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Vertebrate extinction in Mediterranean islets: an example from Cyprus

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SUMMARY

Cyprus is the third island in the Mediterranean with an area of 9.251 Km^2. Is a 15 million year old island of oceanic origin which has never been connected to the mainland. In this study we attempt to tally all the extinctions that took place on the island of Cyprus and compare the emerging pattern with that of other islands. All the endemic animals recorded from the Pleistocene Fauna, the Pygmy hippopotamus *Phanourios minutus*, the Pygmy elephant *Elaphas cypriotas*, the Cyprus genet *Genetta plesictoides*, and the Ancient Cypriot shrew *Crocidura suaveolens praacypria*, are extinct. These animals represent 60% of the endemic mammalian species aver recorded in Cyprus and 20% of the endemic subspecies. From the Archaeological Fauna nine taxa of animals were reported, which (with the exception of the Cyprus mouflon *Ovis gmelini ophion*) are not present today. From the avifauna two species and seven subspecies (12% of the total number of breeding taxa) were noted as endemic. Two of the latter, the Dipper *Cinclus cinclus olympicus* is extinct and the Raven *Corvus corax cyprius* is in danger of extinction. This pattern of extinction of indigenous species was also observed on other islands and is a consequence of small isolated island populations.

INTRODUCTION

A characteristic of modern extinctions of birds and mammals is that they are concentrated on islands (Diamond, 1984). For birds, 171 species and subspecies have become extinct since 1600, and over 90 percent of these extinctions have occurred on islands. For mammals out of 115 documented historic extinctions, 36 percent of these have occurred on islands. This pattern is in part due to the nature of island populations. They are small and isolated; thus they cannot recover from local extirpation following environmental perturbations or long-term climatic changes by immigration from other areas (MacArthur and Wilson, 1967; Leigh, 1981).

A growing body of evidence for birds and mammals indicates that over the last few thousand years, the most important agent of direct change in the environments is human disturbance and alteration of habitats (Diamond, 1984). Most extinct species in recorded history are attributed to some aspects of human interference, such as: habitat destruction; human hunting; effects of introduced taxa particularly predators, and trophic cascades (i.e., secondary extinctions caused by previous extinctions; Diamond and Case, 1986). Usually the period immediately following the initial settlement of islands is correlated

with increased vertebrate extinction rates, especially of large endemic species (Steadman et al., 1984; Olson and James, 1982; Pregill, 1986).

Cyprus, is the third largest island in the Mediterranean, with an area of 9,251 km^2. It is a 15 million year old island of oceanic origin which has never been connected to the mainland. In the Pleistocene glacial episodes the minimum distance to the mainland would have been 30 km (Swiny, 1988). As a result, all the ancestors of the endemic terrestrial mammals of the Pleistocene or later date would have had to reach the island by swimming or to have been imported by humans (Hadjisterkotis, 1993).

In this study we tally all known endemic species recorded from the Pleistocene period, historic (archaeological) and present (past 100 years) times, and the extinctions that took place on Cyprus. This pattern is compared with that of other islands. Theoretically, since Cyprus is an isolated island, it would be expected that the native and particularly the large endemic animals are more vulnerable to extinction than the non-endemic species. In addition, the arrival of man would have probably been associated with increased extinction rates of indigenous species.

METHODS

The literature was reviewed and all mammals from the Pleistocene periods, historic (archaeological period), and present (the last 100 years) were recorded. All birds from the same periods were examined, but only the endemic or extinct taxa were recorded. Based on these data the percentages of the extinct species and subspecies were estimated. The findings were compared with those of other islands. All native extinct taxa were separated into endemic or indigenous.

RESULTS AND DISCUSSION

Table 1 - Past and present wild birds and mammals of Cyprus

A: Pleistocene fauna (All but number five are endemic and extinct)

1. (Cypriot) pygmy hippopotamus *Phanourios minutus* (Cuvier, 1824) [Forsyth Major, 1902; Woodward, 1903; Bate, 1904, 1906; Mantis, 1969; Boekschoten and Sondaar, 1972; Reese, 1975; Simmons, 1988, 1991].
2. (Cypriot) Pygmy elephant *Elephas cypriotes* Bate, 1903 [Bate, 1903a, 1904b; Boekschoten and Sondaar, 1972; Simmons, 1991].
3. (Cypriot) Genet *Genetta plesictoides* Bate, 1903 [Bate, 1903b, 1903c; Boekschoten and Sondaar, 197y].
4. (Ancient Cypriot) Shrew *Crocidura suaveolens praecypria* Reumer and Oberli, 1988.
5. *Mus* spp. (Bate, 1903d; Boekschoten and Sondaar, 1972).

B: Wild mammals known from the archaeological fauna (All but numbers 6, 11, 13 to 16 are not living on the island today)

1. (Mesopotamian) Fallow deer *Dama mesopotamica* (Brooke, 1875). Aceramic Neolithic Period to Late-te Bronze Age sites (Zeuner, 1958; Schwartz, 1973; Davis, 1984; Croft, 1988, 1990, 1991).
2. (European) Fallow deer *Dama dama* (Linnaeus, 1758). Late Cypriot Palaepaphos *Teratsoudhia* (Croft, 1990).

(*segue* Table 1)

3. Red deer *Cervus elaphus* (Linnaeus, 1758). One piece of antler at Late Bronze Kition (Nobis and Lehmann, 1979). Three antlers at Hala Sultan Tekke [Late Cypriot] (Ekman, 1977).
4. Weasel *Mustela nivalis* (Linnaeus, 1758). Late Bronze, Iron Age (Croft, 1990).
5. Wild cat *Felis silvestris/F. lybica*. Aceramic Neolithic, Late Neolithic (Davis, 1989; Croft, 1991).
6. Red Fox *Vulpes Vulpes* (Linnaeus, 1758). Neolithic to present (Davis, 1984, 1989; Croft, 1989, 1993; Harrison and Bates, 1991; Hadjisterkotis, 1993).
7. (Cypriot) pygmy hippopotamus *Phanourios minutus* (Cuvier, 1824). Early postcolonization, early Holocene (Swiny, 1988; Simmons, 1988; Davis, 1989; 1991; Simmons and Reese, 1993).
8. (Cypriot) Pygmy elephant *Elephas cypriotes* (Bate, 1903). Early postcolonization, early Holocene (Swiny, 1988; Simmons, 1988, 1991; Simmons and Reese, 1993).
9. (Cypriot) Genet *Genetta plesictoides* (Bate, 1903). Early postcolonization, early Holocene (Bate, 1903; Reese pers. commun., 1994)
10. (Ancient Cypriot) Shrew *Crocidura suaveolens praecypria* Reumer and Oberli, 1988. 13th-12th century B.C. Kouklia (Reumer and Oberli, 1988).
11. Savi's Pygmy Shrew *Suncus etruscus* Savi, 1822 (Reumer and Oberli, 1988) only a few mandibular fragments and lower dentition found in Bronze Age Kouldia (Reumer and Oberli, 1988).
12. Broad-toothed Field Mouse *Apodemus mystacinus* (Danford and Alston, 1877) Late Cypriot site of Nitovikla (Larje, 1992).
13. Macedonian Mouse *Mus macedonicus* Petrov and Ruzic, 1983. Early Holocene to present (D. Reese, Pers. commun; Aufray et al., 1990; Harrison and Bate, 1991).
14. House Mouse *Mus musculus/M. Domesticus* (Linnaeus, 1758) Neolithic, Bronze Age to Present (Watson and Stanley Price, 1977; Ekman, 1977; Davis, 1987; Jonsson, 1983; Harrison and Bate, 1991).
15. (Cyprus) mouflon *Ovis gmelini ophion* (Blyth, 1841) Neolithic to present (Davis, 1984; Croft, 1991; Hadjisterkotis, 1993).
16. Hare *Lepus europaeus/L. capensis* . Byzantine site of Ayios Kononas to present (Paul Croft pers. commun.).

C. The modern wild Fauna

a. Mammals (terrestrial)

1. (Cypriot) Spiny mouse *Acomys nesiotes* Bate, 1903 [Bate, 1903e; Mitchell, 1903; Spitzenberger, 1978; Harrison and Bates, 1991 (as *Acomys cahirinus*)].
2. (Cypriot) Long-eared hedgehog *Hemiechinus auritus dorotheae* (Spitzenberger, 1978) [Spitzenberger, 1978; Georgiades, 1989 (as *Erinaceus auritus*); Boye, 1991; Harrison and Bates, 1991].
3. (Cypriot) Mouflon *Ovis gmelini ophion* (Blyth, 1841) [Clark, 1964; Valdez, 1982; Georgiades, 1989; Hadjisterkotis, 1993; Hadjisterkotis and Bider, 1993].
4. (Cypriot) Red Fox *Vulpes vulpes indutus* (Miller, 1907) [Spitzenberger, 1979; Hadjisterkotis, 1993].
5. (Cypriot) Hare *Lepus europaeus cyprius* (Barret-Hamilton, 1903) [Barret-Hamilton, 1903; Spitzenberger, 1979; Georgiades, 1989; Harrison and Bates, 1991 (as *Lepus capensis*)].
6. Black rat *Rattus rattus* (Linnaeus, 1758) [Spitzenberger, 1978; Harrison and Bates, 1991].
7. Norway Rat, Brown Rat *Rattus norvegicus* (Berkenhount, 1769) [Spitzenberger, 1978; Harrison and Bates, 1991].
7. House Mouse *Mus musculus* (Linnaeus, 1758) [Spitzenberger, 1978 (as *Mus musculus praetextus*); Georgiades, 1989 (incorrectly published with the caption for the shrew *Crocidura russula cypria*); Harrison and Bates, 1991; Hadjisterkotis, 1993].
8. *Mus Macedonicus* (Petrov and Ruzic, 1983) [Bate, 1903 as *Mus «spredoides»*; Harrison and Bates, 1991].
9. Cyprus shrew *Crocidura suaveolens cypria* (Bate, 1903) [Bate, 1903d; Catzeflis, 1983; Catzeflis et al., 1985; Vogel et al., 1986; Harrison and Bates, 1991].
10. Etruscan or Savi's Pygmy Shrew *Suncus etruscus* (Savi 1822) [Spitzenberger, 1978; Harrison and Bates, 1991].

b. Birds (Endemic) [Bannerman and Bannerman, 1958; Vaurie, 1959, 1965; Flint and Stewart, 1983].

1. Scops Owl *Otus scops cyprius* (Madarasz, 1901)
2. Cyprus Pied Wheatear *Oenanthe pleschanka cypriaca* (Homeyer, 1884)
3. Cyprus Warbler *Sylvia melanothorax* (Tristram, 1872)
4. Coal Tit *Parus ater cypriotes* (Dresser, 1887)
5. Short-toed Tree-creeper *Certhia brachydactyla dorotheae* (Hartert, 1904)
6. Jay *Garrulus glandarius glaszneri* (Madarfisz, 1902)
7. Crossbill *Loxia curvirostra guillemardi* (Madarasz, 1903)

(*segue* Table 1)

8. Dipper *Cinclus cinclus olympicus* (Madarasz, 1903)
9. Raven *Corvus corax cyprius* (Orlando, 1939)

c. Extinct birds (Former breeding) [Flint and Stewart, 1983]

1. Dipper *Cinclus cinclus olympicus (Madarász, 1903)* [Endemic, extinct].
2. Lesser Kestrel *Falco naumanni* Fleischer, 1818 [Migratory breeder, no more breeding].
3. Marbled Teal *Marmaronetta angustrinostris* (Ménétriés, 183V [Formerly bred regularly, no more breeding].
4. Black vulture *Aegypius monachus* (Linnaeus, 1766) [Formerly a fairly common resident, now possibly extinct].

(The endemic races Dipper and the Raven were discounted by Vaurie, (1959, 1965), he did state, however, that the local population of these species required further study. Presently the Dipper is extinct and the Raven is an endangered species).

Table 2 - Breeding birds in Cyprus (Modified from Flint and Steward, 1983).

	Endemic Species	Endemic Subspecies	Resident	Migratory Breeders	Occasional breeders or bred in the past	Total
Number breeding	1	8	37	27	25	98
Number extinct	–	1 (11.1%)	1 (2.7%)	1 (3.7%)	1 (4.0%)	4 (4.1%)

Based on table 1, the animals affected by the highest extinction rates were the endemic species, followed by the endemic subspecies. Seventy five percent of the confirmed endemic mammalian species became extinct, compared to 16.6% of the subspecies and only 11.1% of the avian subspecies (Tables 1b-c and 2). The endemic status of the spiny mouse, which is the only endemic mammalian species that escaped extinction, is not accepted by some authors (Harrison and Bates, 1991).

As it was predicted, the arrival of man in Cyprus is associated with increased vertebrate extinction of endemic species. Most animals present on the island before the arrival of man are extinct. Cyprus appears to represent one of the few good examples of a late Pleistocene/early Holocene human group directly associated with extinction of a vertebrate fauna, specifically the pygmy hippopotamus and the pygmy elephant (Simmons, 1988; Simmons, 1991; Simmons and Reese, 1993). The Ancient Cypriot Shrew survived until the Bronze Age (Reumer and Oberli, 1988). The only species which is probably not extinct is the mouse, however, it is not known if the Pleistocene mouse of Cyprus is an endemic species. Today there are no endemic mice on Cyprus.

Man is also associated with all modern bird extinctions. Shooting (Hadjisterkotis, personal data) and improved pastoral hygiene, mainly to elimi-

nate Echinococcosis from Cyprus (Polydorou, 1986), might have affected the vultures in Cyprus. Several breeding populations of Griffon vulture (*Gyps fulvus*) at Akamas and Paphos Forest were eliminated or reduced, and presently there are no breeding Black vultures. Shooting also might be the cause of the reduction and the cessation of breeding of the Marbled teal and the Lesser Kestrel. Although the reasons for the Dipper's extinction are not known, shooting seems most probable. Despite protection, birds have long been shot for food (Bucknill, 1909-10), and the small population in its limited habitat must have been vulnerable.

Smaller Mediterranean islands suffered even greater numbers of extinctions. For example on the island of Crete since 1945, 24 species of birds possibly became extinct, and another five since 1852 (Sfikas, 1989). The reasons were human actions such as deforestation, shooting and the use of pesticides.

During Neolithic and Chalcolithic times, it seems that man experimented with the introduction of a large number of new species which could contribute to his needs (meat, skins, etc.). Although many of them managed to spread to the wild, they were gradually forced to extinction probably in part by human exploitation.

Contrary to the observation that proportionately more birds than mammals have become extinct on some oceanic islands (Diamond, 1984), the opposite took place in Cyprus. The smaller proportion of island extinctions of mammals on oceanic islands is partly a reflection of their poor representation on islands relative to birds. Many islands (e.g., New Zealand, Hawaii, Fiji, the Mascarenes, and the Seychelles) with large numbers of birds species and many avian extinctions simply have no native mammals except for bats (Case et al., 1992). The reason for the low extinction rates of the avian species in Cyprus is probably the lack of known endemic species or subspecies from the prehistoric or historic Cyprus, and the low number of modern endemic species (only one, see table 1c). The short distance between Cyprus and the mainland possibly allowed an exchange of birds between Cyprus and the mainland, preventing the evolution of many endemic species. The presence on Cyprus of a Genet (at one Pleistocene site [12 bones] and one early Holocene site [two bones]), and later the introduction of nest predators, such as fox, rat, hedgehog and the domestic cat, might have prevented the evolution of flightless, or defenseless birds, which are characteristic of islands without predators. Another problem with birds is that there are few scientists studying fossil birds (Olson, 1981).

A similar extinction pattern observed for the prehistoric endemic Cypriot mammals was observed on other Mediterranean islands. Pygmy elephants were present on Sardinia (one tooth), Sicily, Malta, Crete, Serifos, Delos, Naxos and Tilos. Pygmy hippopotamus, dwarf deer, as well as other bizarre endemic members of a Mediterranean island fauna (giant mice, giant dormice, large shrews and *Prolagus*, a «rat-like» hare) were present on these or other such islands, and are all extinct (Boekschoten and Sondaar, 1972; Azzaroli, 1980, 1981; Davis, 1987; Azzaroli et al., 1990; Sondaar, 1991). A characteristic of most Mediterranean islands is the low diversity of species, which lacked large

ground predators, and on some islands even small predators too (Davis, 1987; Sondaar, 1987). Due to the lack of large ground predators paleoecological conditions on these islands commonly have led to the development of faunas with dwarfed species, having a low gear locomotion (Houtekamer and Sondaar, 1979). The large mammals on these islands are mainly represented by elephant, deer and hippo. Similar examples of such faunas are also found on islands in the Japanese archipelago, Philippines and the Indonesian archipelago (Sondaar, 1977, 1987). Such faunas with slow moving dwarfs are vulnerable if large predators enter the island environment and mostly a sharp break in faunal composition can be observed after man's arrival on the island, marked by extinction of many island endemics. This is clear when the Neolithic man colonized the islands and brought its live-stock (Sondaar, 1987).

Conventional explanations for island extinctions emphasize the extreme vulnerability of native island species to introduced predators. Mainlands and large islands have endemic predators with which the fauna has presumably coevolved. The prey have probably evolved better defenses and the predators' populations are in turn kept in check by higher-order predators and parasites. Perhaps equally important, low extinction rates are expected given a large area and thus increased opportunity for migration after local extirpation (Case et al., 1992).

The theory of island biogeography, first developed by Preston (1962) and MacArthur and Wilson (1963, 1967), predicts that island biota tend to approach dynamic equilibria in the number of species. The forces that bring about the equilibria are immigration and extinction. For a particular island, the precise number of species at equilibrium depends mostly on island size and the distance from the source of immigrants, the «area effect» and the «distance effect» respectively. According to the theory, once an island is at its equilibrium for a particular taxon (such as bird or mammal), the rate at which species are last equals the rate at rohich unrepresented species colonize the island, by definition. It is an obvious deduction from the species-area relationship that any decrease in the area of an island (this might also be a forest, lake, or any fragmented habitat) will lead to a loss of species and the eventual attainment of a new lower equilibrium (Wilcox, 1980; Frankel and Soulé, 1981). Deforestation, soil erosion, the exposure of the pristine vegetation to a variety of exotic herbivores imported by human colonizers, human colonization, changes of land use for agriculture purpose, draining of marshes to fight malaria, all which are widely used practices on Cyprus and other Mediterranean islands, led to the degradation of habitats, making small islands even «smaller» for the animals living on them, thus, increasing the extinction rate. These together with the introduced predators, livestock and human hunting, brought new equilibriums and all the above extinctions.

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