poplin, 1979; Azzaroli, 1983). Domestic caprines originated, in fact, in the Near East (Clutton-Brock, 1981; Davis, 1993). The Asiatic moufflon and the bezoar goat possibly began to be introduced artificially to the islands and continental areas of the western Mediterranean after they had already experienced some cultural control (see Logan *et al.*, 1994), in the form of animal keeping or loose herding. Animals up to the size even of a deer can be shipped rather easily over long distances on small and primitive boats (Clutton-Brock, 1981) like those on which early groups ventured out into the Mediterranean sea. The available archaeological documentation, based on still quite fragmentary evidence, would tend to indicate that the first relocations by sea in the Mediterranean basin were already carried out by hunter-gatherers, in expression contexts of a Mesolithic type, probably as early as the 9th millennium B.C. (Jacobsen, 1976; Perlès, 1979; Cherry, 1981, 1990, 1992; Simmons, 1991). Evidence from the islands of Corsica (Camps, 1988; Vigne and Desse-Berset, 1995), Melos (Cyclades) (Perlés, 1979; Renfrew and Aspinall, 1990) and, perhaps, Kythnos (Cherry, 1979) and Cyprus (Simmons, 1988, 1991) indicate an improved seafaring capability. In fact, from the late Mesolithic onwards, the Mediterranean sea can be considered the privileged path of penetration by navigation, for the process of colonization from the Near East towards southern Europe (Payne, 1975; Perlès, 1979; Shackleton *et al.*, 1984; Fedele, 1988; Pennacchioni, 1996). It is possible that, since early Neolithic times, some of the caprines that were imported as tamed and/or semi-domestic livestock on the Mediterranean islands escaped from their guardians' control, giving origin to the free-ranging population, the descendants of which persist until today. Back in the wild, they maintained the morphological patterns of their Near Eastern ancestors. In fact, as observed by Ryder (1983), the recognition of the origin of domestication is made difficult by the fact that the first domestic animals did not differ considerably from their wild counterparts. Analyses of the available osteological materials suggest a low level of morphological difference between the extant wild caprines of the Mediterranean islands and their prehistorical relatives. In fact, if any difference occurs, it seems to be limited more to the effects of domestication, such as the modification of the morphology of the horn cores (Boessneck, 1962; Vigne, 1988b) and of the size, than to other patterns. As observed by Davis (1984, 1989), the modern Cypriot moufflon is slightly smaller than its supposed ancestor - the Neolithic sheep - which may be due to island dwarfing. Paleontological data confirm that, on islands, dwarfism can develop in just a few millennia (Azzaroli, 1977). Still regarding Cyprus, however, throughout the periods of occupation of Khirokitia and Cape Andreas-Kastros, none of the three species - goat, fallow deer and boar - underwent any remarkable change in size (Davis, 1989), whereas it has been registered a small size increase in sheep (Davis, 1994). Measurements of fallow deer bones found in Vrysi (Legge, 1982) indicate that fallow deer did not change in size at least until the Ceramic Neolithic. The measurements of the cranial capacities of different insular population of extant wild

sheep and goats indicate that they are somewhat lower, on average, than those of their wild continental counterparts (Groves, 1989).

The possibility of studying the areas of provenance of the exotic elements is very complicated, partly because there might have existed special forms of "contamination" through the mediation of the coastal areas of the mainland. The examination of data reported from the archaeological sites of the circum-Mediterranean area, yielding the first documentation of the appearance of Near Eastern caprines, reveals that the westward oriented artificial diffusion of sheep and goats in the Mediterranean region seems to be quite independent from the cultural context in which it appears for the first time: Pre-Pottery and Aceramic Neolithic respectively in the eastern Mediterranean and in the Aegean region (8th-7th millennia BC), and Early Neolithic characterized by the production of impressed ware in the central and western Mediterranean, with a sort of Mesolithic enclave in southern France and in the Pyrenees (6th millennium BC) (Masseti, 1997b). To a certain extant, this diffusion also seems to contrast with the diffusionist model of the Neolithic colonization of Southern Europe (Ammerman and Cavalli-Sforza, 1984), due to the fact that proceeding toward the west, the evidence of the first introduction of sheep and goat is not accompanied by the contemporary diffusion of cultural elements of eastern origin, but it appears at times associated with different cultural stages and *facies*, characterized by the absence or the production of ceramics. For example, the Early Mediterranean Neolithic culture, associated with the appearance of tamed caprines and with the production of Cardial ware in the Western Mediterranean region, has been recognized as a locally developed cultural stage and not as a culture of Near Eastern origin (cf. Fagan, 1989).

The earliest known *Ovis* fossils from Sardinia are reported from Corbeddu Cave and have been referred to the 6th millennium BC (Sanges, 1987; Masseti and Vianello, 1991). This date coincides with the advent of the Early Neolithic culture of the Mediterranean region (6th millennium BC) on the island and the appearance of other continental mammals, perhaps including the red deer (*Cervus elaphus* L., 1758) and the fox (*Vulpes vulpes* L., 1758). According to Hartl *et al.* (1995), recent analyses of the mtDNA of several European red deer populations have demonstrated the similarity between the extant Sardinian deer and the deer of southern Bulgaria, possibly representing *C. e. maral* (Gray, 1850) (see Groves and Grubb, 1987). In addition, recent genetic evidence seems also to support the hypothesis that the extant Sardinian foxes are more related to eastern Europe populations than others (Frati *et al.*, 1997). These findings, together with the discovery of more ancient osteological remains of red deer, mouflon and fox in the same archaeological contexts on Sardinia, may also suggest a common origin (Hartl *et al.*, 1995; Frati *et al.*, 1997, 1998). Thus it can be assumed that, around the 6th millennium BC, in certain parts of the Mediterranean, some kind of contact had already been established between the Near Eastern prehistoric cultures bearing tamed ungulates and, perhaps, foxes, and representatives of the Early Mediterranean Neolithic culture, producer of the Impressed ware. One could also suggest that it was definitely not a Neolithic colonization from the Near East that invested the central Mediterranean and imported eastern artiodactyls, since that culture was characterized as early as the 6th millennium by ceramics that were completely different from the Impressed ware.

It now appears sufficiently credible that up to the early Holocene, the Mediterranean sea increasingly represented less a barrier than a bridge (Uerpmann, 1979; Lewthaite, 1987; Binder, 1989; Guilaine, 1994; Orliac, 1997), promoting and multiplying in a relatively short time the circulation of ideas, of merchandise, of faunal elements, and of human groups, which spread into new and different environments, and over time, in various ways, became grafted onto the autochtonous substratum.

Aspects of early husbandry in the Mediterranean islands

Man brought with him the animals he needed as economic supplies for the colonization of the new geographical areas. Together with sheep, goats, pigs, cattle and dogs, a variety of wild species were also brought onto the Mediterranean islands, including shrews, hedgehogs, hares, mice, spiny mice, dormice, foxes, weasels, martens, badgers, cats, red and fallow deer. It is necessary again to argue that these species have not been yielded by any of the Pleistocene deposits of the islands. It is not immediately apparent why man should have wanted to introduce all these animals. This phenomenon can only be explained considering each case individually. The evidence suggests that continental carnivores were imported voluntarily by man, otherwise they would not have been able to pass unobserved on board the small boats employed to reach the islands (Vigne, 1988a, 1995; Masseti, 1995). Synanthropic species, such as shrews and mice, in contrast, could well have been transported involuntarily by man, hidden within foodstuffs. Furthermore, ethnozoological enquiry documents that hedgehogs (Vigne, 1988a) and dormice (Carpaneto and Cristaldi,

1994) were utilized as food, medicine or for other purposes from prehistorical times onwards. With respect to the exploitation of the imported animals, human behaviour might have differed as the circumstances suggested, moving from the basis either of the colonists' economic needs or of the biological patterns of the different species exploited. As noted above, several of the Near Eastern large herbivores were of great economic importance in prehistory. Their biological patterns must have had some influence on related human behaviour. Not all of the tamed and/or semi-domestic ungulates that were imported into the islands might have been exploited in the same way, some of them being destined to breed in conditions of captivity and others in a free-ranging state, while others still could have returned to the wild after their introduction and were subsequently hunted by man as fully established wild game. As early as 1976, Jarman summarized the prehistoric relationships between man and ungulates in six main patterns, basing his classification on human economic behaviour rather than on morphological and zoological criteria as follows: random predation, controlled predation, herd following, loose herding, close herding, and factory farming (Jarman, 1976). Regarding human behaviour toward ungulates imported on islands, however, Jarman's first pattern of exploitation - random predation - was not fully appropriate, because it totally devoids aspects of "husbandry", in the sense of an effective long-term economic strategy which favours the continued existence of both partners in the relationship. There is sufficient archaeological evidence from the Mediterranean islands for the other types of "husbandry" classified by Jarman (1976), such as factory farming, loose and close herding, and even controlled predation. According to Croft (1991), for example, the range of animals exploited during the Chalcolithic period on Cyprus shows continuity from the preceding Aceramic and Ceramic Neolithic periods. Caprines and pigs, both domesticated at the same time on the nearby mainland, were most probably kept in herds, but free-ranging populations may also have been hunted. As already noted, the Neolithic fauna of Cyprus also includes the Mesopotamian fallow deer, but it is unlikely that this species, also of great economic importance in Early Prehistoric Cyprus, was ever fully domesticated (Croft, 1991). Fallow deer seem to have made a relatively important contribution to man's subsistence, and was possibly an animal that was released and hunted rather than a full domestic element. The prehistoric introduction of the other extant representative of the genus *Dama*, the European or common fallow deer, *D. d. dama* L., 1758, on islands such as Ayios Petros (Kyra-Panagya, Northern Sporades), Saliagos (between Paros and Antiparos, Cyclades), Rhodes (Dodecanese), and Crete, in sufficient number to act as a breeding stock for the substantial population for which there is archaeological evidence (Masseti, in press) clearly argues for a high degree of control over the animals and for their sophisticated management (Jarman, 1982). Often the examination of the osteological elements provided by a prehistorical site, such as caves occasionally inhabited by man, seems to indicate that the animals were not slaughtered inside but outside the cave. Only certain parts of the carcass, mainly legs and limbs, were carried inside. The rarity of certain species in the excavation levels does not necessarily reflect a rarity of the animal themselves, because the larger pieces of meat may have been eaten outside the cave (Sampson, 1987). The bones of cattle, pig, sheep and goat provided by the Neolithc levels of Kalythies Cave on Rhodes (Dodecanese archipelago, Greece), for example, derived from nearly all parts of the skeleton; variations in the representation of different parts of the skeleton could be purely the product of differences in the fragmentation, the survival, the recovery and the recognition of each anatomical element. It is likely, therefore, that these animals - which supposedly were kept in conditions of loose or close herding management - were killed and consumed in the vicinity of the cave (Halstead, 1987; Halstead and Jones, 1987). Among the deer material, in contrast, the best represented parts of the skeleton are the proximal humerus and proximal and distal femur. In this case it seems likely that particular joints of meat were selectively brought to the site probably from further afield (Halstead, 1987; Halstead and Jones, 1987), maybe from those areas of the island where the deer herds were previously released and then maintained in conditions of controlled predation.

In addition to Cyprus and Rhodes, the practice of keeping wild mammals as hunting game is also documented from other territories of the Eastern Mediterranean region, from prehistory up to protohistorical and early historical times. In Minoan Crete, for example, the local wild goat was regarded as a true game animal as it is shown by several artistic representations (Masseti, 1997a). In prehistorical and early historical Mediterranean cultures, iconographical sources furnish valid information that supports the paleontological and zooarchaeological data, and this also counts for the Minoan art. In case of a naturalistic representation, an artistic production might easily become an important source of paleofaunistic and paleoenvironmental evidence. In this regard, a sanctuary stone vase (*rython*; Middle Minoan II-Late Minoan I, about 1650-

1500 BC, Herakleion Museum) from the Minoan palace of Zakros, in eastern Crete, shows an interesting decorative motif: a peak sanctuary, on the roof of which a group of four wild goats is resting, probably ruminating (cf. Platon, 1971). The rendering of the morphological patterns of the artiodactyls is so accurate that they can be referred without doubt to the Cretan wild goat or *agrimi*, which presently survives in the White Mountains range (Lefka Ori; Masseti, 1997a). This Near Eastern continental species was introduced to Crete by man in early Neolithic times (Jarman and Jarman, 1968; Jarman, 1996), generating free-ranging populations that still persisted into Minoan periods (Masseti, 1997a, b). Osteological material recorded from the archaeological site of Festos document, however, the occurrence of two distinct forms of goat at least since the Terminal Neolithic (about 3.000 BC) on Crete (Wilkens, 1996). One of these is identical to the present *agrimi*, and was often represented pursued by dogs among the rocky landscapes of the island. The other one is characterized by morphological characters of a domestic race. According to Vigne (1993), the appropriation to hunting (*kinegetisation*) might be a component of neolithisation, just as is animal domestication: while some species were appropriate to breeding, others were appropriate to hunting.

Islands as natural enclosures. Concluding remarks

In the light of all this, it cannot be excluded that deer, as well as part of the caprines and the boars imported to the islands, could have been kept and bred since prehistory in a free-ranging state, while man exerted his control on the animal number through hunting being justified as occasionly demanded (fig. 4). This particular relatonship between man and ungulates is not so far removed from husbandry patterns still adopted on many islands of the Mediterranean, where domestic sheep and goats are kept in free-ranging conditions. These animals belong to a number of owners who capture them as need arises. This is one way of simplifying management problems, considering the islands as natural enclosures and allowing the livestock to derive its food supply directly from the carrying capacity of the environment. In many of the Aegean islands the custom of keeping livestock in free-ranging

Fig. 4: Several islets of the Aegean sea, such as Theodorou, Dia and Ayii Pantes facing the northern coast of Crete, are still employed as natural enclosures for the breeding of the Cretan wild goat, *C. aegarus cretica* SCHINZ, 1838 (Photograph by M. Masseti).

Fig. 5: On the island of Skyros (Northern Sporades, Greece), herds of the local small-sized horse are still kept in a free-ranging state (Photograph by M. Masseti).

conditions is still used not only in regard to domestic caprines, but also to other types of ungulates, for instance the horses of the island of Skyros, in the Northern Sporades (fig. 5). These small-sized horses possibly originated from very ancient introductions. They still graze and breed on the rocky plateaus of the island. As far as known today, they have been scantily employed as mounts due to their small size, that does not exceed the height of one meter at the withers. Until the 1960s, however, many of them were caught at harvesting time to be employed in threshing, and were then released again in the wild for the rest of the year (Coulentianou, 1981). According to Digard (1990), there is a category of domestic animals that are in a permanent condition of instable equilibrium between the domestic condition and the wild state, representing the relic of a very ancient breeding still adopted in several economically marginal areas of the world. To conclude, one may not overestimate the importance of the islands inhabited by free-ranging populations of herbivores, which represented living depositories of animal proteins available at any time along the marine routes of Antiquity since prehistorical periods. Indeed, some of the species, such as the hare and the goat, most adaptable to peculiar environmental conditions even of small islands were brought by sailors and let loose on islands so that they could breed and provide a store of fresh meat that would be readily available for the passengers of ships. As noted above, archaeological evidence of seafaring capability do exist since the pre-Neolithic period (Cherry, 1981, 1990, 1992; Vigne and Desse-Berset, 1995), and of the introduction of caprines on islands since the Pre-Pottery Neolithic (Jarman and Jarman, 1968; Davis, 1984; Halstead and Jones, 1987; Trantalidou, 1990, 1996; Guilaine *et al.*, 1996), and of lagomorphs since probably the Bronze Age (Jarman, 1996), even underlined by reports of classical authors, such as Homer (*Odissy*, IX, 116-124) and others. Xenophon, in his *Kinegeticon* (24-26), observed that hares were particularly abundant on islands due to the lack of predators that occurred conspicuously on the mainland. This practice was maintained up to historical times in the *leporaria* of the Roman period (Varro, *De re rustica*, III, 12, 1; Bodson, 1978) and the Middle Ages. For the same reasons,

rabbits are now found on several Mediterranean islands, in northern Europe and in many other parts of the world (Clutton-Brock, 1981; Flux and Fullagar, 1992; Flux, 1994; Callou, 1995).

This might be seen in contrast with the fact that for centuries these islands were better known for their richness in certain animals, most useful as a source for meat than for their faunal repertoire in general. This is reflected even in the names of several Mediterranean islands, especially some of the smaller ones, such as Conejera, Isola dei Conigli, Levrera, Cabrera, Caprara, Caprera, Capraia, Capri, Egadi islands, and Polyaigos.

Acknowledgements

This research was made possible by the financial support of the EEC Human Capital and Mobility Project CHRX-CT94-0597. I would like to express my appreciation and gratitude to the following friends and colleagues for their suggestions and assistance as I was preparing this paper: A. Azzaroli, P.-O. Barome, J. Clutton-Brock, F. Fanfani, P. Halstead, A. Legakis, F. Masini, P. Mazza, C. Peretto, D. S. Reese, M. Sanges, M. Sarà, S. Swiny, A. Trichas, B. Wilkens. Special thanks are due to S. J. M. Davis and J.-D. Vigne for the critical reading of the manuscript and for their suggestions.

Bibliography

ADAMAKOPOULOS P., ADAMAKOPOULOS T., BOUSBOURAS D., GIANNATOS G., HATZIRVASSANIS V., YOANNIDIS Y., PAPAIOANNOU D. H. and SFOUGARIS A., 1991.– Les grands mammifères de Grèce (Carnivores et Artiodactyles) : situation actuelle, répartition, habitat - les espèces menacées, perspectives de protection. *Biologia Gallo-hellenica*, 18: 107-126.

ALCOVER J. A., 1980.– Note on the origin of the present mammalian fauna from the Balearic and Pityusic Islands. *Miscellania zool.*, 6: 141-149.

ALCOVER J. A., 1988.– *Els mamìfers de les Balears*. 2nd edition. Palma de Mallorca: Editorial Moll, 192 p.

ALCOVER J. A., MOYA'-SOLA' S. and PONS-MOYA' J., 1981.– *Les quimeres del passat*. Palma de Mallorca: Editorial Moll, 265 p.

AMBROSETTI P., 1968.– The Pleistocene dwarf elephants of Spinagallo (Siracusa), southeastern Sicily. *Geologica Romana*, 7: 277-397.

AMMERMAN A. J. and CAVALLI-SFORZA L., 1984.– *The Neolithic transition and the genetics of populations in Europe*. Princeton: Princeton University Press, 210 p.

ATALLAH S. I., 1978.– Mammals of the Eastern Mediterranean region: their ecology, systematics and zoogeographical relationships. *Säugetierk.*, 26: 1-50.

AZZAROLI A., 1962.– Il nanismo dei cervi insulari. *Paleont. It.*, 26: 1-31.

AZZAROLI A., 1971.– Il significato delle faune insulari quaternarie. *Le Scienze*, 30: 84-93.

AZZAROLI A., 1977.– Considerazioni sui mammiferi fossili delle isole mediterranee. *Boll. Zool.*, 44: 201-211.

AZZAROLI A., 1983.– Biogeografia dei mammiferi della Sardegna. *Lavori della Società italiana di Biogeografia*, 8: 35-52.

BACCETTI B., 1964.– Considerazioni sulla costituzione e l'origine della fauna di Sardegna. *Arch. Bot. Biogeogr. Italiano*, 9 (6): 217-283.

BAROME P.-O., LYMBERAKIS P., MONNEROT M. and GAUTUN J.-C., 1998.– Molecular phylogeny brings new elements on Mediterranean *Acomys* species (*Rodentia, Muridae*). *In:* S. Reig ed., *Abstracts Euro-American Mammal Congress*. Santiago de Compostela: Universidade de Santiago de Compostela, p. 15.

BINDER D., 1989 - Aspects de la néolithisation dans les aires padane, provençale et ligure. *In*: O. Aurenche and J. Cauvin eds., *Néolithisation. BAR Int. Ser.*, 516: 199-226.

BLONDEL J. and VIGNE J.-D., 1993.– Space, time, and man as determinants of diversity of birds and mammals in the Mediterranean region. *In*: R. E. Ricklefs and D. Schluter eds., *Species diversity in ecological communities*. Chigaco and London: The University of Chicago Press, p. 135-146.

BODSON L., 1978.– Données antiques de zoogéographie. L'expansion des Léporidés dans la Méditerranée classique. *Les Naturalistes Belges*, 59: 66-81.

BOESSNECK J., 1962.– Die Tierreste aus der Argissa-Magoula vom Präkeramischen Neolithikum bis zur Mittleren Bronzezeit. *In*: V. Milojcic, J. Boessneck and M. Hopf eds., *Die Deutschen Ausgrabungen auf der Argissa-Magoula in Thessalien I: Das Präkeramische Neolithikum sowie die Tier- und Pfalnzenreste*. Bonn: Rudolf Habelt Verlag, p. 27-99.

BONFIGLIO L., INSACCO G., MARRA A. C. and MASINI F., 1997.– Large and small mammals, amphibians and reptiles from a new late Pleistocene fissure filling deposit of the Hyblean Plateau (South Eastern Sicily). *Bollettino della Società Paleontologica Italiana*, 36: 92-122.

BONHOMME F., FERNANDEZ J., PALACIOS F., CATALAN J. and MACHORDON A., 1986.– Caractérisation biochimique du complexe d'espèces du genre *Lepus* en Espagne. *Mammalia*, 50 (4): 495-506.

CALLOU C., 1995.– Modifications de l'aire de répartition du lapin (*Oryctolagus cuniculus*) en France et en Espagne, du Pléistocène à l'époque actuelle. État de la question. *Anthropozoologica*, 21: 95-113.

CAMPS G., 1988.– *Préhistoire d'une île*. Paris: Editions Errance, 284 p.

CARPANETO G. and CRISTALDI M., 1994.– Dormice and man: a review of past and present relations. *Hystrix* (n.s.), 6 (1-2): 303-330.

CASSOLA F. and MONNI A., 1989.– Status and conservation of Sardinian red deer. (*Abstracts of the World Conference on Mountain Ungulates, Camerino (Italy) 4th-6th September 1989*). Università degli Studi di Camerino (Macerata): 10.

CASTELLS A. and MAYO M., 1993 - Guia de los mamiferos en libertad de España y Portugal. Madrid: Ediciones Piràmide, 470 p.

CASU T., LAI G. and PINNA G. L., 1989.– *Guida alla Flora e alla Fauna della Sardegna*. Nuoro: Editrice Archivio Fotografico Sardo, 417 pp.

CATALISANO A., COSTANZO M., FAIS I., LO VALVO F., LO VALVO M., LO VERDE G., MASSA B., SARA' M., SORCI G. and ZAVA B., 1991.– Atlas Faunae Siciliae - Mammalia primi dati. *Suppl. Ric. Biol. Selvaggina*, 16: 569-572.

CHERRY J. F., 1979.– Four problems in Cycladic prehistory. *In*: J. L. Davis and J. F. Cherry eds., *Papers in Cycladic Prehistory. UCLA Institute of Archaeology Monograph*, 14: 22-47.

CHERRY J. F., 1981.– Pattern and process in the earliest colonization of the Mediterranean islands. *Proceedings of the Prehistoric Society*, 47: 41-68.

CHERRY J. F., 1990.– The first colonization of the Mediterranean islands: A review of recent research. *Journal of Mediterranean Archaeology*, 3: 145-221.

CHERRY J. F., 1992.– Palaeolithic Sardinians? Some questions of evidence and method. *In:* R. H. Tykot and T. K. Andrews eds., *Sardinia in the Mediterranean: A footprint in the sea*. Sheffield: Sheffield Academic Press, p. 28-39.

CHEYLAN G., 1990.– Endemism and speciation in Mediterranean mammals. *Vie et Milieu*, 40 (2/3): 137-143.

CIANI F. and MASSETI M., 1991.– Considerazioni sull'origine della popolazione ircina dell'isola di Montecristo, nel Mar Tirreno settentrionale. Elementi per un confronto cronologico-culturale con l'antica diffusione artificiale dell'egagro (*Capra aegagrus* Erxleben, 1777) nelle isole del Mediterraneo orientale. *Suppl. Ric. Biol. Selvaggina*, 18: 123-133.

CLUTTON-BROCK J., 1981.– *Domesticated animals from early times*. London: Heinemann and British Museum (Natural History), 208 pp.

CLUTTON-BROCK J., DENNIS-BRYAN K., ARMITAGE P. L. and JEWELL P. A., 1990.– Osteology of the Soay sheep. *Bulletin British Museum (Natural History)*, 56 (1): 1-56.

CROFT P., 1991.– Man and beast in Chalcolithic Cyprus. *BASOR*, 282/283: 63-79.

COULENTIANOU J., 1981.– The misfits of Skyros. Modern problems of survival facing an ancient breed of horses. *The Athenian*, 1981: 25-29.

COUTURIER A. J., 1959.– Statut actuel des représentants du genre *Capra* dans le bassin méditérranéen. *Colloque du Service de Sauvegarde IUCN*, 5: 12-19.

DAVIS S. J. M., 1984.– Khirokitia and its mammal remains. A Neolithic Noah's ark. *In:* A. Le Brun ed., *Fouilles récentes à Khirokitia (Chypre), 1977-1981*. Paris: Éditions Recherche sur les Civilisations, p. 189-162.

DAVIS S. J. M., 1987.– *The archaeology of animals*. London: B. T. Batsford Ltd, 224 p.

DAVIS S. J. M., 1989.– Some more animal remains from the Aceramic Neolithic of Cyprus. *In:* A. Le Brun ed., *Fouilles récentes à Khirokitia (Chypre) 1983-1986*. Paris: ADPF, Éditions Recherche sur les Civilisations, p. 189-221.

DAVIS S. J. M., 1993.– The zoo-archaeology of sheep and goat in Mesopotamia. *Bulletin of Sumerian Agriculture* (1993): 1-7.

DAVIS S. J. M., 1994.– Even more bones from Khirokitia: The 1988-1991 excavations. *In:* A. Le Brun ed., *Fouilles récentes à Khirokitia (Chypre) 1988-1991*. Paris: ADPF, Éditions Recherche sur les Civilisations, p. 305-333.

DE BEAUX O., 1955.– Posizione sistematica degli stambecchi e capre selvatiche viventi (*Capra* Linneo, 1758) e loro distribuzione geografica. *Atti dell'Accademia Ligure di Scienze e Lettere*, 12: 1-110.

DIETERLEIN F., 1963.– Zur Kenntnis der Kreta-Stachelmaus, *Acomys (cahirinus) minous* Bate. *Z. Säugetierk.*, 28: 47-57.

DIGARD J.-P., 1990.– *L'homme et les animaux domestiques*. Paris: Fayard, 325 p.

DUCOS P., 1965.– Le daim à Chypre aux époques préhistoriques. *RDAC*: 1-8.

ELTON C., 1958.– *The ecology of invasions by animals and plants*. London: Chapman and Hall.

FAGAN B. M., 1989.– *People of the earth*. Glenview (Illinois), Boston, London: Scott, Foresman and Company.

FEDELE F., 1988.– Malta: origini e sviluppo del popolamento preistorico. *In:* A. Fradkin Anati and E. Anati eds., *Missione a Malta*. Milano: Jaca Book, p. 51-90.

FLUX J. E. C., 1994.– World distribution. *In:* H. V. Thompson and C. M. King eds., *The European Rabbit*. Oxford, New York and Tokyo: Oxford University Press, p. 8-21.

FLUX J. E. C. and FULLAGAR P., 1992.– World distribution of the rabbit *Oryctolagus cuniculus* on Islands. *Mammal Review*, 22: 151-202.

FRATI F., FLEBA L., HARTL G. B. and LOVARI S., 1997.– L'origine della volpe sarda. *Suppl. Ric. Biol. Selvaggina*, 27: 533-537.

FRATI F., HARTL G. B., LOVARI S., DELIBES M. and MARKOV G., 1998.– Quaternary radiation and genetic structure of the red fox *Vulpes vulpes* in the Mediterranean basin, as revealed by allozymes and mitochondrial DNA. *J. Zool. London*, 245: 43-51.

GEDDES D. S., 1985.– Mesolithic domestic sheep in West Mediterranean Europe. *J. of Archaeological Science*, 12: 25-48.

GISBERT J., 1996.– Taxonomia y distribucion de los carnivoros ibericos actuales. *In:* R. Garcia-Perea, R. A. Baquero, R. Fernandez-Slavador and J. Gisbert eds., *Carnivoros: evolucion, ecologia y conservacion*. Madrid: Museo Nacional de Ciencias Naturales, p. 79-100.

GROVES C. P., 1989.– Feral mammals of the Mediterranean islands: documents of early domestication. *In:* J. Clutton-Brock ed., *The Walking Larder*. London: Unwin Hyman, p. 46-58.

GROVES C. P. and GRUBB P., 1987.– Relationships of Living Deer. *In:* C. M. Wemmer ed., *Biology and Management of the Cervidae*. Washington D.C. and London: Smithsonian Institution Press, p. 21-59.

GUILAINE J., 1994.– *La Mer Partagée. La Méditerranée avant l'Écriture (7000-2000 avant Jesus-Christ)*. Paris: Hachette.

GUILAINE J., BRIOIS F., COULAROU J., VIGNE J.-D. and CARRÉRE I., 1996.– Shillourokambos et les débuts du Néolithique à Chypre. *Espacio, Tiempo y Forma, Serie I, Prehistoria y Arquelogia*, 9: 159-171.

HADJISTERKOTIS E. and MASALA B., 1995.– Vertebrate extinction in Mediterranean islets: an example from Cyprus. *Biogeographia*, 18: 691-699.

HALSTEAD P., 1987.– Man and other animals in later Greek Prehistory. *B.S.A.*, 82: 71-83.

HALSTEAD P. and JONES G., 1987.– Bioarchaeological remains from Kalythies Cave, Rhodes. *In*: A. Sampson ed., *The Neolithic period in the Dodecanese*. Athens: Ministry of Culture, p. 135-152.

HARRISON D. L., 1964.– *The mammals of Arabia. Vol. I. Insectivora, Chiroptera, Primates*. London: Ernest Ben Ltd, 192 p.

HARRISON D. L. and BATES P. J. J., 1991.– *The mammals of Arabia*. Sevenoaks (England) : Harrison Zoological Museum, 354 p.

HARTL G. B., NADLINGER K., APOLLONIO M., MARKOV G., KLEIN F., LANG G., FINDO S. and MARKOWSKY J., 1995.– Extensive mitochondrial differentiation among European red deer (*Cervus elaphus*) populations: implications for conservation and management. *Z. Säugetierk.*, 60: 41-52.

HELD S. O., 1993.– Insularity as a modifier of culture change: The case of Prehistoric Cyprus. *BASOR*, 292: 25-33.

HELMER D., 1992.– La domestication des animaux par les hommes préhistoriques. Paris: Masson, 184 p.

HUTTERER R., 1990.– Temporal and geographic variation of shrews of the Sicilian-Maltese archipelago since the Pleistocene. *Vie et Milieu*, 2/3: 213-217.

HUTTERER R., LÒPEZ-JURADO L. and VOGEL P., 1987.– The shrews of the Eastern Canary Islands: a new species (Mammalia: Soricidae). *J. nat. Hist.*, 21: 1347-1357.

JACOBSEN T. W., 1976.– 17.000 anni di preistoria greca. *Le Scienze*, 98: 68-81.

JARMAN M. R., 1976.– Early animal husbandry. *Phil. Trans. R. Soc. London*, B. 275: 85-97.

JARMAN M. R., 1982.– Palaeoeconomic perspectives. *In*: M. R. Jarman, G. N. Bailey and H. N. Jarman eds., *Early European agriculture: Its foundations and development*. Cambridge: Cambridge University Press, p. 49-71.

JARMAN M. R., 1996.– Human influence in the development of the Cretan mammalian fauna. *In:* D. S. Reese ed., *Pleistocene and Holocene fauna of Crete and its first settlers*. Madison (Wisconsin) : Prehistory Press, p. 211-229.

JARMAN M. R. and JARMAN H. N., 1968.– The fauna and economy of Early Neolithic Knossos. *B.S.A.*, 63: 241-276.

KAHMANN H., 1965.– Notes sur le statut actuel de quelques mammifères menacés dans la région méditerranéenne. *Mammalia*, 23: 329-331.

KING J. E., 1952.– Mammal bones from Khirokitia and Erimi. *In:* P. Dikaios ed., *Khirokitia. Monograph of the Cyprus Dep. of Antiquities,* Nicosia: 431-437.

KOTSAKIS T., 1986.– *Crocidura esui* n. sp. (Soricidae, Insectivora) du Pléistocène de Spinagallo (Sicilie orientale, Italie). *Geologica Romana*, 23: 51-64.

LE BRUN A., 1989.– La néolithisation de Chypre. *In:* O. Aurenche and J. Cauvin eds., *Néolithisation: Proche et Moyen Orient, Méditerranée orientale, Nord de l'Afrique. Europe méridionale, Chine, Amérique du Sud. B.A.R. Int. Ser.*, 516: 95-107.

LEGGE A. J., 1982.– Ayios Epiktitos: the recent farming economy and the economic evidence. *In:* E. Peltenburg ed., *Vrysi; a subterranean settlement in Cyprus. Prehistoric excavations 1969-73*. Warminster: Aris and Phillips, p. 14-20 and 76-90.

LEHMANN E. von and NOBIS G., 1979.– Subfossile Mauswiesel *Mustela nivalis* Linné, 1766 aus Enkomi-Alasia auf Zypern. *Bonn. zool. Beitr.*, 30: 32-37.

LEWTHWAITE J., 1987.– Three steps to leaven: applicazione del modello di disponibilità al Neolitico italiano. *In: Atti della XXVI Riun. Scient. U.I.P.P. "Il Neolitico in Italia"*, Firenze, 7-10 November 1985: 89-102.

LOGAN G. T., BROWN J. H., HUSBAND T. P. and NICHOLSON M. C., 1994.– Conservation biology of the Cretan agrimi. *Biologia Gallo-hellenica*, 22: 241-246.

MACHOLÁN M., ZIMA J., CERVENA' A. and CERVENY' J., 1995.– Karyotype of *Acomys cilicicus* Spitzenberger, 1978 (Rodentia, Muridae). *Mammalia*, 59 (3): 397-402.

MASSETI M., 1981.– La capra selvatica nel Mediterraneo. *L'Universo*, 2: 177-218.

MASSETI M., 1993.– Post-Pleistocene variations of the non-flying terrestrial mammals on some Italian islands. *Suppl. Ric. Biol. Selvaggina*, 21: 209-217.

MASSETI M., 1995.– Quaternary biogeography of the Mustelidae family on the Mediterranean islands. *Hystrix*, 7 (1-2): 17-34.

MASSETI M., 1996.– The post-glacial diffusion of the genus *Dama* Frisch, 1775, in the Mediterranean region. *Suppl. Ric. Biol. Selvaggina*, 25: 7-29.

MASSETI M., 1997a.– Representation of birds in Minoan art. *International Journal of Osteoarchaeology*, 7: 354-363.

MASSETI M., 1997b.– The prehistorical diffusion of the Asiatic mouflon, *Ovis gmelini* Blyth, 1841, and of the Bezoar goat, *Capra aegagrus* Erxleben, 1777, in the Mediterranean region beyond their natural distributions. *In:* E. Hadjisterkotis ed., *Proceedings of the 2nd International Symposium on Mediterranean mouflon "The Mediterranean Mouflon: Management, Genetics and Conservation"*. Nicosia: Game Fund, Ministry of Interior, p. 12-27.

MASSETI M., in press.– The fallow deer, *Dama dama* L., 1758, in the Aegean region. *Contributions to the zoogeography and ecology of the Eastern Mediterranean region*, 1.

MASSETI M. and VIANELLO F., 1991.– Importazioni preistoriche di mammiferi alloctoni nelle isole del Mar Tirreno centro-settentrionale. *Rivista di Scienze Preistoriche*, 43 (1-2): 275-292.

MATTHEY R., 1963.– Polymorphisme chromosomique intraspécifique et intraindividuel chez *Acomys minous* Bate (Mammalia - Rodentia - Muridae). *Chromosoma*, 14: 468-497.

MILLER G. S., 1912.– *Catalogue of the mammals of Western Europe*. London: British Museum (Natural History), 1020 p.

NIETHAMMER J., 1989.– Gewöllinhalte der Schleiereule (*Tyto alba*) von Kos und aus Südwestanatolien. *Bonn. zool. Beitr.*, 40: 1-9.

NOBIS G. and LEHMANN E. von, 1979.– Ein Geweistück vom Rothirsch, *Cervus elaphus* Linné, 1758, aus Kition, Zypern. *Säugetierk.*, 27 (2): 158-160.

ONDRIAS J. C., 1965.– Die Säugetiere Griechenlands. *Säugetierk. Mitt.*, 13: 109-127.

ONDRIAS J. C., 1966.– The taxonomy and geographical distribution of the rodents of Greece. *Säugetierk. Mitt.*, 14: 1-136.

ORLIAC M., 1997.– L'homme marin. *In:* J.-D. Vigne ed., *Îles. Vivre entre ciel et mer*. Paris: Éditions Nathan et Muséum national d'Histoire naturelle, p. 39-53.

PAYNE S., 1968.– The origins of domestic sheep and goats; a reconsideration in the light of fossil evidence. *Proc. Prehist. Soc.*, 34: 368-384.

PAYNE S., 1975.– Faunal change at Franchthi Cave from 20,000 B.C. to 3,000 B.C. *In:* A. T. Clason ed., *Archaeozoological studies*. Amsterdam and New York: Elsevier, p. 120-131.

PENNACCHIONI M., 1996.– Correnti marine di superficie e navigazione durante il Neolitico. *Abstracts of the sections of the XIII International Congress of Prehistoric and Protohistoric Sciences*. Abaco, Forlì: A.B.A.C.O., p. 257-258.

PERLÈS C., 1979.– Des navigateurs méditerranéens il y a 10.000 ans. *La Recherche*, 10 (96): 82-85.

PIEPER H., 1965-66.– Über einige bemerkenswerte Kleinsäuger-Funde auf den Inseln Rhodos und Kos. *Acta biol. Hellenica*, 1: 21-28.

PLATON N., 1971.– *Zakros. The discovery of a lost palace of Ancient Crete*. New York: Charles Scribner's sons, 339 p.

POPLIN F., 1977.– Paléontologie du mouton. *In*: *Les débuts de l'élevage du Mouton. Ethnozootechnie*, 21: 9-10.

POPLIN F., 1979.– Origine du mouflon de Corse dans une nouvelle perspective paléontologique : par marronage. *Ann. Génet. Sél. Animale*, 11: 133-143.

POPLIN F. and VIGNE J.-D., 1983.– Observation sur l'origine des Ovins en Corse. *Congr. Préhistorique de France*, 21 (2): 238-345.

RAGNI B., MASSETI M., ROUSSOS T., BELARDINELLI A. and CICCONI P., in press.– The carnivores of the island of Crete (Greece). *Contributions to the Zoogeography and Ecology of the Eastern Mediterranean Region*, 1.

RENFREW C. and ASPINALL A. A., 1990.– Aegean obsidian and Franchthi Cave. *In*: C. Perlès ed., *Les industries lithiques taillées de Franchthi (Argolide, Grèce)*. Tome 2 : *Les industries lithiques du Mésolithique et du Néolithique initial*. Bloomington and Indianapolis: p. 257-270.

REUMER J. W. F., 1986.– Notes on the Soricidae (Insectivora, Mammalia) from Crete. I. The Pleistocene species *Crocidura zimmermanni*. *Bonn. zool. Beitr.*, 37 (3): 161-171.

REUMER J. W. F., 1996.– Shrews (Soricidae) on islands, with special reference to *Crocidura zimmermanni* from Crete. *In:* D. S. Reese ed., *Pleistocene and Holocene fauna of Crete and its first settlers*. Madison (Wisconsin): Prehistory Press, p. 173-179.

REUMER J. W. F. and OBERLI U., 1988.– Shrews (Mammalia: Soricidae) from a Bronze Age deposit in Cyprus, with the description of a new subspecies. *Bonn. zool. Beitr.*, 39 (4): 305-314.

REUMER J. W. F. and PAYNE S., 1986.– Notes on the Soricidae (Insectivora, Mammalia) from Crete. II. The shrew remains from Minoan and Classical Kommos. *Bonn. zool. Beitr.*, 37 (3): 173-182.

RYDER M. L., 1983.– *Sheep and man*. London: Gerald Duckworth & Co. Ltd, 846 p.

SALOTTI M., 1992.– Carnivores sauvages actuels de Corse. *Encyclopédie des carnivores de France. Hors-Série*. Paris: Soc. fr. Et. Protect. Mammifères, p. 29-36.

SAMPSON A., 1987.– The Neolithic period in the Dodecanese. *In:* A. Sampson ed., *H Neoliqikh periodos sta Dwdekanhsa*. Athens: Ministry of Culture, p. 183-190.

SANDERS E. A. C. and REUMER J. W., 1984.– The influence of prehistoric and Roman migrations on the vertebrate fauna of Menorca (Spain). *BAR Int. Series*, 229: 119-144.

SANGES M., 1987.– Gli strati del Neolitico antico e medio nella Grotta Corbeddu di Oliena (Nuoro). Nota preliminare. *In: Atti della XXVI Riun. Scien. U.I.P.P.*, Firenze, 7-10 November 1985: 825-830.

SARÀ M., 1995.– The Sicilian (*Crocidura sicula*) and the Canary (*C. canariensis*) shrew (Mammalia, Soricidae): peripheral isolate formation and geographic variation. *Boll. Zool.*, 62: 173-182.

SARÀ M., 1996.– *Crocidura* populations (Mammalia, Soricidae) from the Sicilian-Maltese insular area. *Hystrix*, (1-2): 121-132.

SCHENK H., 1976.– Analisi della situazione faunistica in Sardegna. Uccelli e mammiferi. *In:* F. Pedrotti ed., *SOS fauna. Animali in pericolo in Italia*. Camerino: Edizione W.W.F., p. 465-556.

SCHULTZE-WESTRUM T., 1963.– Die Wildziegen der ägäischen Inseln. *Säugetierk. Mitt.*, 4: 145-182.

SHAKLETON J. C., VAN ANDEL T. H. and RUNNELS C. N., 1984.– Costal palaeogeography of the Central and Western Mediterranean during the last 125,000 years and its archaeological implications. *Journal of Field Archaeology*, 11: 307-314.

SIMMONS A. H., 1988.– Extinct pygmy hippopotamus and early man in Cyprus. *Nature*, 333: 554-557.

SIMMONS A. H., 1991.– Humans, island colonization and Pleistocene extinctions in the Mediterranean: the view from Akrotiri *Aetokremnos*, Cyprus. *Antiquity*, 249: 857-869.

SONDAAR P. Y., 1971.– Palaeozoogeography of the Pleistocene mammals from Aegean. *In:* A. Strid ed., *Evolution in the Aegean. Opera botanica*, 30: 65-70.

SONDAAR P. Y., 1977.– Insularity and its effects on mammal evolution. *In:* M. K. Hecht, P. C. Goody and B. M. Hecht eds., *Major patterns in vertebrate evolution*. NATO Advanced Study Inst., (A) 14. New York and London: Plenum Press, p. 671-707.

SONDAAR P. Y., DE BOER P. L., SANGES M. and KOTSAKIS T., 1984.– First report on a Paleolithic culture in Sardinia. *BAR Int. Ser.*, 229: 29-47.

SONDAAR P. Y., SANGES M., DE BOER P. L. and KOTSAKIS T., 1986.– The Pleistocene deer hunter of Sardinia. *Geobios*, 19: 17-25.

SPITZENBERGER F., 1978.– Die Säugetierfauna Zypern. I: Insectivora und Rodentia. *Ann. Naturhist. Mus. Wien*, 81: 401-441.

SPITZENBERGER F., 1979.– Die Säugetierfauna Zypern. II: Chiroptera, Lagomorpha, Carnivora und Artiodactyla. *Ann. Naturhist. Mus. Wien*, 82: 439-465.

STORRS R. and O'BRIEN B. J., 1930.– *The Handbook of Cyprus*. London: Christophers, 136 p.

SWINY S., 1988.– The Pleistocene fauna of Cyprus and recent discoveries on the Akrotiri peninsula. *Report of the Department of Antiquities Cyprus, 1988 (Part 1)* : 1-14.

TCHERNOV E., 1984.– Commensal animals and human sedentism in the Middle East. *In:* J. Clutton-Brock and C. Grigson eds., *Animal and Archaeology. BAR International Series*, 202: 91-115.

TCHERNOV E., 1991.– Biological evidence for human sedentism in Southwest Asia during the Natufian. *In:* O. Bar-Yosef and F. R. Valla eds., *The Natufuan culture in the Levant*. Ann Arbor, Michigan: International Monographs in Prehistory, Archaeological Series 1., p. 315-340.

TOSCHI A., 1953.– Note sui vertebrati dell'isola di Montecristo. *Ric. Zool. Appl. Caccia*, 23: 3-52.

TRANTALIDOU K., 1990.– Animals and human diet in the Prehistoric Aegean. *In:* D. A. Hardy ed., *Thera and the Aegean World III. Vol. Two. Earth Sciences*. London: The Thera Foundation, p. 392-405.

TRANTALIDOU K., 1996.– Agriculture, animal husbandry, hunting, fishing. *In:* G. A. Papathanassopoulos ed., *Neolithic culture in Greece*. Athens: Nicholas P. Goulandris Foundation, p. 95-102.

UERPMANN H.-P., 1979.– *Probleme des Neolithisierung des Mittelmeersraumen.* Beihefte Tübingen Atlas Vorderes Orient Reihe. B28. Wiesbaden: Reichert.

UERPMANN H.-P., 1981.– The major faunal areas of the Middle East during the Late Pleistocene and Early Holocene. *In:* J. Cauvin and P. Sanlaville eds., *Préhistoire du Levant*. Paris: Éd. C.N.R.S., p. 99-106.

VIGNE J.-D., 1987.– L'extinction holocène du fond (*sic)* de peuplement mammalien indigène des îles de Méditerranée occidentale. *Mém. Soc. geol. France*, 150: 167-177.

VIGNE J.-D., 1988a.– Apports de la biogéographie insulaire à la connaissance de la place de mammifères sauvages dans les sociétés néolithiques méditerranéennes. *Anthropozoologica*, 8: 31-52.

VIGNE J.-D., 1988b.– Les mammifères post-glaciaires de Corse. Etude archéozoologique. *26e suppl. Gallia Préhistorie*. Paris: Éd. CNRS.

VIGNE J.-D., 1990.– Biogeographical history of the mammals on Corsica (and Sardinia) since the Final Pleistocene. *Atti Conv. Lincei*, 85: 370-392.

VIGNE J.-D., 1992.– Zooarchaeology and the biogeographical history of the Mammals of Corsica and Sardinia since the last Ice Age. *Mammal Review*, 2: 87-96.

VIGNE J.-D., 1993a.– Les transferts anciens de mammifères en Europe occidentale: histoires, mécanismes et implications dans les sciences de l'homme et les sciences de la vie. *In:* L. Bodson ed., *Des animaux introduits par l'homme dans la faune de l'Europe. Coll. hist. conn. zoologiques*, 5. Université de Liège: 15-37.

VIGNE J.-D., 1993b.– Domestication ou appropriation pour la chasse: histoire d'un choix socio-culturel depuis le Néolithique. L'exemple des cerfs (*Cervus*). *In:* J. Desse et F. Audoin-Rouzeau eds., *Exploitation des animaux sauvages à travers le temps*. Juan-les-Pins: Éditions APDCA, p. 201-220.

VIGNE J.-D., 1995.– Aproximacions arquezoològiques de la relacio' home-animal en els territoris insulars: l'exemple mediterrani. *Cota Zero*, 11: 61-70.

VIGNE J.-D., 1996.– Did man provoke extinctions of endemic large mammals on the Mediterranean islands? The view from Corsica. *Journal of Mediterranean Archaeology*, 9 (1): 117-120.

VIGNE J.-D. and ALCOVER J. A., 1985.– Incidence des relations historiques entre l'Homme et l'Animal dans la composition actuelle du peuplement amphibien, reptilien et mammalien des îles de Méditerranée occidentale. *Actes du 11e Congrès national des Sociétés Savantes* (Montpellier, 1985), 2: 79-91.

VIGNE J.-D. and DESSE-BERSET N., 1995.– The exploitation of animal resources in the Mediterranean Islands during the Pre-Neolithic: the example of Corsica. *In:* A. Fischer ed., *Man and sea in the Mesolithic.* Oxford: Oxbow Books, p. 309-318.

VIGNE J.-D. and VALLADAS H., 1996.– Evolution of the man-made environment in Northern Corsica (Western Mediterranean) during the last 2,500 years, from the small mammal fossils of Monte di Tuda. *J. Archaeological Science*, 23: 199-215.

VOGEL P., HUTTERER R. and SARÀ M., 1989.– The correct name, species diagnosis and distribution of the Sicilian shrew. *Bonn. zool. Beitr.*, 40: 243-248.

VOGEL P., MADDALENA T. and SCHEMBRI P. J., 1990.– Cytotaxonomy of shrews of the genus *Crocidura* from Mediterranean islands. *Vie et Milieu*, 2/3: 124-129.

WATSON J. P. N., STANLEY-PRICE N. P. and ARNOLD E. N., 1977.– The vertebrate fauna from the 1972 sounding at Khirokitia. *Rep. Dep. Antiquities*, Nicosia (1977): 232-260.

WETTSTEIN O. von, 1941.– Die Säugerwelt der Ägäis, nebst einer Revision des Rassenkreises von *Erinaceus europaeus*. *Ann. Naturhist. Mus. Wien*, 52: 245-278.

WILKENS B., 1996.– Faunal remains from Italian excavations on Crete. *In:* D. S. Reese ed., *Pleistocene and Holocene fauna of Crete and its first settlers. Monographs in World Archaeology*, 28: 241-261.

ZEUNER F. E., 1958.– Animal remains from a Late Bronze Age sanctuary on Cyprus, and the problem of the domestication of fallow deer. *J. Palaeont. Soc. India, Lucknow. Birbal Sahni Memorial*, 3: 131-135.

ZIMMERMANN K., 1952.– Das Gesamtbild der Säuger-Fauna Kretas. *Z. Säugetierk.*, 67: 1-72.