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The origin and extinction of the large endemic Pleistocene mammals of Cyprus

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SUMMARY

All fossil terrestrial mammal sites on the island of Cyprus are dated from the Late Pleistocene period and consist almost exclusively of the remains of two terrestrial mammals, pygmy hippopotamus (*Phanourios minutus*) and pygmy elephant (*Elephas cypriotes*). Two theories exist on the arrival of these species on Cyprus. The first is that they arrived by a land bridge. This took place during the Pliocene about five to six million years ago when the Mediterranean sea was sealed at both ends due to tectonic movements and its water evaporated creating a land bridge. However, there are no fossils dating from the Pliocene The second theory is that they arrived under circumstances described by the Island Sweepstakes model. The latter theory refers to cases in which animals may venture far from the coast, reach an isolated island from which they cannot return and are forced to settle there. We reject the possibility that the Late Pleistocene mammals of Cyprus arrived by a land bridge, because during the Pleistocene such a bridge never existed. The cause of extinction of the earlier Cypriot endemic large mammals remain unclear. The discovery at the site of Akrotiri *Aetokremnos* of the above pygmy mammal species together with man-made artefacts has been interpreted by some researchers as proof of a human role in the extinction of these mammals. Others rejected this view. We review the facts about this discovery and believe that humans did play a role in the final extinction of these species.

THE ORIGIN OF THE LARGE PLEISTOCENE MAMMALS OF CYPRUS

In Cyprus, Late Pleistocene fossil and subfossil sites consist almost exclusively of pygmy hippopotamus (*Phanourios minutus*) (Forsyth Major, 1902; Bate 1906; Boekschoten and Sondaar, 1972; Houtekamer and Sondaar, 1979; Faure et al., 1983, Hadjisterkotis and Masala, 1995; Reese, 1975, 1989, 1992, 1995, 1996; Simmons, 1988a, b, 1989, 1991a,b,c, 1992, 1996; Swiny, 1988, 1995; Simmons and Reese, 1993; Simmons and Wigand, 1994) and pygmy elephant (*Elephas cypriotes*) (Bate, 1903a, 1904a,b,c; Hadjisterkotis and Masala, 1995; Reese, 1995, 1996b; Simmons, 1988, 1989, 1991a,b,c, 1992, 1996). Both species were considerably smaller than their mainland counterparts, and most researchers believe that the dwarfism was an evolutionary response both to the lack of predators and to the limited resources available (Sondaar, 1977; Azzaroli, 1982).

The question how these species arrived, and how they became extinct on Cyprus, has been the focus of debate for several decades. In this paper we bring together all the theories involved and critically review them.

Some researchers (Kuss, 1973; Spitzenberger, 1979; Hsü, 1983; Palikarides, 1997) suggested that the large mammals of Cyprus could have arrived by a means of a land bridge, or when the island was joined to the nearby mainland. The suggestion that Cyprus was attached to the mainland was also presented by Zohary (1973), based on the presence in Cyprus of non-Mediterranean vegetation. According to him the "...flora of Cyprus includes some thirty Euro-Siberian, sixty Irano-Turanian and twenty Saharo-Arabian species... The mere occurrence of so many "foreigners" in the heart of the Mediterranean area raises a series of problems as to the paleogeography of the island and the history of its flora. Particularly puzzling are the Irano-Turanian and Saharo-Arabian species emanating from the areas far distant from the island. These and other finds are not only clear evidence of Cyprus past connections with Syria and southern Anatolia, but also support the assumption that this link has lasted long enough to permit the penetration of elements in a sense alien to this westernmost part of the former Levant. On the other hand, the occurrence of a comparatively large number of endemics in this island points to the long span of time during which the island has been separated from the mainland."

Zohary's suggestion was seen by some researchers as an indication that Cyprus was connected to the mainland, and led them to suggest that the large mammals could have arrived at the same time as the non-Mediterranean plants via the same land bridge (V. Pantelas, pers. comm. to E.H., 1998).

Other researchers (Sondaar, 1977, 1986; Hadjisterkotis, 1993, 1995; Swiny, 1995; Hadjisterkotis and Masala, 1995) noted that this seems unlikely because such land bridges never existed, and the animals could have arrived only by swimming or rafting. To establish whether or not a land bridge was present, a review of the geological history of the island is necessary.

GEOLOGICAL HISTORY OF CYPRUS

The creation of Cyprus began between 85 and 92 million years ago (time scale of Harland et al., 1982), with the genesis of the Troodos Massif which is a fragment of uplifted oceanic crust (Gass, 1980; Mukasa and Ludden, 1987; McCallum and Robertson, 1990). The ophiolite was generated during the opening of a small Neotethyan ocean basin, which lay along the northern margin of Gondwana (Robertson and Dixon, 1984). However, spreading was short-lived and significant uplift of the Troodos Massif has mainly taken place in a pulsed nature in the Miocene, Pliocene and Pleistocene (McCallum and Robertson, 1990; Robertson, 1990). By the Late Miocene, the Troodos Massif was a low-lying island, and the

Kyrenia Range which had been deeply submerged, begun to rise. A severe compression and drastic uplift occurred in Cyprus in the Pleistocene. The Troodos Massif, Kyrenia lineament and Mesaoria basin were uplifted together, and for the first time, Cyprus acted as a single structural unit (McCallum and Robertson, 1990). That uplift raised Mt. Olympus to 1951 m. Superimposed on regional uplift were Quaternary fluctuations of sea level. These have contributed to the generation of the river terraces and raised beaches of Cyprus and further study of these may assist to evaluate whether the uplift is continuing.

Seven to 5.5 million years ago, due to the tectonic movements the north-western coast of Africa came into contact with the southern tip of Spain and the Mediterranean was sealed at both ends (Hsü et al. 1973; Hsü et al., 1977; Hsü et al., 1978; Cita and Wright, 1979; Hsü, 1983; Attenborough, 1987). Six million years ago, the climate was somewhat hotter than it is today, so the waters must have disappeared by evaporation, turning the Mediterranean sea into a salt desert. The evidence to support this was presented by scientists working in 1970 and in 1975 on the American research ship, the *Glomar Challenger*, who were investigating the structure of the sea-floor. Wherever they drilled, often in as much as 1 000 feet of water, at around five hundred feet in the rocks of the sea-bed, they encountered a layer of salts which in places was over a kilometer thick. This salt could have been created only if the Mediterranean had lost its water by evaporation. It was found that the Mediterranean had been a brackish lake for several hundred thousand years after the salt deposition. The lake was mainly formed by the great rivers of the eastern and central Europe. The influx of vast quantity of fresh water into the salt desert gave rise to one or a series of great lakes to the southern part of the Troodos and Pendadactylos, which consisted Cyprus at that time (see Hsü 1983: fig. 40). During this period of desertification of the Mediterranean, Cyprus was probably connected to the mainland.

The removal of an immense amount of water from the Mediterranean basin must have caused major movements in this part of the earth's crust. The underlying quasi-liquid basalt layer is likely to have risen slightly, elevating the rocks of what was once the sea floor. Cracks developed along the edges of the continents and caused a long series of earthquakes in the process. Old volcanoes became active again and new ones developed along fresh lines of weakness. About 5.3 million years ago, a series of deep faults running east and west broke the compacted junction between Morocco and Gibraltar, and the land shifted and fell. Through this isthmus, once again, the Atlantic flooded the Mediterranean.

Evidence for this flooding was also found in Cyprus. Pliocene sediments in the Mesaoria basin overlie a marked unconformity surface, directly overlain by marine silts of the Nicosia Formation (McCallum and Robertson 1990: table 1, p. 219). This records the rapid return of open seas to the basin, following the salinity crisis (Hsü et al., 1978; Hsü, 1983).

Hsü (1983) and Attenborough (1987) noted that the mountains that stood above the empty Mediterranean were probably colonised by animals even before the sea returned. Their cool, green upper slopes must have provided a refuge for any animal that strayed down from the continents on either side into the hot depths of the valley between. According to Hsü (1983), after the desiccation of the Mediterranean, "African antelopes and horses could gallop to Spain across the isthmus of Gibraltar... And apparently, hippopotami made their way from the Nile to Cyprus. The migratory traffic might have been more frequent if the wanderers had not had to travel across a desert 2,000 to 3,000 meter below sea level."

Attenborough noted that soon after the refilling of the Mediterranean basin, all the islands were inhabited by a range of animals, including, even hippopotami and elephants. The same opinion was expressed by Palikarides (1997), who wrote that the animals of the Mediterranean islands, including elephants, arrived about 6.5 million years ago when the Mediterranean Sea evaporated.

There is no doubt that a number of animals might have traveled to Spain across Gibraltar or to some of the Mediterranean islands during the Miocene. But fossil bones of elephants and hippopotami do not appear on the Mediterranean islands until several million years later. According to Caloi et al. (1996), fossil endemic pygmy elephants have been collected in the Quaternary deposits of many Mediterranean islands. Although at that time some of the Mediterranean islands may have been connected to the mainland with land bridges, Cyprus was not.

Cyprus is separated from Asia Minor by the Adana Trough and from the Levant by the Latakia Basin which have depths of up to 1,000 m. Even at times of minimum sea levels during Pleistocene glacial maxima, when the sea dropped to at least 120 m. below its present level (due to the vast amount of water trapped in the polar ice caps), the island remained separated from the now submerged Gulf of Alexandretta, on the coast of Asia Minor, by at least 30 km (Flint, 1974; Held, 1989; Swiny, 1988, 1995; Simmons, 1991; Reese, 1989). Since Cyprus originated from the raised seabed, Moores et al. (1984) noted that Cyprus is geologically and biogeographically one of the most isolated Mediterranean islands. This means that for the last five million years the island was never joined by a land bridge or an ice bridge to the mainland shore line.

Since the only land bridge that existed between Cyprus and the mainland was a salty desert inhospitable to plant life five million years ago, how did the Irano-Turanian and Saharo-Arabian flora arrive on Cyprus? Interpretive ecological plant geography depends upon a synthesis of knowledge of many things e.g., tolerance ranges, evolutionary history, ecological mobility, and the paleoecology of the species (Billings, 1978). The present distribution of most species is a product of the species' tolerance range, its ability and opportunity to cross barriers, the effect of paleoecological events, and time. The presence of a species in a place is ample evidence that the environment is suitable and that the species has been able to get there. The absence of a species from a place tells us nothing in itself, but presents a problem to be solved. A species can be absent for one or more reasons: (1) the environment can be beyond the tolerance range, (2) it may once been there but was eliminated by some paleoecological event. According to Hsü (1983), the presence of a hot desert where the Mediterranean Sea is now would have had a serious climatic impact. The hotter climate six million years ago which turned the Mediterranean Sea into a hot salt desert could favour the expansion of the Irano-Turanian and Saharo-Arabian species around the Mediterranean Sea. Although Cyprus is a Mediterranean island, its central plain (Mesaoria), has a semi-desert hot climate (Pantelas, 1996). In this climate some Irano-Turanian and Saharo-Arabian species are within their tolerance range. One such species is jujube (*paloúra* in Greek) (*Ziziphus lotus*). This is a plant with a wide range of tolerance and is found not only in Cyprus but also in Portugal, Spain, Sicily, southern Greece, North Africa, Palestine and Arabia (Meikle, 1977; Polunin and Huxley, 1981). It is not known if this plant, together with the rest of the Irano-Turanian and Saharo-Arabian species found on Cyprus managed to arrive during the desiccation of the Mediterranean Sea, or during some other time. In considering plant dispersal in the Mediterranean area, the role of humans should not be overlooked; over the last few thousand years deliberately or accidentally carried seeds or plants to new places. Good examples of Irano-Turanian species found on Cyprus which produce edible seeds or fruits are: jujube, almond (*Amygdalus communis*), hawthorn (*Crataegus aronia*), wild pear (*Pyrus syriaca*) and pistachio (*Pistacia atlantica*) (Zohary, 1973).

If a land bridge between Cyprus and the mainland never existed during the Pleistocene, then the most probable scenario for colonisation of Cyprus by Late Pleistocene mammals was the so-called Island Sweepstakes model, proposed by Simpson (1940, 1965), and strongly advocated by Sondaar (1977, 1986). This theory refers to cases in which animals may venture far from the coast, reach an isolated island from which they cannot return and are forced to settle there. Large animals can arrive by swimming and smaller animals can be swept across water on natural rafts, such as floating vegetation (Sondaar, 1986, 1991).

According to Swiny (1995), it seems most logical to postulate that breeding populations of both hippopotami and elephants swam to Cyprus during a major Pleistocene glaciation. None of the bone bearing rocks in Cyprus are much over 300,000 years old (Swiny, 1988, 1995; Held, 1989) so these two animals probably arrived during one of the later glaciations that occurred around 380,000 years ago, or between 195,000 and 165,000 years ago. Reese (1996) in a review of the dates of the hippopotami and elephant bones found on several Mediterranean islands, noted that some of the oldest fossils on Crete are about 850,000 years old. The hippopotamus and elephants of Cyprus are the youngest known species in the Mediterranean. The oldest know fossils are about 22,000 years BP. Therefore there is no evidence to indicate that the Cypriot or any of the other Mediterranean hippopotami or elephants could have arrived five or six million year ago when the Mediterranean was dry. Other pre-Pleistocene or Miocene mammals such as equids, bovids, goats, antelopes, lagomorphs, rodents, shrews etc., did arrive on Crete, Samos and some other Mediterranean islands but not on Cyprus. One elephant-like mammal, a choerolophodont mastodon *(Choerolophodon chioticus)* arrived during the Miocene on Chios (Tobien, 1980). Chios might have been attached to Asia Minor at the time, but this species is so far unique to Chios.

The theory of island sweepstakes was rejected by Azzarolli (1978), who noted that: "Animals do not move outside their natural environment and their sources of food. No hippopotamus, not to say elephants or deer, will ever venture in the open sea, where he can find nothing to eat... Why did deer not reach Cyprus?"

If we examine the behaviour of elephants and hippopotami we can see that there are many records of swimming elephants (Carrington, 1962; Johnson, 1980), though information on hippopotami is more scarce (Frädrich, 1968). If we look at living elephants and hippos, we can see that these land animals are excellent swimmers. Elephants love bathing, and there are many reports of them swimming from island to island in the open sea of India and Sri Lanka, by using their trunks as snorkels (see Chadwick, 1991: 24). The average speed of an adult is about 1.5 km an hour, and with the help of a current, the swim from the mainland would have taken a minimum of 15 hours, something which is not beyond the endurance capabilities of elephants.

According to Carrington (1962) elephants are remarkably good swimmers, and are undeterred by the broadest rivers. Sanderson (1878) gives a remarkable example of their swimming abilities:

"A batch of seventy-nine that I despatched from Dacca to Barrackpur, near Calcutta, in November 1875, had the Ganges and several of its large tidal branches to cross. In the longest swim they were six hours without touching the bottom; after a rest on a sand-band, they completed the swim in three more; not one was lost. I have heard of more remarkable swims than this".

Recently the migratory movements of elephants were studied extensively in Kenya by using satellite transmitters and VHF signal. Observations on Kenya's second largest herd of elephants (about 6000 animals) indicated that they roam over great distances, and into difficult territory for no apparent reason (Tudge and Flint, 1991). It is therefore likely that they could swim towards the open sea, probably guided by their acute sense of smell. During an Ice Age they may have been attracted by the more plentiful food on the island which was less affected by the severe cold of the mainland. The prevailing south-westerly winds could have carried the smell of vegetation all the way to the Cilician shore (Swiny, 1995).

Hippopotami, which live in or near rivers, have been known to swim from the East African mainland to the island of Zanzibar, which is more than 35 km away. This island, which is 90 km long and only about 116 m high, is more inaccessible and less visible than Cyprus, yet hippopotami are known to cross the Zanzibar channel. In addition, they reached the island of Madagascar by overcoming the 450 km wide Mozambique Channel (Held, 1989). There is no evidence to suggest the existence of a land bridge, and the nearest island, Juan de Nova is 320 km from the mainland and 140 km from Madagascar. Perhaps the presence of the rivers flowing down to the Mozambique coast, all of which would have been populated with hippopotami, had a role to play in the colonisation process.

Before Europeans introduced firearms to south Africa in the 1830s, hippopotami were reported to favour swimming in the sea as much as in rivers. Smith (1849) made the following comment:

"It is difficult to decide, whether the hippopotamus prefers the pools of the rivers or the waters of the ocean for its abode during the day. When the opportunity of exercising a choice exists, some individuals embrace the one, and some the other."

During the Pleistocene period, it is probable that hippopotami and elephants would have inhabited the estuaries of the large rivers such as the Seyhan, the Ceyhan or the Orontes that flow into the Mediterranean both to the north and to the east of Cyprus. The possibility that the currents carried a number of these animals all the way to Cyprus is not beyond the realm of credibility (Swiny, 1995).

VERTEBRATE EXTINCTIONS: THE CASE OF CYPRUS

The presence of pygmy hippo and/or pygmy elephant is now documented at almost 40 bone-bearing localities throughout Cyprus (Held, 1989; Reese, 1989, 1995, 1996) with almost all assemblages weighed heavily in favour of the hippos. Many sites occur in caves or rockshelters, as well as near rivers or ponds and on alluvial fans. These localities are spread from one side of the island to the other indicating that these animals were common. However, the hippopotamus and elephant seem to have disappeared at about the same time that humans first arrived. The extinction of the endemic mammals took place not only on Cyprus but also on other Mediterranean islands.

The Neolithic people who arrived on some of these islands brought with them a range of domestic livestock which replaced the earlier endemic fauna. For example, the endemic elephants, hippos, deer, *Myotragus*, rodents and so on vanished, and today the only wild mammals are feral descendants of imported livestock: Wild boar on Corsica and Sardinia, wild goat on Crete, Gioura and Antimilos, and mouflon on Corsica, Sardinia and Cyprus, as well as foxes, mustelids, rodents, shrews, etc. (Davis, 1987, 1989).

The reasons for the extinction of the earlier endemic mammals remain unclear. Probably there were several causes for their extinction. Overpopulation might be one possibility. The role of man is enigmatic (Davis, 1987, 1989; Sondaar, 1987). Despite occasional claims to the contrary (e.g. Sondaar 1986; Davis, 1987), recent evidence from many Mediterranean islands indicates that some of the large mammals became extinct before the human colonisation of the islands (Vigne, 1996). However, there is one exception, from Cyprus.

The association of cultural remains with extinct fauna on a Mediterranean island was not known until the excavations at Akrotiri-*Aetokremnos* (or "Vulture Cliff") in Cyprus (Reese, 1996; Simmons, 1988a,b, 1989, 1991a,b,c, 1992, 1996, 1999). This is a collapsed rock shelter where a surface scatter of bones were identified as the extinct pygmy hippopotamus, as well as marine shells, and a few chipped stone artefacts. After excavating this shelter there were found 218,000 hippopotamus bones from at least 502 individuals. Of 15,628 bones from 52 individuals found on the rockshelter floor 14.5% are burnt. There were 225 pygmy elephant bones from at least three individuals, with several burnt. There were also two bones of a young endemic genet (*Genetta* cf. *plesictoides*). The few mouse remains of one individual, with a few bones burnt, have been determined to be more related to *Mus macedonicus* than *Mus musculus*, the former not previously described from any Cypriot site. There were 3,205 bird bone fragments (529 of them identifiable) from a minimum of 73 individual birds, which is one of the largest bird bone samples from any Early Holocene

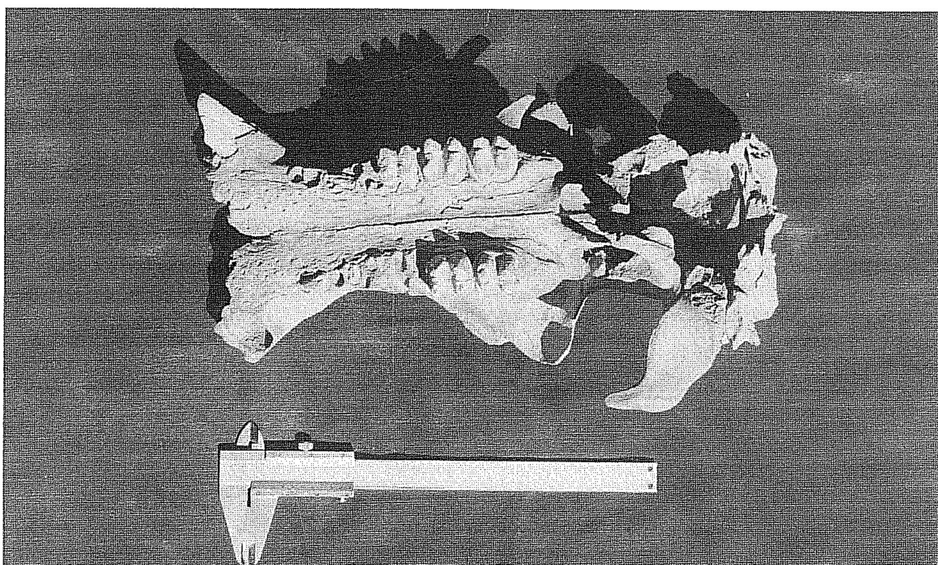

Fig. 1 - Skull of pygmy hippopotamus (*Phanourios minutus* from Akrotiri-*Aetokremnos*, photo by E. Hadjisterkotis).

archaeological site in the East Mediterranean. These include: *Otis tarda* (Great Bustard, 349 bones), *Anser anser* or *A. fabalis* (Greylag Goose or Bean Goose, 24 bones), *Anser* sp. (54 bones), *Athene noctua* (Little Owl, 22 bones of one individual), one bone from the Short-eared owl (*Asio flammeus*), one bone of a Water Rail (*Rallus aquaticus*), one bone of a Harrier (*Circus* sp.), eight bones (5 burnt) from a Shag (*Phalacrocorax aristotelis*), one bone of a Manx or Levantine Shearwater (*Puffinus puffinus*), one bone (burnt) of the Black-necked or Eared Grebe (*Podiceps nigricollis*), five bones from three Rock Doves or Stock Doves (*Columba livia* or *C. oenas*), one Carrion/Hooded crow (*Corvus corone*), one Thrush (burnt) (*Turdus iliacus* or *T. philomelos*), and one small passeriform. There were also eggshells. There were snake remains from the Levant viper (*Vipera lebetina*), Cyprus grass snake (*Natrix natrix cypriaca*) and one Whip snake (*Coluber jugularis*). Other reptiles found were the remains of tortoises (*Testudo* sp., *Geochelone* sp.). One fish vertebra of a Gray mullet was found, and 73,000 fragments of edible marine shells from more than 21,000 individuals. There were many artefacts found, dominated by small thumbnail scrapers, and about 75 shell and stone ornaments (Simmons 1996).

The discovery at *Aetokremnos* of pygmy mammal bones and human artefacts was interpreted by the researchers as proof of a human role (at least partially) in the extinction of the endemic large mammals of Cyprus during the 11th millennium Cal BP. Based on ethnographic and animal behavioural patterns, Simmons (1996, 1999) estimated a hippopotamus population of ca. 2700 animals for the Akrotiri peninsula. He also suggested that a group of 50 people could have occupied the peninsula, and that such a group could have eliminated the population of hippopotami in a relatively short time.

Simmon's interpretation of the human role in the extinction of the endemic large mammals of Cyprus were doubted by Bunimovitz and Barkai (1996) who provided a critical examination of the preliminary published data from *Aetokremnos*. This prompted a considerable debate on this subject, followed by a series of papers supporting Simmons' and Reese's results (Simmons, 1996; Reese, 1996, Strasser, 1996) which appeared before the final excavation (Simmons, 1999).

After reviewing the large number of species found in the rockshelter, we attempted to determine whether all these species could have been carried there by humans. We believe that it is possible that a number of the species found may have arrived there by natural means. Some species of owls such as the Little Owl, are known to use caves for refuge or for nesting, and might had arrived in the rockshelter on its own. Owls are known to feed on mice and to emit them as pellets around their nest or resting place. Therefore, the remains of the single mouse, or the small passeriform could had been collected by owls, or possibly entered on their own. Another species which can enter a cave to nest is the Rock

Dove. However, it is not certain if the dove bones found were Rock Dove or Stock Dove. Stock Doves live in old woods which provide holes to nest in; it seldom nests in conifer forest or in holes in rock or clay faces. Presently only the Rock dove nests in Cyprus. The shag also can nest on rock faces and on sea cliffs, often in more or less inaccessible holes and hollows, and is a local resident of Cyprus (E.H. pers. observ.). Most of the other birds however, are found or nest in open areas on the ground or on trees.

Most of the birds found are large geese and great bustard, which are excellent game birds even today. Even the smaller birds such as the Thrush and the passeriform are hunted today. Could these birds have been brought into the rockshelter by predators other than humans? The only predator at that time was the genet. Genets feed on invertebrates, particularly insects and small rodents. Reptiles, amphibians, birds and other small mammals are taken, as well as wild fruits. They can be a problem to poultry-owners and if they gain access to a poultry-run or hen-house often kill far more than they require (Stuart and Stuart, 1992). Although the behaviour of the Cypriot genet is unknown, one can assume that if the modern genet can kill large birds the size of poultry, it is possible that the Cypriot genet could kill birds the size of a goose or bustard. Genets give birth in the summer months in holes, rock crevices or amongst dense vegetation. Therefore *Aetokremnos* could be a good place where a genet could give birth, after being abandoned by its human inhabitants. *Aetokremnos* produced two bones of a young genet from Stratum 4, a left maxila fragment and a tibia fragment with an unfused proximal end. The two remains probably come form the same young individual, who perhaps was born there. In such a case the mother could carry a large number of birds, small mammals, reptiles and amphibians to feed her young. This could partly explain the great variety of birds found in the rockshelter. However, the genet is from Str. 4b, and most birds are from Str. 2. So it is less likely for birds to be brought in by the genet.

It is not certain if a genet could carry the bird eggs found in the rock shelter. Gray fox *(Urocyon cinereoargenteus)* and red fox (*Vulpes vulpes*) are known to grab one egg at a time and depart immediately to cache it. The process is repeated until all the eggs are cached. Animals the size of Racoon (*Procyon lotor*) or Skunk (*Mephitis mephitis*) cannot easily carry or hold chicken-sized eggs; therefore the eggshells are found near the nest (1-5 m) (Hernandez et al., 1997). Ducks and geese are know to use open spaces for nesting. Of 13 deposits with eggshell, one is Str. 1/2, 11 are Str. 2 and one is Str. 4a-b. So 12 of 13 are found later than the genet and so could not have been brought in by genet. Although it is possible that some of the species were not collected by humans, it is impossible to say for sure that this is the way that they were collected. The possibility that they were collected by humans is very strong, since many of the bird bones and eggshells were burned.

The three snake species found in the rockshelter are still found on Cyprus today (Reese and Hadjisterkotis, 1994; Blosat and Hadjisterkotis, 1995; Blosat et al., 1996; Antoniou, 1996). The viper as well as the whip snake are common species while the grass snake is an endangered species. All these species are known to use crevices, or openings under rocks for their winter hibernation. A pile of bones, or wood collected for the fire inside the rockshelter would make an excellent hibernation refuge. However, some snake bones were burnt. This might indicate that these animals were collected for food and were cooked by the inhabitants. Snakes are even today an important protein source in some countries.

Although there might be some doubts on the origin of some of the species, we find it difficult to attribute the 218,000 hippopotamus bones, 225 elephant bones and 21,000 edible marine shells mixed with the cultural artefacts to anything but human factors. Bunimovitz and Barkai (1996) noted that the lowest bone deposit (Str. 4) is natural, not cultural. In our opinion, the piling of such a large number of animals such as hippopotami in such a small spot usually takes place in the case of water holes or sink holes with steep sides. Animals in their attempt to drink are unable to get out, and the hole becomes a "death trap" (Turner and Weaver, 1981: fig. 7.3). However, there is no geomorphic evidence for such a trap. The floor of the rock shelter did not have any evidence of sedimentation and there are no features on the cliffs or plateau above *Aetokremnos* to account for a repeated natural jump site (Mandel and Simmons, 1997; Simmons, 1999).

Therefore, based on the above evidence from *Aetokremnos* we accept the conclusions presented by Simmons (1988a, 1988b, 1989, 1991a,b,c, 1996), Reese (1992, 1993, 1996), Simmons and Reese (1993), and Simmons and Wigand (1994) and in the 1999 Simmons volume, that the people of the Akrotiri peninsula were responsible for the final extinction of two endemic species in that area.

The Cypriot species are the latest known surviving pygmy hippopotami and elephants in the Mediterranean (Reese 1996). It must be noted that recent excavations at Aceramic Neolithic Pareklisha *Shillourokambos*, dated to the beginning of the 8th millennium Cal BC (*i.e.*, one millennium earlier than the Khirokitia phase) have not to date produced any bones of hippopotami or elephants (Vigne, 1996; Guilaine et al., 1995, 2000) but do have the ealiest cattle. The fauna at Khirokitia *Vounoi* and Kalavassos *Tenta* did not include any of the endemic pygmy mammal species found at *Aetokremnos*, but yielded a fauna with fallow deer (*Dama mesopotamica*), mouflon/sheep (*Ovis* sp.), Goat (*Capra* sp.), pig (*Sus scrofa*), dog (*Canis* sp.), cat (*Felis silvestris/lybica*) and fox (*Vulpes vulpes*) (Davis, 1984, 1987, 1989; Hadjisterkotis, 1995). This seems to confirm that the large endemic fauna was mostly, if not completely, extinct two millennia after the *Aetokremnos* deposits.

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