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The evolution dynamics of the Strigiformes in the Mediterranean islands with the description of *Aegolius martae* n. sp. (Aves, Strigidae)

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Abstract

Living and fossil owls (Aves, Strigiformes) constitute an important group for understanding the evolutionary dynamics of birds in island environments. After their different trends in island evolution, the Strigiformes can be seen as a representative of insular adaptations of birds as a whole. In fact they respond quickly to isolation with deep changes in body size, including dwarfism and gigantism, and allometric variations, such as reduction of wings, lengthening of hindlimbs and strengthening of digits and claws. The only exception is the loss of the ability to fly, which has never been recorded in Strigiformes. In this paper I report on all the endemic owls found in Mediterranean Islands, both living and fossil, in order to emphasize trends in insular evolution and the relationships between the different species sharing a certain island. The description of *Aegolius martae* n. sp. completes the guild of endemic Strigiformes of the early Middle Pleistocene of Sicily and allows to use Sicily as the best example of a biogeographical island type with intermediate characteristics between the oceanic and the continental ones, with the presence of some non-flying mammals, but the lack of terrestrial carnivores.

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1. Introduction

After the works of Darwin (1859) and Wallace (1881) the study of islands became a powerful tool in many biological studies, as the study of the fossil of past faunas gives an historical dimension to the insular biogeography and ecology. Typical insular communities are characterized by their disharmony, the so-called “insular poverty”, their high degree of endemism and an organisation of ecological relationships among species that are different from those on continents.

Birds are a key group in understanding the biological changes in island environments. According to their geological origin, islands can be divided into two different groups: oceanic islands and continental ones. The former are volcanic islands of fairly recent origin, less than 10 million years, which have emerged from the ocean floor and have been never connected to any continent. Continental islands were originally parts of a continent, which have since separated from the main land mass. Oceanic

islands are inhabited only by a subset of continental species, those with the highest vagility; they tend to lack non-flying mammals, amphibians and freshwater fishes. Continental islands still lie close to continents, to which many were connected as recently as the last glaciations, 10,000–12,000 years ago, when sea-levels dropped. Due to their proximity to the mainland, or to the presence of land bridges during glaciations, the plants and animals of these islands are more or less representative subsets of mainland species, even if some new species can eventually evolve.

The number of terrestrial bird species found on a particular island is normally related to the size of the island and its degree of isolation. These two parameters lead to the equilibrium theory of MacArthur and Wilson (1967), according to which the rate at which a species reaches oceanic island declines with the increasing remoteness of the island, while the rate of extinction of an established species declines as the size of the island increases. Certain case studies show that the colonisation of an island can be rapid, such as for Krakatoa, in Indonesia, where a century after the complete destruction of the island following a volcanic eruption, more than 40 bird species have been reported (Thornton et al., 1993)

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along with a great variety of plants and insects. Additionally, modifications such as the evolution of flightlessness and the loss of bright colours, especially the full colour plumage of males in dimorphic species (e.g. Anatidae: Newton, 2003), can be very rapid in insular environments. Moreover the insular endemic forms tend to be more “K-selected” than their mainland relatives, with lower reproductive and mortality rates, and longer life spans.

The study of fossil associations changed island biogeography paradigms based only on the study of extant faunas (Segui and Alcover, 1999). The fossil record reveals that the data obtainable from extant taxa alone are artificial. Natural extinctions are caused mostly by two geological events, volcanic eruptions and tsunamis, and less often by variations in sea levels. These factors are normally felt more strongly on small oceanic islands. In addition to natural extinctions, many island birds have disappeared in the last 1500 years because of human actions. Even if human impact is not always clearly demonstrated, in each case the extinctions followed soon after human colonisation (Newton, 2003). Human influences are usually indirect, such as the introduction of predators or competitors and landscape modifications, but direct over-hunting is sometimes an important factor (James and Olson, 1991; Olson and James, 1991; Milberg and Tyrberg, 1993; Steadman, 1995; Mourer-Chauviré et al., 1999; Blackburn et al., 2004). The lack of recently extinct taxa in present-day insular associations, even if still endemic, make them unnatural. The only way to approximate natural communities and complete taxon lists is to integrate both living faunas and recently extinct taxa (Louchart, 2005). This is especially true for birds, where the number of extinct species in the Late Pleistocene and Holocene is very high (Milberg and Tyrberg, 1993). The study of island fossil birds also reveals that extinction processes are often selective; in fact selective impacts are responsible for eradicating larger species along with the ones resulting from extreme evolutionary pathways.

On the basis of the study of many fossil island bird associations (see Louchart, 2005 for a list of references), general trends of modifications occurring in endemic island bird species can be summarized, if any exist. It is not clear whether general trends are towards dwarfism, gigantism or other allometric variations, although it seems that gigantism, along with the reduction or loss of the ability to fly, is more frequent. There have been few studies so far, most of them restricted to limited groups of species, based on extant forms and often considered only at a low taxonomic level (Grant, 1965). These studies found both opposing trends, i.e. increasing and decreasing size. They thus showed that there is no simple, uniform trend for birds in insular environments. Gigantism is in fact often recorded in vegetarian species, such as *Aepyornis*, *Dinornis*, *Sylviornis*, *Pezophaps*, *Raphus*, and is normally linked to a reduced or lost flying ability; on the contrary dwarfism is reported for small Passeriformes, although there are examples of the opposite, such as dwarfism in emu (*Dromaius*) and

cassowary (*Casuarius*) (Parker, 1984; Rich et al., 1988) and gigantism in the extinct Passeriformes *Emberiza alcoveri* of the Canary Islands (Rando et al., 1999). The coexistence of both gigantism and dwarfism in the genus *Cygnus* during the Pleistocene, with the giant *Cygnus falconeri* and the dwarf *Cygnus equitum* (Northcote, 1992), both endemic to the Sicilian–Maltese archipelago, although probably not coeval, as demonstrated by recent analyses of Sicilian fossil bird assemblages is worth mentioning (Bonfiglio et al., 2002). Apart from overall size variations, a significant number of insular bird species are affected by allometric variations. In this case, generic trends can be detected in many bird orders, such as Falconiformes, Psittaciformes, Strigiformes and Passeriformes, in which main variations concern bill, wing and tarsus measurements (Grant, 1965; Segui, 1998; Rando et al., 1999; Suarez and Olson, 2001; Louchart, 2005). The modifications affecting wings normally lead to a reduction or loss in the ability to fly, as recorded in at least 14 bird orders (Louchart, 2001). Trends in allometric variation can be summarized as an increase in the relative size of the bill and the relative length of the tarsus, and a decrease in the relative size or length of the wing. These trends are usually explained by more terrestrial habits, specialised and sedentary (Louchart, 2005).

As recently stated by Louchart (2005) the Strigiformes are a key group in understanding the evolutionary trends of birds in insular environments. In this paper I deal with the Strigiformes inhabiting Mediterranean islands during the Neogene, as they show all the types of modifications that occur in birds. The description of *Aegolius martae* n. sp. also completes the Strigiformes guild of the early Middle Pleistocene of Sicily, presently composed of two other extinct species, *Tyto mourerchauvireae* and *Athene trinacriae* (Pavia and Mourer-Chauviré, 2002; Pavia, 2004).

2. The endemic Strigiformes

The Strigiformes constitute one of the best groups for studying insular bird taxa, both living and fossil. Indeed, about 150 of the 611 recognized extant taxa are insular endemics, while extinct endemics recorded so far include only 36 taxa from the Miocene up to the present. Furthermore, they are widespread and frequently exhibit size and allometrical modifications; moreover, the extinct taxa have an abundant fossil record on islands, and are also relatively easy to identify osteologically, as even the smallest owls are still small to medium-sized birds with peculiar osteological characteristics. Owls are common on islands. This can easily be explained by their intermediate vagility; they are sedentary enough to undergo insular evolution, but they occasionally cross significant bodies of water, up to 3500 km away from the closest mainland, such as the Hawaiian Islands (Olson and James, 1991). Studies of endemic Strigiformes seem to show that the higher the degree of endemism, the more body-size evolves and,

therefore, under condition of endemism, it seems that owls frequently undergo size modifications (Louchart, 2005).

Extant insular taxa show a general trend towards a slight decrease in body size (Louchart, 2005). On the other hand, the fossil record shows opposite trends, with a general increase in body size, as for *Tyto riveroi* and *Tyto gigantea* (Ballmann, 1973; Arredondo, 1982), for a significant number of taxa showing allometric variations, such as *Mascarenotus grucheti*, *Grallistrix geleches* and *Athene cretensis* (Weesie, 1988; Olson and James, 1991; Mourer-Chauviré et al., 1994), and only one single example of dwarfism, *Bubo insularis* from the Plio-Pleistocene of Corsica and Sardinia (Louchart, 2002; Abbazzi et al., 2004). The lack of gigantism in living owls, with the only exception of *Mimizuku gurneyi* of the Philippines (del Hoyo et al., 1999), seems to be the effect of differential extinctions or extirpations. As a matter of fact, broadly speaking, extinctions of Strigiformes took place through selective impacts that eradicated the larger species faster and more easily, so that the more specialised taxa went extinct first. The largest species have lower population densities than the smallest ones (Peters, 1983), so the populations of large insular species are limited in number by the small area inhabited, and thus are more vulnerable to extinction (Soulé, 1987). In addition the species with allometric modifications suffered relatively more extinctions.

The analysis of the extinct and extant owl records made by Louchart (2005) revealed that there is no general trend in insular evolution of this group, neither is there an “island rule” (Lomolino, 1985). These conclusions can be applied to birds as a whole, but they need to be confirmed with more comprehensive studies on these topics including more bird groups. In addition body size alone seems not to be a powerful estimator of ecological traits, because it is influenced by too many factors, such as climate, competition or predation, sometimes in opposition to one another. On the contrary, in the case of owls, allometric variations seem to be more informative than body size, such as variations related to the strengthening of pedal digits and claws, as a response to unusually large prey items (Louchart, 2005). Longer hindlimbs and shorter wings observed in owls on islands are allometric modifications known for island birds in general.

Owl records on islands, both living and fossil, show that the sympatry of two species belonging to one genus is not rare, even if they are normally of different sizes. It can be explained by local adaptations to the various food niches, which are normally empty in an impoverished island fauna. It occurs in various fossil records, such as in Cuba (Arredondo, 1982), Hawaii (Olson and James, 1991) and the paleo-archipelago of the Gargano, in Southern Italy, where three species of the genus *Tyto* coexisted together with three other more or less endemic Strigidae (Ballmann, 1973, 1976; M. Pavia, unpublished data).

The study of insular Strigiformes also gave Louchart (2005) the opportunity to identify a new type of island,

from a biogeographical point of view. In fact, he emphasized the presence of an intermediate type of island, between oceanic and continental ones, which lacks terrestrial carnivorous mammals but hosts some non-flying mammals, mainly rodents. In these “intermediate” islands the Strigiformes represent the top of the food chain, perhaps following an insular endemic evolution. This is the case in some Caribbean Islands with many endemic Strigiformes, such as *Tyto riveroi* and *Ornimegalonyx oteroi*, in the former Gargano archipelago, with *Tyto gigantea* and *T. robusta*, and in Sicily, with *Athene trinacriae*, *Tyto mourerchauvireae* and *Aegolius martaee* n. sp. (Ballmann, 1973, 1976; Arredondo, 1982; Steadman and Hilgartner, 1999; Pavia and Mourer-Chauviré, 2002; Pavia, 2004; Louchart, 2005).

3. Mediterranean islands with endemic Strigiformes

The islands of the Mediterranean are characterized by endemic associations of animal and plants, both extant and extinct. The fossil record of birds comprises several endemic associations with many extinct species. These associations inhabited the major islands or archipelagos from the Late Miocene to the Late Pleistocene (Ballmann, 1973, 1976; Mourer-Chauviré et al., 2001; Bonfiglio et al., 2002; Abbazzi et al., 2004). Strigiformes occur very frequently in the fossil records of these islands, including some endemic taxa; all of them became extinct, except for *Tyto alba ernesti*, which is currently endemic to Corsica and Sardinia (del Hoyo et al., 1999; Pavia, 2004; Louchart, 2005). (Fig. 1)

Up to now at least 12 taxa of endemic Strigiformes have been reported from Mediterranean islands. They cover all the modifications already recognized in birds, except the loss of flying ability, which has never been recorded in owls (Louchart, 2005).

On Crete a huge fossil bird association was studied by Weesie (1988). It comprises at least 65 taxa, including the two endemic forms *Aquila chrysaetos simurgh* and *Athene cretensis* and the recently described *Meridiochicla salotti*, regarded as an endemism of the Mediterranean Basin (Louchart, 2004). *Athene cretensis* is a local offshoot of the extant *Athene noctua*, which evolved allometrically including a general increase in size and a significant lengthening of the hindlimbs, in particular the tibiotarsus and the tarsometatarsus (Pavia and Mourer-Chauviré, 2002). This species was also reported from the small island of Armathia (Pieper, 1984), but according to Pavia and Mourer-Chauviré (2002), the specific identity of the bone from Armathia needs to be re-evaluated.

The former Gargano archipelago (De Giuli et al., 1990) in the Late Miocene was inhabited by a highly endemic vertebrate fauna, comprising several extinct species of birds (Ballmann, 1973, 1976; Göhlich and Pavia, in press) and mammals (see Abbazzi et al., 1996 for a list of taxa and references). The bird association is not very diversified, with around 25 taxa, most of them endemic and some still



Fig. 1. Mediterranean Islands with endemic Strigiformes remains considered in this paper.

undescribed (M. Pavia, unpublished data). The Strigiformes are well represented with at least 6 taxa. In fact Ballmann (1973, 1976) reported three species of *Tyto*: *T. gigantea*, *T. robusta* and *T. sanctialbani*; the last one refers to *T. balearica* (Mlíkovský, 1998). In the same papers he reported three Strigidae, one of which is the new *Strix perpasta*. The Gargano material is under revision and its ongoing study reveals that probably all the *Tyto* species are endemic as are two of the three Strigidae as well (M. Pavia, orig.). In the Gargano taxa some of the size modifications normally associated with island Strigiformes can be observed: a great size increase in *Tyto gigantea* and *Strix perpasta*, while in *Tyto robusta* a lengthening of the hindlimbs is evident. The other species seem to be less modified, although their ancestors are unknown, and hence the trends that affected them are very difficult to determine.

The Pleistocene birds from Sicily are quite well-known from a taxonomical and biochronological point of view (Pavia, 2000, 2001, 2004; Bonfiglio et al., 2002; Pavia and Mourer-Chauviré, 2002). The different vertebrate associations have been recently divided into five Faunal Complexes (FC) with biochronological significance, four of them containing fossil birds (Bonfiglio et al., 2002). Among the four fossil avifaunas, only two have endemic characteristics, those of the early Middle Pleistocene *Elephas falconeri* FC and the Late Pleistocene *Elephas mnaidriensis* FC. The latter is less endemic than the former; the giant endemic *Cygnus falconeri* is the only endemic taxon (Pavia, 2001). The *Elephas falconeri* FC is much more diversified and contains at least 66 taxa, with five extinct endemisms: the dwarf *Cygnus equitum*, *Grus melitensis*, *Tyto mour-*

erchauvireae, *Athene trinacriae*, *Aegolius martae* n. sp., and a still undescribed Corvidae species of small size (Pavia, 2000; Bonfiglio et al., 2002; Pavia and Mourer-Chauviré, 2002; Pavia, 2004, this paper). As listed above, the Strigiformes represent half of the endemic taxa, and two of them show great increases in body size, *Tyto mourerchauvireae* and *Aegolius martae* n. sp. On the contrary, *Athene trinacriae* shows a lengthening of the hindlimbs similar, although less extensive, to that of *Athene cretensis*. In the *Elephas falconeri* FC Strigiformes represent the top carnivores. In particular *Tyto mourerchauvireae* was probably at the top of the food chain and it was the major culprit in the accumulation of many fossil vertebrate deposits (Pavia, 2004). The deep faunal change that occurred between the *Elephas falconeri* FC and the *Elephas mnaidriensis* FC, involved the endemic macro-mammals and birds with the extinction of the fossil taxa and their complete replacement by non-endemic forms, such as *Bubo bubo* and *Athene noctua* (Pavia, 2001). Much like birds, macro-mammals were also totally replaced by new forms, most of them still endemic, but the whole association itself became less insular with the arrival of terrestrial carnivores (Bonfiglio et al., 2002). During the Middle and Late Pleistocene, Sicily and Malta were joined in an archipelago with the same vertebrate taxa (Bonfiglio et al., 2002). However, no endemic Strigiformes have been reported from Malta, except for *Tyto melitensis*, described by Lydekker (1891) and later synonymized with the extant *Tyto alba* (Mourer-Chauviré et al., 1980; Mlíkovský, 1998). This absence probably reflects a poor knowledge of the Maltese fossil birds (Alcover et al., 1992).

As for Sicily, the fossil bird remains from Corsica and Sardinia have been well-known for a long time (Louchart, 2002 for a list of references; Abbazzi et al., 2004). The fossil assemblages of these two islands are quite homogenous and they share almost all the endemic taxa (Abbazzi et al., 2004; Pereira et al., 2005; van Der Made, 2005). This is also true for the eight endemic bird taxa described so far: *Aquila nipaloides*, *Falco peregrinus cyrneus*, *Tyto balearica cyrneichnusae*, *Tyto alba ernesti*, *Bubo insularis*, *Athene angelis*, *Pyrhacorax graculus castiglioni*, *Pyrhacorax pyrhororax macrorhynchus* (Louchart, 2002; Louchart et al., 2005). The three endemic species of Strigiformes of Corsica and Sardinia show different evolutionary patterns from their ancestors. In particular they are distinct in bone proportions, as is the case for *Tyto balearica cyrneichnusae*, by a noticeable increase in body size in *Athene angelis* and a decrease in body size in *Bubo insularis* (Louchart, 2005). The latter is the sole case of dwarfism in the extinct endemic Strigiformes and it is probably due to the extreme specialisation of *Bubo insularis* in eating the ocotonid *Prolagus*, which is very abundant in all fossil deposits of Corsica and Sardinia (Pavia and Bedetti, 2003). The extant endemic *Tyto alba ernesti*, the only insular endemic Strigiformes still present in the Mediterranean islands, evolved during the Middle Pleistocene and partially cohabited with the extinct *Tyto balearica cyrneichnusae* (Louchart, 2002).

The Balearic Islands yielded a huge amount of fossil bird assemblages of different ages (Alcover, 1989; Florit et al., 1989; Segui, 1996, 1998, 1999, 2001; Segui et al., 1997, 2001; Alcover et al., 2005). Some extinct endemic forms have been described, mostly from the Neogene deposits (Mourer-Chauviré et al., 1980; Alcover, 1989; Segui, 1999, 2001; Segui et al., 2001). The Balearic Islands, like all other Mediterranean islands, were inhabited by continental island vertebrates with more or less endemic taxa, with the exception of Eivissa, the only oceanic island of the whole Mediterranean basin (Alcover et al., 1994). The Strigiformes record in the Balearic Islands only contains non-endemic species, with the exception of *Tyto balearica balearica* described from the Plio-Pleistocene of Mallorca and Minorca (Mourer-Chauviré et al., 1980). This large-sized *Tyto* was later reported from various localities in both mainland Spain and France (Sanchez-Marco, 2001) and in the Pleistocene of Corsica and Sardinia with the endemic subspecies *Tyto balearica cyrneichnusae* (Louchart, 2002). The relationships between the type material of *Tyto balearica balearica* and the mainland fossil remains are not clear (Louchart, personal communication 2006); what is the taxonomical level at which *Tyto balearica* can be considered an insular owl is not yet defined, except for the subspecies *T. b. cyrneichnusae* (Louchart, 2002). A single bone of *Athene* sp. was reported from the Plio-Pleistocene of Eivissa: it was previously determined as *Athene cf veta* (Alcover, 1989), but it has not yet been described in detail (Pavia and Mourer-Chauviré, 2002). In conclusion, no endemic Strigiformes can be reported with certainty from the Balearic Islands.

In general, to summarize what could have been the moving cause of Strigiformes evolution on Mediterranean Islands, it is worth noting that these areas were inhabited by more or less impoverished endemic vertebrate associations, with few or non-terrestrial carnivores and many endemic rodents. This scenario favoured the local evolution of endemic Strigiformes. In some cases they are at the top of the food chain, as in Sicily for *Tyto mourerchauvirae* (Pavia, 2004), or are highly specialized predators.

4. Systematic palaeontology

The fossil material here examined has been collected in two karst localities of Sicily: Marasà Cave (Palermo) and Spinagallo Cave (Siracusa) (Fig. 2), whose fossil vertebrate assemblages have been attributed to the early Middle Pleistocene *Elephas falconeri* FC (Bonfiglio et al., 1997, 2001, 2002). One bone referable to the new species of *Aegolius* is part of the material collected at Marasà Cave and deposited in the Museo di Geologia e Paleontologia of the University of Torino, Italy (PU). Two bones that have been found in the Spinagallo Cave are kept in the Museo di Paleontologia of the University “La Sapienza” of Roma, Italy (MPUR).

Comparisons were made with recent skeletal material stored in the “Dipartimento di Scienze della Terra” of the University of Torino, Italy (Marco Pavia Osteological Collection (MPOC)), in the “Museo Civico di Storia Naturale” of Carmagnola, Italy (MCC) and in the University Claude Bernard Lyon-1, Villeurbanne, France. Measurements are in millimetres, in accordance with the indications proposed by Mourer-Chauviré (1975). The osteological terminology is from Baumel and Witmer (1993).

Class Aves Linnaeus, 1758
Order Strigiformes Wagler, 1830
Family Strigidae Vigors, 1925
Genus *Aegolius* Kaup, 1829

The fossil here described are placed in the genus *Aegolius* due to their stout tarsometatarsus (holotype). In the

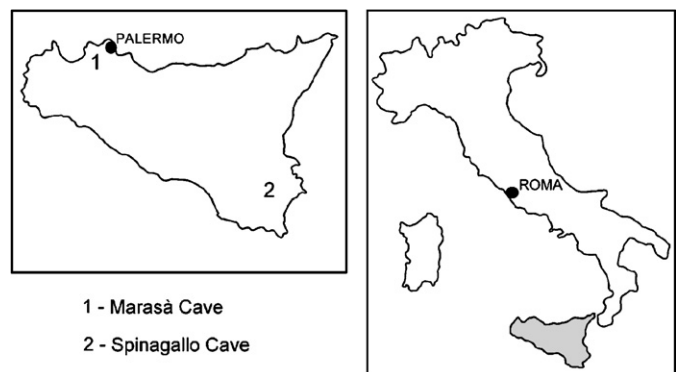


Fig. 2. Map of Sicily (Italy). The insert shows the position of the localities with *Aegolius martae* n. sp. remains cited in the text.



Fig. 3. *Aegolius martae* n. sp. a, c: right tarsometatarsus, holotype PU 100045, Marasà Cave: a: dorsal view and c: medial view. e, f: right femur, paratype MPUR 5010, Spinagallo Cave: e: cranial view and f: caudal view. *Aegolius funereus*. b, d: right tarsometatarsus, MCC 1146: b: dorsal view and d: medial view. g: left femur, MCC 1146, caudal view. The scale bars represent 1 cm.

Palaeartic Strigiformes, two other genera show a similarly shaped tarsometatarsus, *Glaucidium* and *Surnia*. The former is very small, while the latter is similar in size to the fossil. Nevertheless, after direct comparison, they can be excluded because the fossil's tarsometatarsus is not as stout as in these two genera, *Surnia* in particular. Moreover in *Aegolius martae* n. sp. the sulcus extensorius is well developed, while it is virtually absent in the extant *Surnia ulula*. The sulcus extensorius of the fossil bone is also medially and laterally delimited by two well-developed cristae, in particular the medial one, both absent in the other two genera. The fossil femur (paratype) shows similar proportions of *Surnia ulula*, but best fits *Aegolius* because the crista trochanteris is not tilted medially as in the other genera of Strigidae, in addition, it shows a deep and narrow fossa poplitea typical of this genus.

Aegolius martae n. sp.

(Fig. 3 a, c, e, f)

1999. cf. *Surnia ulula* – Pavia, p. 125.

2000. cf. *Surnia ulula* – Pavia, p. 53.

Holotype: Marasà Cave, PU 100045, right tarsometatarsus, lacking Trochlea IV.

Paratype: Spinagallo Cave, MPUR 5010, right femur, almost complete.

Tentatively referred specimen: Spinagallo Cave, MPUR 5712, sternum, cranial fragment.

Etymology: This species is dedicated to Marta Arzarello, of Ferrara University, who gives me unique emotions in my life and everyday enthusiasm in my work.

Type locality: Marasà Cave, near Palermo, north-western Sicily (Fig. 2).

Additional locality: Spinagallo Cave, near Siracusa, south-eastern Sicily (Fig. 2).

Age: Early Middle Pleistocene, “*Elephas falconeri* FC” according to Bonfiglio et al. (1997, 2002).

Measurements: See Table 1.

Diagnosis: A large species of the genus *Aegolius*, which shows a larger body size, about 30% increase, and a stouter tarsometatarsus compared with the extant *Aegolius funereus*, its probable ancestor.

Description and comparisons: The extant *Aegolius funereus* can be excluded by the smaller size of all the considered skeletal elements (Fig. 3; Table 1). The sternal fragment from Spinagallo Cave can only be tentatively attributed to *Aegolius martae* n. sp., because it fits well in terms of size,

Table 1

Measurements of the bones of *Aegolius martae* n. sp., compared with recent *Aegolius funereus*. Measurements are in millimeters. (Data of *Aegolius funereus* courtesy G. Boano and C. Mourer-Chauviré)

	Total length	Proximal width	Proximal depth	Distal width	Distal depth	Width in the middle
Tarsometatarsus						
<i>Aegolius martae</i> n. sp. Holotype PU 100045	28.9	9.2	7.9	—	6.2	6.2
<i>Aegolius funereus</i>	22.1–23.9 (n = 5)	6.2–6.7 (n = 5)	5.7–6.4 (n = 5)	6.4–7.2 (n = 5)	4.6–5.4 (n = 5)	3.5–4.1 (n = 5)
Femur						
<i>Aegolius martae</i> n. sp. Paratype MPUR 5010	52.5	10.6	6.6	9.9	8.5	4.3
<i>Aegolius funereus</i>	36.2–38.6 (n = 7)	6.3–7.2 (n = 7)	4.0–4.5 (n = 7)	6.3–6.8 (n = 7)	4.8–5.5 (n = 7)	2.7–3.0 (n = 7)

but shows some morphological differences, such as a wider foramen pneumaticum, a more developed spina externa and different shape of the sulci articulares coracoidei.

Remarks: The fossils of *Aegolius martae* n. sp. from Spinagallo Cave have been known since the papers of Pavia (1999, 2000). In these studies the femur and the sternum fragment were determined as cf. *Surnia ulula*, and hereafter is always considered as such (Bonfiglio et al., 2002). The holotype tarsometatarsus was later found in the material collected by Fabiani at Marasà Cave (Fabiani, 1928) and sent to the Museo di Geologia e Paleontologia of the Torino University in 1929. The material is mainly constituted by a huge collection of endemic Gliridae *Leithia* and *Maltamys* and a few remains of other animals. The fossil tarsometatarsus of *Aegolius martae* n. sp. was found during a recent management of the collection, together with a few other bird bones.

The genus *Aegolius* is today represented by four species found in Eurasia, North and South America, all linked to woodland habitat (del Hoyo et al., 1999). *Aegolius funereus* is widespread throughout the Northern Hemisphere; it is a sedentary species which shows a patchy distribution in the mountain areas of the southern part of the range. Some of the isolated populations, originated after north–south movements during glacial and interglacial phases of the Late Pleistocene, locally evolved into different subspecies (del Hoyo et al., 1999). The endemic *Aegolius martae* n. sp. probably represents a local offshoot of *Aegolius funereus*, known since the Late Pliocene (Mlíkovský, 2002), which probably colonized Sicily after a southward movement during a glacial phase of the Early Pleistocene. The increased body size of the new species is a response to the high endemic conditions of Sicily during the early Middle Pleistocene *Elephas falconeri* FC. Sicily was characterized by temperate climate conditions and dense woodlands, as testified by the great number of endemic Gliridae remains (Bonfiglio et al., 2002). *Aegolius martae* n. sp., though very rare as only three bones were found among a huge quantity of remains (Pavia, 2000), confirms the propensity of Strigiformes to colonise new areas and

their tendency to evolve into endemic forms soon after their isolation.

5. Conclusions

Birds are a very important group in the study of the island evolution, as their responses to isolation are rapid and easy to identify. Including fossils in the study of island bird communities can fill the gap of the recent extinctions, which are mainly due to human colonisation and its direct and indirect effects, and which lead to an artificial view of island communities if one looks at extant taxa only (Newton, 2003). Fossils thus allow us to have as precise a picture as possible of the naturally evolved bird communities of a single island. These extinctions mostly involved larger and more specialized species. The Strigiformes are a key group for understanding the endemic evolution of birds; in fact they show the same body size and allometrical modifications as shown by birds as a whole, except for the loss of the ability to fly, the only insular modification that has never been recorded in Strigiformes (Louchart, 2005). Moreover owls have sedentary habits, with few exceptions, but also the ability to colonise areas as far as 3500 km from the mainland. This gives them the opportunity to evolve a great number of insular endemic taxa. The study of endemic Strigiformes also reveals that there is no general trend in insular evolution of body size; neither is there an “island rule” for this group, as recently suggested by Clegg and Owens (2002). This also seems to be the case for birds as a whole (Louchart, 2005), in contrast.

The Strigiformes often form a guild in a single island, with more endemic species living together, often originating from different mainland ancestors in response to local conditions. This is the case of various islands or archipelagos, including those of the Mediterranean Sea, such as Corsica, Sardinia and Sicily (Louchart, 2005), where they constitute the most important predators for small to mid-sized vertebrates. At present, the Sicilian guild of endemic Strigiformes of the early Middle Pleistocene

Elephas falconeri FC includes three species, two of them showing increased body size, *Tyto mourerchauvireae* and *Aegolius martaee* n. sp., while the other, *Athene trinacriae*, shows longer hindlimbs in response to mostly terrestrial habits.

More generally, it is worth concluding that the vertebrate association of the *Elephas falconeri* FC represents one of the best examples of a faunal association inhabiting a biogeographical island type that is intermediate between the oceanic and the continental ones. In fact, it shows a very impoverished mammal fauna with high degree of endemism and no terrestrial carnivores, and a diversified bird fauna with some endemic species, one of which, *Tyto mourerchauvireae*, is at the top of the food chain. Incidentally this study also confirms the difficulty of determining the palaeoclimatic and palaeoenvironmental conditions of a given area using a single or a few bird species, particularly endemic ones.

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