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Geobios 37 (2004) 631–641

GEOBIOS

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A new large barn owl (Aves, Strigiformes, Tytonidae) from the Middle Pleistocene of Sicily, Italy, and its taphonomical significance

Une nouvelle espèce d'effraie géante (Aves, Strigiformes, Tytonidae) du Pléistocène moyen de Sicile, Italie, et son importance taphonomique

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Received 3 March 2003; accepted 19 May 2003

Abstract

A new species of Tytonidae, *Tyto mourerchauvireae*, is described from the Sicilian cave deposits of Spinagallo, Luparello and Marasà, which have yielded a common vertebrate fossil assemblages referred to the early Middle Pleistocene. *T. mourerchauvireae* nov. sp. shows a pronounced increase in body size compared to other congeneric taxa. It is larger than the extant *Tyto alba* and the extinct *Tyto balearica* and *Tyto sanctialbani* and comparable in size among the Mediterranean taxa only with the extinct *Tyto robusta*, which differs in some morphological characteristics of the long bones. The insular adaptations of *T. mourerchauvireae* nov. sp. and the differences from the other forms of the genus *Tyto* which spread through the Mediterranean area during Neogene and Pleistocene are discussed. The fossil assemblages of the early Middle Pleistocene of Sicily are dominated by extinct giant Gliridae of the genus *Leithia* and *Maltamys*; these taxa are regarded as the primary prey items of *T. mourerchauvireae* nov. sp. The Gliridae remains were analysed microscopically to detect possible modifications of bones and teeth caused by ingestion and digestion processes. This type of analysis, together with the qualitative study of the fossil assemblages, allows to show the taphonomical importance of *T. mourerchauvireae* nov. sp. as agent of accumulation in such Sicilian fossil assemblages. Incidentally the taxonomic validity of *T. robusta* is discussed and confirmed.

Résumé

Une nouvelle espèce de Tytonidae, *Tyto mourerchauvirae*, est décrite dans trois gisements de Sicile, les Grottes de Spinagallo et de Luparello, et la Grotte Marasà, qui ont livré d'abondants restes de vertébrés datant du début du Pléistocène moyen. *Tyto mourerchauvirae* nov. sp. montre une augmentation de taille prononcée par rapport à d'autres espèces du même genre. Elle est plus grande que l'espèce actuelle *Tyto alba* et que les espèces éteintes *Tyto balearica* et *Tyto sanctialbani*, et parmi les autres espèces méditerranéennes elle peut être comparée en taille uniquement avec l'espèce éteinte *Tyto robusta*, mais elle s'en distingue par des caractères morphologiques des os post-crâniens. Les adaptations insulaires de *Tyto mourerchauvirae* nov. sp. et ses différences par rapport aux autres espèces du genre *Tyto* qui existaient dans les régions méditerranéennes durant le Néogène et le Pléistocène sont discutées. En Sicile les associations de vertébrés du début du Pléistocène moyen sont dominées par les Gliridae géants éteints des genres *Leithia* et *Maltamys*. Ces taxons sont considérés comme la principale ressource alimentaire de cette nouvelle effraie géante. Les restes de Gliridae ont été analysés au microscope pour vérifier la présence de traces, sur les os et sur les dents, causées par l'ingestion et la digestion. Ce type d'analyse, en même temps que l'étude qualitative des assemblages fossiles, a permis de montrer l'importance taphonomique de *Tyto mourerchauvirae* en tant qu'agent d'accumulation de ce matériel fossile sicilien. Par la même occasion la validité taxonomique de l'espèce *Tyto robusta* a été examinée et confirmée.

Keywords: Tytonidae; *Tyto mourerchauvireae* nov. sp.; Middle Pleistocene; Italy; Insularity; Taphonomy

Mots clés : Tytonidae ; *Tyto mourerchauvireae* nov. sp. ; Pléistocène moyen ; Italie ; Insularité ; Taphonomie

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doi:10.1016/j.geobios.2003.05.007

1. Introduction

The fossil avifauna of Sicily is little known, except for a few studies on bird remains from archaeological sites, where only extant species and continental-like bird associations are listed (Tyrberg, 1998), and for preliminary analyses of Middle Pleistocene birds from Contrada Fusco and Spinagallo Cave (Siracusa, southeastern Sicily) (Cassoli and Tagliacozzo, 1996; Pavia, 1999, 2001). In the recent revision of the Pleistocene avifaunas of Mediterranean islands, Alcover et al. (1992) excluded the bird assemblages of Sicily because it was supposed that the island and mainland were connected, though it was known to sustain endemic vertebrate taxa, due to the isolation of Sicily during Middle and early Late Pleistocene. In the last two centuries, many Sicilian localities with fossil vertebrate assemblages have been found and excavated (Bonfiglio and Burgio, 1992). Recent palaeontological analyses (Bonfiglio et al., 1997, 2001, 2002; Di Maggio et al., 1999) arranged the Pleistocene vertebrates into five Faunal Complexes (FC). Four of these mainly include endemic fossil mammals and reptiles, while the fifth, dating from the latest Pleistocene, contains extant continental species together with Palaeolithic artefacts. Fossil bird remains were found in each FC (Bonfiglio and Insacco, 1992; Bonfiglio et al., 1997, 2002), except for the oldest one, the “Monte Pellegrino FC” which contains only endemic small mammals and reptiles (Burgio and Fiore, 1988a). The recent analysis of some Sicilian fossil bird assemblages (Pavia, 2000) furnished detailed information on the avifaunas of the Middle Pleistocene “*Elephas falconeri* FC” and “*Elephas mnaidriensis* FC”, i.e. the 2nd and the 3rd FC of Bonfiglio et al. (2001). These data are now included in a revision of the fossil bird associations of the Mediterranean islands isolated during Middle and Late Pleistocene (Mourer-Chauviré et al., 2001). Some endemic forms are present in these fossil bird assemblages, particularly in the “*Elephas falconeri* FC”. The most important locality of this FC, that yielded hundreds of bird bones together with a huge amount of mammal and reptile bones, is the Spinagallo Cave, near Siracusa (southeastern Sicily) (Fig. 1).

This paper describes fossil remains from Spinagallo Cave and other Sicilian localities of the same age (Luparello Cave and Marasà Cave) from which a new species of *Tyto* has been found. Besides it is clear that the widespread presence of the new Tytonidae in the Sicilian Middle Pleistocene vertebrate assemblages is the consequence of a certain synecological role of this strigiform in the middle to small size vertebrate communities. Hence, the importance of the new *Tyto* species in the formation of those fossil assemblages needs a detailed discussion.

2. Material and methods

Sixteen bones referable to the new species of *Tyto* have been found in the material collected in the Spinagallo Cave and deposited in the “Museo di Paleontologia” of the University “La Sapienza” of Roma, Italy (MPUR). Six bones and one bone have instead been found in Luparello and Marasà Cave respectively, they are all kept in the Museo Geologico “G.G. Gemmellaro” of the University of Palermo, Italy (MGUP).

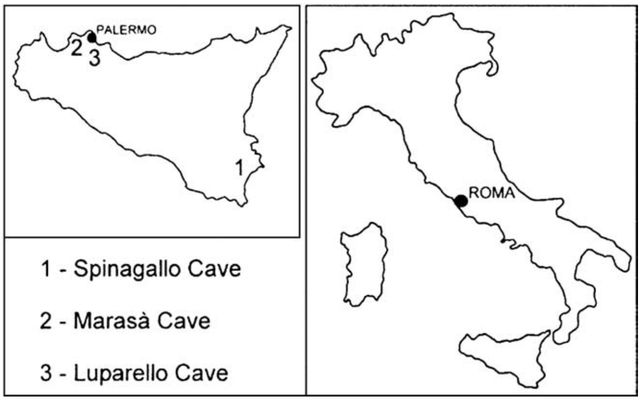

Fig. 1. Map of Sicily (Italy) showing the position of the fossil localities with remains of *Tyto mourerchauvireae* nov. sp. cited in the text.
Fig. 1. Carte de Sicile (Italie) montrant les localités fossilifères avec les restes de *Tyto mourerchauvireae* nov. sp. mentionnés dans cet article.

Comparisons have been 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 and in the University Claude Bernard Lyon-1, Villeurbanne, France. Comparisons have also been made with fossil remains of *Tyto robusta* and *Tyto gigantea*, from the Late Miocene of Chirò and Pizzicoli quarries near Apricena, Gargano, Italy (Ballmann, 1973, 1976), stored in the National Museum of Natural History (Naturalis) of Leiden, The Netherlands (RGM), the “Dipartimento di Scienze della Terra” of the University of Firenze, Italy, and in the “Museo di Geologia e Paleontologia” of the University of Torino (PU); comparisons with bones of *Tyto sanctialbani* from the Miocene of La Grive-St. Alban, France, and *Tyto balearica* from the Pliocene of the Balearic Islands and the Middle Pleistocene of Corsica (Louchart, 2002; Sanchez-Marco, 2001), were made in the University Claude Bernard Lyon-1, Villeurbanne. The microscopic analysis of the bone surfaces was made using a stereomicroscope with variable 6.3× to 50× magnification, backed up with a scanning electronic microscope (SEM).

Measurements are in millimetres, in accordance with the indications proposed by Mourer-Chauviré (1975). The osteological terminology is from Baumel and Witmer (1993).

3. Systematic palaeontology

Class AVES Linnaeus, 1758
Order STRIGIFORMES (Wagler, 1830)
Family TYTONIDAE Ridgway, 1914
Genus ***Tyto*** Billberg, 1828

Remarks: According to Del Hoyo et al. (1999), the family Tytonidae contains only two living genera: *Tyto* and *Phodilus*. The first one is widespread in the world with at least 14 species with only one, *Tyto alba*, occurring in the Western Palearctic (Cramp, 1985). *Phodilus* instead is known to have two species: *Phodilus badius* from Asia and *Phodilus prigoginei* from Africa (Del Hoyo et al., 1999). The genus *Tyto* differs from *Phodilus* in some morphological characteristics, as also pointed out by Mourer-Chauviré (1987); in particular, in *Tyto* the processes supracondylaris dorsalis at the distal humerus is more robust than *Phodilus*, moreover, the ridge of the condylus lateralis of the distal tibiotarsus in *Phodilus* is straight on the diaphysis more like in the Strigidae than in the Tytonidae, the tarsometatarsus of *Phodilus* is stout, while in *Tyto* it is slender.

The Tytonidae also comprises several fossil genera, such as *Nocturnavis*, *Necrobyas*, *Palaeobyas*, and *Palaeotyto* from the Middle Eocene to the Upper Oligocene of the Phosphorites du Quercy (Mourer-Chauviré, 1987), while the genus *Palaeoglaux*, found in the Phosphorites du Quercy and in the Middle Eocene of Messel, was formerly referred to the monotypic subfamily Palaeoglaucinae (Mourer-Chauviré 1987) which has been later elected to family rank by Peters, (1992). The genus *Basityto*, described by Mlíkovský (1998) with the species *B. rummeli* and placed in the subfamily Tytoninae, family Strigidae, contrary to the most widespread opinion of the family identity of Tytonidae (Del Hoyo et al., 1999; Sibley and Ahlquist, 1990), has been recently synonymized with the genus *Balearica*, family Gruidae, by Mourer-Chauviré, (2001).

The genus *Tyto* is known since the Upper Miocene with the species *T. sanctialbani* reported from various European localities (Bocheński, 1997a; Sanchez-Marco, 2001). The species *Tyto ignota* from the Middle Miocene of Sansan was long regarded as the oldest form of the genus (Bocheński, 1997a; Mlìkovský, 1996), but has been recently moved by Cheneval, (2000) into the Strigidae, as *Asio* (?) *ignotus*. The fossil record also comprises a rich variety of insular species, like the ones described from the Neogene and Pleistocene of the Mediterranean Islands and from the Pleistocene of the Western Indies (Steadman and Hilgartner, 1999). In the Mediterranean area four extinct species of *Tyto* are known so far: *Tyto melitensis*, *T. balearica*, *T. gigantea* and *T. robusta*, the latter three with a marked increasing of body-size compared to the living *T. alba*.

Tyto melitensis, an extinct form described by Lydekker, (1891) from the Pleistocene of Malta, was synonymized with the extant *T. alba* (Mlíkovský, 1998; Mourer-Chauviré et al., 1980) and will not further considered here. *T. balearica* is an extinct species described by Mourer-Chauviré et al., (1980) as an insular form endemic of the Plio-Pleistocene of the Balearic Islands and subsequently found in several Neogene and Pleistocene localities of the Western Mediterranean basin (Sanchez-Marco, 2001), also with the recently described subspecies *T. balearica cyrneichnusae* endemic of Corsica and Sardinia (Louchart, 2002).

T. gigantea and *T. robusta* were described from the Miocene of the Gargano peninsula (Ballmann, 1973, 1976); these two species, with definite endemic characteristics, were recently synonymized by Mlíkovský (1998) as *T. gigantea*, according to the opinion that they represent diacronous steps of a single phyletic lineage. The effective coexistence of the two forms in the same karst fissures (Ballmann, 1973, 1976) and some morphological differences pointed out by the analysis of new material from Gargano, such as the different robustness of the tarsometatarsus, allow to exclude this hypothesis (author's personal observation), so I am considering here *T. robusta* as a valid species.

Tyto mourerchauvireae, nov. sp.
Fig. 2(1–3,6–9,11,14,15).
1998. *Tyto* nov. sp.—Tyrberg, p. 547.
1999. *Tyto* undescribed species—Pavia, p. 125–126.
2000. *Tyto* nov. sp.—Pavia, p. 50, Pl. 4, Fig. 4, 5.

Holotype: Spinagallo Cave, MPUR 5218, right femur.

Paratypes: Spinagallo Cave: MPUR 5640, left humerus, distal part; MPUR 5641, right ulna; MPUR 5220, left femur; MPUR 5700, right femur; MPUR 5756, right tibiotarsus, distal part; MPUR 5642, right tarsometatarsus, proximal part.

Referred material: Spinagallo Cave: MPUR 5305 incomplete skull; MPUR 5615, right radius, distal part; MPUR 5757, left ulna, distal part; MPUR 5758, left ulna, proximal part; MPUR 5760, left ulna, proximal part; MPUR 5617, right ulna, proximal part; MPUR 5423, incomplete synsacrum; MPUR 5759, left femur, proximal part; MPUR 5219, right femur. Marasà Cave: MGUP-MA 229/86, incomplete right scapula. Luparello Cave: MGUP-GL 425/3, incomplete right scapula; MGUP-GL 434/4, right radius, proximal part; MGUP-GL 238, right ulna, proximal part; MGUP-GL 361, left femur, distal part; MGUP-GL 410, right tibiotarsus, distal part; MGUP-GL 345, right tarsometatarsus, proximal part.

Etymology: This species is dedicated to Cecile Mourer-Chauviré, of the French CNRS, who has studied and described many endemic birds, especially Strigiformes. It is a honour to regard her as my particular friend and teacher from whom I learned all I know on fossil birds.

Type locality: Spinagallo Cave, near Siracusa, south-eastern Sicily (Fig. 1).

Additional localities: Luparello Cave and Marasà Cave, near Palermo, north-western Sicily (Fig. 1).

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

Measurements: See Tables 1,2.

Diagnosis: A large species of the genus *Tyto*, larger than the extant *T. alba* and the extinct *T. balearica* and *T. sanctialbani*. The cranium shows a shallow depressio frontalis with respect to *T. alba*. The femur shows a small tubercular prominence in the proximal part of the linea intermuscularis cranialis, which is absent in *T. alba* and in the extinct forms of the genus; the distal epiphysis of the femur is proportionally wider than the other species, due to the lateral development of the condylus medialis.

Fig. 2. **1–16.** Various skeletal element of *Tyto mourerchauvireae* nov. sp. **(1, 2, 3, 6, 11, 14, 15)** compared with the extinct *Tyto robusta* (10) and the extant *Tyto alba* (4, 5, 12, 13, 16). *Tyto mourerchauvireae* nov. sp. from Spinagallo Cave: **1**, right femur (holotype, MPUR 5218), caudal view; **2**, right femur (holotype, MPUR 5218), cranial view; **3**, right femur (paratype, MPUR 5700), cranial view; **6**, right ulna (paratype, MPUR 5641), ventral view; **11**, proximal end of right tarsometatarsus (paratype, MPUR 5642), dorsal view; **14**, distal end of left humerus (paratype, MPUR 5640), cranial view; **15**, distal end of right tibiotarsus

(paratype, MPUR 5756), cranial view. *Tyto mourerchauvireae* nov. sp. from Luparello Cave: **7**, distal part of right tibiotarsus (MGUP-GL 410), lateral view; **8**, distal part of right tibiotarsus (MGUP-GL 410), cranial view; **9**, proximal end of right ulna (MGUP-GL 238), cranial view. *Tyto robusta* Ballmann, 1973 from Pizzicoli quarry: **10**, proximal end of right tarsometatarsus (RGM 425479), dorsal view. *Tyto alba* (Scopoli, 1769), recent (MPOC 37): **4**, right femur, cranial view; **5**, right ulna, ventral view; **12**, right tarsometatarsus, dorsal view; **13**, left humerus, cranial view; **16**, right tibiotarsus, cranial view. Specimens coated with ammonium chloride to enhance details. The scale bars represent 10 mm.

Fig. 2. : **1–16.** *Tyto mourerchauvireae* nov. sp. de la Grotte de Spinagallo: **1**, fémur droit (holotype, MPUR 5218), vue caudale; **2**, fémur droit (holotype, MPUR 5218), vue crâniale; **3**, fémur droit (paratype, MPUR 5700), vue crâniale; **6**, ulna droite (paratype, MPUR 5641), vue ventrale; **11**, tarsométatarse droit, partie proximale (paratype, MPUR 5642), vue dorsale; **14**, humérus gauche, partie distale (paratype, MPUR 5640), vue crâniale; **15**, tibiotarse droit, partie distale (paratype, MPUR 5756), vue crâniale. *Tyto mourerchauvireae* nov. sp. de la Grotte de Luparello: **7**, tibiotarse droit, partie distale (MGUP-GL 410), vue latérale; **8**, tibiotarse droit, partie distale (MGUP-GL 410), vue crâniale; **9**, ulna droite, partie proximale (MGUP-GL 238), vue crâniale. *Tyto robusta* Ballmann, 1973 de la carrière Pizzicoli: **10**, tarsométatarse droit, partie proximale (RGM 425479), vue dorsale. *Tyto alba* (Scopoli, 1769), récent (MPOC 37): **4**, fémur droit, vue crâniale; **5**, ulna droite, vue ventrale; **12** tarsométatarse droit, vue dorsale; **13** humérus gauche, vue crâniale; **16**, tibiotarse droit, vue crâniale. Tous les exemplaires ont été blanchis au chlorure d'ammonium. Échelle graphique 10 mm.

Description: The fossil bones show morphological characteristics which fit exactly those of Tytonidae, in particular those of the genus *Tyto*. The fossil remains exhibit the following morphological features: at the cranium the os mesethmoidale is wide and pneumatic. The fossa musculi brachialis of the distal humerus is well defined and deep; at the proximal epiphysis of the ulna, the tuberculum ligamenti collateralis ventralis forms a little ridge and the trochlea humeralis ulnaris is deep and shows a pneumatic surface; the cotyla humeralis of the proximal radius is rounded and the depressio ligamentosa at the distal part of the bone is deep. The crista trochanteris of the proximal femur is perpendicular to the longitudinal axis of the diaphysis and at the distal part of the bones the proximal portion of the crus condylus lateralis is rather pointed in posterior view; the sulcus extensorius on the distal tibiotarsus is not as deep as in the Strigidae and, in lateral view, the condylus lateralis extends caudally (Fig. 2(7)), also in caudal view the condylus medialis is narrow. In the proximal part of the tarsometatarsus the arcus extensorius is absent. The femur groups into two different dimensional classes of bones, even at the same locality, as indicated in Table 2; this can be interpreted as the expression of sexual dimorphism. The same fact has been found by Steadman and Hilgartner (1999) concerning the endemic *Tyto neddi* of the Pleistocene of the West Indies.

Comparison: The bones of *T. mourerchauvireae* nov. sp. have been compared with the extant species *T. alba* and all the extinct forms of the Neogene of the Mediterranean basin known so far: *T. sanctialbani*, *T. balearica*, *T. robusta*, and *T. gigantea*. The fossil remains are clearly larger than those of *T. alba*, *T. sanctialbani*, and *T. balearica* and thus do not require any comparison; the fossil remains are also definitively smaller than those of *T. gigantea*, so they are not compared further. It is instead necessary to compare the

Table 1

Measurements of the forelimb bones of *Tyto mourerchauvireae* nov. sp., compared with the extinct *Tyto robusta*, *Tyto balearica balearica*, *T. balearica cyrneichnusae* and the extant *Tyto alba*. (Data from Ballmann, 1973 (1); Langer, 1980 (4); Louchart, 2002 (2) ; Mourer-Chauviré et al., 1980 (3))

Dimensions des éléments du membre antérieur de *Tyto mourerchauvireae* nov. sp., comparées avec celles des espèces éteintes *Tyto robusta*, *Tyto balearica balearica*, *T. balearica cyrneichnusae* et de l'espèce actuelle *Tyto alba*. (Données d'après Ballmann,1973 (1); Langer, 1980 (4); Louchart, 2002 (2); Mourer-Chauviré et al., 1980 (3)).

	Total length	Proximal width	Proximal depth	Distal width	Distal depth	Width in the middle
Humerus						
Tyto mourerchauvireae nov. sp. MPUR 5640 paratype	–	–	–	20.4	–	–
Tyto robusta (1)	–	26.0	–	24.0	–	–
Tyto balearica balearica (3)	103.0	–	–	17.1	7.4	–
Tyto balearica cyrneichnusae (2)	110.6	17.5–17.8 (*n* = 2)	–	15.2–16.6 (*n* = 4)	– –	6.3–7.1 (*n* = 7)
Tyto alba (4)	73.7–85.3 (*n* = 28)	12.8–14.5 (*n* = 30)	–	11.6–13.5 (*n* = 28)	–	4.6–5.6 (*n* = 28)
Ulna						
Tyto mourerchauvireae nov. sp. MPUR 5167	–	11.7	11.0	–	–	6.1
Tyto mourerchauvireae nov. sp. MPUR 5641 paratype	134.3	12.3	11.3	9.2	10.1	6.1
Tyto mourerchauvireae nov. sp. MPUR 5757	–	–	–	9.0	10.4	6.2
Tyto mourerchauvireae nov. sp. MPUR 5758	–	12.3	11.3	–	–	6.2
Tyto mourerchauvireae nov. sp. MPUR 5760	–	12.0	11.0	–	–	–
Tyto mourerchauvireae nov. sp. MGUP–GL 238	–	12.9	11.2	–	–	–
Tyto robusta (1)	–	14.5	–	–	11.0	–
Tyto balearica cyrneichnusae (2)	–	10.0–10.7 (*n* = 5)	8.7–9.1 (*n* = 2)	7.6–8.4 (*n* = 10)	8.3–9.2 (*n* = 8)	4.4–5.4 (*n* = 21)
Tyto alba (4)	82.9–83.3 (*n* = 26)	7.5–8.4 (*n* = 27)	–	–	6.3–7.1 (*n* = 26)	3.4–3.9 (*n* = 27)

Table 2
Measurements of the hindlimb bones of *Tyto mourerchauvireae* nov. sp., compared with the extinct *Tyto robusta*, *Tyto balearica balearica*, *T. balearica cyrneichnusae* and the extant *Tyto alba*. (Data from Ballmann, 1973 (1); Langer, 1980 (4); Louchart, 2002 (2); Mourer-Chauviré et al., 1980 (3))
Dimensions des éléments du membre postérieur de *Tyto mourerchauvireae* nov. sp., comparées avec celles des espèces éteintes *Tyto robusta*, *Tyto balearica balearica*, *T. balearica cyrneichnusae* et de l'espèce actuelle *Tyto alba*. (Données d'après Ballmann, 1973 (1); Langer, 1980 (4); Louchart, 2002 (2); Mourer-Chauviré et al., 1980 (3)).

	Total length	Proximal width	Proximal depth	Distal width	Distal depth	Width in the middle
Femur						
Tyto mourerchauvireae nov. sp. MPUR 5218 holotype	74.3	15.4	8.7	16.3	13.4	6.8
Tyto mourerchauvireae nov. sp. MPUR 5219	75.7	15.2	8.6	16.6	13.6	6.4
Tyto mourerchauvireae nov. sp. MPUR 5220 paratype	74.6	16.0	9.6	16.0	13.8	7.2
Tyto mourerchauvireae nov. sp. MPUR 5700 paratype	85.5	17.5	10.7	–	15.5	7.7
Tyto mourerchauvireae nov. sp. MPUR 5759	–	15.9	7.3	–	–	7.3
Tyto mourerchauvireae nov. sp. MGUP-GL 361	–	–	–	18.9	15.4	7.5
Tyto robusta (1)	–	16.0	–	15.0	–	–
Tyto balearica balearica (3)	–	–	–	12.6–12.7 (*n* = 2)	11.1–11.3 (*n* = 2)	5.6–6.0 (*n* = 2)
Tyto balearica cyrneichnusae (2)	62.9–67.2 (*n* = 4)	12.0–13.1 (*n* = 16)	7.8–8.2 (*n* = 8)	11.9–13,5 (*n* = 11)	10.0–11.6 (*n* = 8)	5.3–6.3 (*n* = 25)
Tyto alba (4)	46.4–53.7 (*n* = 34)	8.5–10.1 (*n* = 34)	4.9–6.0 (*n* = 34)	8.9–10.5 (*n* = 34)	7.7–9.2 (*n* = 34)	3.8–4.4 (*n* = 34)
Tibiotarsus						
Tyto mourerchauvireae nov. sp. MPUR 5756 paratype	–	–	–	17.1	15.5	7.8
Tyto mourerchauvireae nov. sp. MGUP-GL 410	–	–	–	15.6	15.1	–
Tyto robusta (1)	– –	14.0–17.0 (*n* = 2)	– –	15.0	– –	– –
Tyto balearica cyrneichnusae (2)	103.4	10.5–12.7 (*n* = 6)	10.9–12.3 (*n* = 4)	10.5–12.7 (*n* = 12)	11.1–11.7 (*n* = 2)	5.0–6.1 (*n* = 16)
Tyto alba (4)	77.7–88.8 (*n* = 28)	– –	– –	8.5–10.0 (*n* = 29)	8.3–9.7 (*n* = 29)	3.9–4.5 (*n* = 29)
Tarsometatarsus						
Tyto mourerchauvireae nov. sp. MPUR 5642 paratype	–	14.9	10.3	–	–	7.3
Tyto robusta (1)		15.0–16.0 (*n* = 2)				
Tyto balearica balearica (3)	–	–	–	14.4	11.0	6.0
Tyto balearica cyrneichnusae (2)	68.7–72.5 (*n* = 5)	11.0–12.8 (*n* = 9)	10.5–11.9 (*n* = 9)	12.1–14.0 (*n* = 12)	10.3–11.2 (*n* = 4)	5.0–6.1 (*n* = 32)
Tyto alba (4)	55.4–64.6 (*n* = 29)	8.4–9.9 (*n* = 29)	6.8–8.6 (*n* = 21)	9.5–11.2 (*n* = 28)	7.5–8.8 (*n* = 21)	3.5–4.3 (*n* = 29)

bones of the new species with the corresponding ones of *T. robusta*, because of their similar dimensions in some osteological elements.

At the distal part of the humerus of *T. mourerchauvireae* nov. sp. the tuberculum supracondylare ventrale is more strongly developed than in *T. robusta*, which also shows a more slender humerus. At the distal part of the ulna, the condylus ventralis ulnaris is more developed in *T. mourerchauvireae* nov. sp. The proximal epiphysis of the femur of the new species is characterized by a small tubercular prominence on the linea intermuscularis cranialis close to the facies articularis antitrochanterica, which is absent in *T. robusta*; in the latter species the crista trochanteris extends distally and forms a continuous ridge, while in *T. mourerchauvireae* nov. sp. it is interrupted by the impressiones iliotrochantericae and thus constitutes of two distinct cristae. At the distal part of the femur of *T. mourerchauvireae* nov. sp. the fossa poplitea is deep; moreover the condylus medialis and the crista supracondylaris medialis are laterally more developed. At the distal tibiotarsus of *T. mourerchauvireae* nov. sp. the incisura intercondylaris is wider and the condylus medialis is larger and thinner. The tarsometatarsus of *T. robusta* is more slender than the one of *T. mourerchauvireae* nov. sp., which also differs in the more protruding eminentia intercondylaris (Fig. 2(10,11)).

4. Discussion

4.1. Evolution and synecology

The few specimens of *T. mourerchauvireae* nov. sp. known so far do not allow an analysis of the phylogenetic relationships among this species and the other *Tyto* species described in the Mediterranean area, both continental and insular forms. Among the five FCs in which the Sicilian fossil vertebrate assemblages have been divided (Bonfiglio et al., 1997, 2002), the "*Elephas falconeri* FC", of early Middle

Pleistocene, is the oldest one in which bird remains have been found. Thus the direct ancestors of *T. mourerchauvireae* nov. sp. are unknown since no bird remains occur in the Early Pleistocene "Monte Pellegrino FC" (Burgio and Fiore, 1988a). Nevertheless it seems likely that the new species evolved autochthonously after an early colonization of Sicily by a smaller form like *T. balearica*, the only Tytonidae recorded in the Early Pleistocene of the Mediterranean area (Tyrberg, 1998). It is well known that insular predatory birds, both diurnal and nocturnal, tend to enlarge their size (Azzaroli, 1982), and this is particularly true in the genus *Tyto*, in which the trend to gigantism in insular environments is well demonstrated by different species from the Pleistocene of the West Indies (Steadman and Hilgartner, 1999) and the Miocene of Gargano (Ballmann, 1973, 1976). This fact seems to be closely related to prey size, mostly of small mammals, which on islands tend to increase their body size, favoured by the absence of small terrestrial carnivores.

In Sicily the presence of endemic Gliridae of the genus *Leithia* and *Maltamys* has been reported during the "*Elephas falconeri* FC" (Bonfiglio et al., 2002). One of them, *Leithia melitensis*, is a gigantic Gliridae, while the other species *Leithia cartei* and *Maltamys wiedincitensis* show a slight increase in body size compared to *Glis glis*, the largest extant European Gliridae. During the early Middle Pleistocene no terrestrial carnivores inhabited the Sicilian country except for the endemic otter *Lutra trinacriae* (Burgio and Fiore, 1988b). Thus, the presence of various large big rodents might have favoured the local evolution of the endemic species *T. mourerchauvireae* nov. sp., which represented the top of the food chain. In fact, birds are the most common predators of small vertebrates on islands, and often they predate on middle- and large-sized vertebrates, especially if they have increased their body size (Alcover and Mc Minn, 1994).

The extinction on islands of various endemic large species of *Tyto* probably was related most often to the loss of their favourite prey species (Steadman and Hilgardner, 1999). This is not the case concerning *T. mourerchauvireae* nov. sp., as in the younger "*Elephas mnaidriensis* FC" the new species has never been recorded and was possibly replaced by the extant *Bubo bubo*, while the endemic giant glirids *Leithia melitensis* and *Maltamys wiedincitensis* still survive (Bonfiglio et al., 2002; Pavia, 2001). The deep faunal renewal occurred at the end of the Middle Pleistocene, as testified by the onset of the "*Elephas mnaidriensis* FC", involved all the macro-mammals, with the extinction of the dwarf *Elephas falconeri* and the arrival of many continental forms (Bonfiglio et al., 2002). During the "*Elephas mnaidriensis* FC" the endemic bird species became all-extinct and were partially replaced by continental forms (Pavia, 1999, 2001). This renewal, though so deep to involve such sedentary birds as the Strigiformes, did not modify the endemic micromammal communities at all, which disappeared in the more recent "Pianetti-S. Teodoro FC" (Bonfiglio et al., 2001). In conclusion, the extinction of *T. mourerchauvireae* nov. sp. seems to be more related to the direct competition with the more powerful *Bubo bubo*, which arrived from the mainland, than to the loss of food source; probably it took place in the middle part of the Middle Pleistocene, in a time confined between the "*Elephas falconeri* FC" and the "*Elephas mnaidriensis* FC".

The analysis of fossil vertebrate assemblages of the "*Elephas falconeri* FC" found in the karst cavities allows an estimate of the food range of *T. mourerchauvireae* nov. sp. It could have included the giant *Leithia melitensis*, the other Gliridae and the endemic *Crocidura esuae*, which were all of average abundance. In the food range of the new species a rich variety of birds probably played an important role: a large number of species is usually present in the fossil assemblages (Pavia, 2000) and they are interpreted as the product of predation; these birds are closely related to different environments, such as open habitat, as is the case with *Calandrella brachydactyla*, or dense woods, e.g. *Dendrocopos leucotos*, while other species are typical of aquatic environment, like *Larus minutus*. In fact, according to the abundance of remains, it is possible to conclude that the food range of *T. mourerchauvireae* nov. sp. was mostly characterized by *Leithia melitensis*, while other animals like small mammals and several bird species of various dimensions played a secondary role. In the fossil assemblages, the prevalence of one or few species together with the presence of a good variety of other species is similar to that observed in the pellets of the extant *T. alba*; while the possibility to take animals of different sizes, from a small *Crocidura* to a big *Anser*, is also observed in extant species with body size similar to *T. mourerchauvireae* nov. sp., such as *Bubo bubo* and *Nyctea scandiaca* (Cramp, 1985).

4.2. *Taphonomical importance of* T. mourerchauvireae *nov. sp.*

Several authors have pointed out the role of predators as accumulators of small fossil vertebrate remains. It is particularly true in the case of the Strigiformes, in which the hunting, ingestive and digestive processes caused no or scarce modifications on the skeletal elements found in their pellets (Andrews, 1990; Bocheński, 1997b; Bocheński and Tomek, 1997; Fernández-Jalvo, 1995). After the analysis of a big sample of pellets and scats of both nocturnal and diurnal raptors and mammal carnivores, Andrews (1990) identified different kinds of modifications of the small mammal bones. Five categories were defined and the predator species were grouped according to the degree of modification of the bones of their prey. These five predator groups range from the least destructive, with very little modifications and no or light digestion traces, to the most destructive with massive modification and digestion of bones.

The first category includes only Strigiformes, such as *Tyto alba*, *Nyctea scandiaca*, *Asio otus* and *Asio flammeus*; the second one also includes only Strigiformes, such as *Bubo bubo* and *Strix aluco*, but shows evident modifications and breakage both in teeth enamel and in the long bones. From the third to the fifth groups the modifications of bones and teeth become more and more evident and they include only diurnal raptor and terrestrial carnivores. In the same paper, Andrews (1990) applied those categories to the Late Pleistocene small-mammal assemblage of Westbury sub-Mendip (England), to understand the taphonomy of this fossil accumulation. This method has been successfully used in some other localities (Fernández-Jalvo, 1995, 1996; Fernández-Jalvo and Andrews, 1992; Fernández-Jalvo et al., 1998), with detailed taphonomical analyses carried out in order to improve the palaeoecological reconstruction. In fact the palaeoecological inferences obtained from fossil predators are not as precise as the ecological studies on living species (Andrews, 1992). This is because the various predators can introduce species from different habitats and thus produce an overrepresentation of the favourite prey (Andrews, 1990), thus possibly masking the real species composition and distorting the palaeoenvironmental reconstruction. Taphonomical analyses may correct the bias due to the hunting preference since the predator is detected and identified (Fernández-Jalvo, 1995).

Small vertebrate remains, particularly bones of *Leithia*, dominate the Sicilian karst fossil localities referred to the "*Elephas falconeri* FC", like the Spinagallo Cave, where thousand of *Leithia* remains have been found and described (Petronio, 1970), together with many bones of reptiles, bats and the endemic *Crocidura esuae* (Kotsakis, 1977, 1984; Kotsakis and Petronio, 1980). Important collections of small vertebrate bones have been found in other caves, such as Poggio Schinaldo (Esu et al., 1986), Luparello (Burgio and Costanza, 1999) and Marasà (author's personal observation). In all these localities the bones of small vertebrates are very well preserved and mostly complete. The fossil assemblages mainly comprise vertebrate species with no troglophilous habits, such as Gliridae and aquatic or woodland birds. This fact, together with the good preservation of the fossil remains, suggests that the fossil assemblages have been generated by the hunting activities of owls, such as *T. mourerchauvireae* nov. sp., *Otus scops*, *Athene trinacriae*, *Asio otus*, and cf. *Surnia ulula*, known so far in the "*Elephas falconeri* FC" (Pavia, 2000; Pavia and Mourer-Chauviré, 2002).

In the "Museo di Geologia e Paleontologia" of the University of Torino, a large sample of Gliridae remains from Marasà Cave, collected by Fabiani in 1929, is present together with some bones of *Leithia melitensis*, *Maltamys wiedincitensis* and *Crocidura esuae* from Spinagallo Cave that I collected during a recent survey. Macroscopic analyses of this material and of other specimens from Spinagallo Cave (Kotsakis, 1984; Petronio, 1970) and Poggio Schinaldo Cave (Esu et al., 1986) show that the skulls and mandibles are in fact often almost complete, with the incisors still in place, and the percentages of complete long bones are very high (Fig. 3(3,4)). The microscopic analyses made on the bone and teeth surfaces reveal no or very little signs of digestion (Fig. 3(1,2)); those features are in accordance to that described by Andrews (1990) in the food remains of the extant *T. alba*. Following the conclusions of Andrews (1990), Bocheński (1997b) and Bocheński and Tomek (1997), the other species of Strigiformes found as fossils in the "*Elephas falconeri* FC", e.g. *Asio otus* and *Athene trinacriae*, had to produce much more marks on the bones, of which there is no evidence in the studied material.

The mean dimensions of the presumed prey species also correlate to a large predator, such as *T. mourerchauvireae* nov. sp. The giant Gliridae *Leithia melitensis* was as large as a rabbit and the other Gliridae were larger than the extant *Glis glis* (Petronio, 1970). In fact also some open land or aquatic bird species, probably taken into the assemblages as preys, are of medium or large size, such as *Anser erythropus* and *Recurvirostra avosetta* (Pavia, 1999); and this can be correlated with a wide range of predation.

In conclusion, the degree of modification and digestion of the bones, typical of the genus *Tyto*, together with the mean dimensions of the animals found in the assemblages, indicate *T. mourerchauvireae* nov. sp. as the main species responsible of the accumulation of small and medium sized vertebrates in Sicily during the "*Elephas falconeri* FC". These results confirm the importance of predatory birds in fossil vertebrate accumulations, even on islands, as previously suggested by other studies in continental environments (Andrews, 1990; Fernández-Jalvo, 1995, 1996; Fernández-Jalvo and Andrews, 1992; Fernández-Jalvo et al., 1998).

5. Conclusions

T. mourerchauvireae nov. sp. is described from fossil material of three karst localities of Sicily: Spinagallo Cave, Luparello Cave and Marasà Cave, whose fossil vertebrate assemblages have been attributed to the early Middle Pleistocene "*Elephas falconeri* FC" (Bonfiglio et al., 1997, 2001, 2002). *T. mourerchauvireae* nov. sp. shows a marked increase in body size towards gigantism; this characteristic has been previously recognized in several other endemic species of the genus *Tyto* as the result of an insular evolution: *Tyto neddi*, *T. noeli*, *T. ostologa*, *T. pollens* and *T. riveroi*, from the Western Indies (Steadman and Hilgartner, 1999), *T. robusta* and *T. gigantea* from the Late Miocene of Gargano (Ballmann, 1973, 1976). The presence of *T. mourerchauvireae* nov. sp. in the early Middle Pleistocene of Sicily confirms the tendency of the genus *Tyto* to generate endemic forms in insular environments, even after a short colonization period, as also demonstrated in other insular areas (Del Hoyo et al., 1999; Steadman and Hilgartner, 1999).

The analysis of other vertebrate remains in the various cave localities of the "*Elephas falconeri* FC" allows to estimate the food range of *T. mourerchauvireae* nov. sp. and its role in the genesis of the fossil assemblages, which contain a number of species with scarce or no troglophilous habits, and thus were probably taken into the cave as preys. The width of the food range is similar to that observed in the extant *T. alba*,

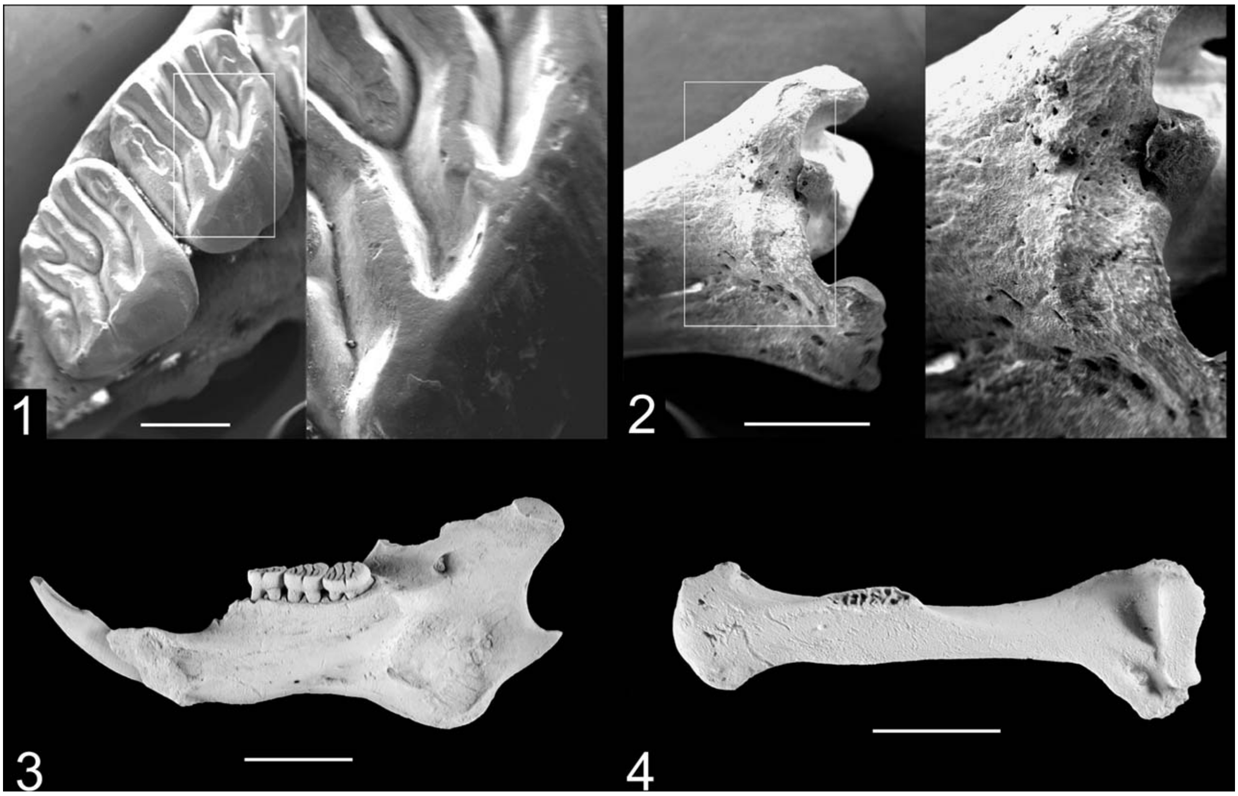

Fig. 3. **1–4.** Gliridae remains showing no breakage or traces of digestion. *Leithia melitensis* (Adams, 1863) from Marasà Cave. **1**, SEM photograph of fragment of right maxilla (PU 100046), occlusal view; **3**, right mandible (PU 100047), lingual view; **4**, left humerus (PU 100048), anterior view. *Maltamys wiedincitensis* (Zammit Maempel and De Bruijn, 1982) from Spinagallo Cave. **2**, SEM photograph of the distal part of right tibia (PU 100049), anterior view. Specimens **3** and **4** coated with ammonium chloride to enhance details. The scale bars **1** and **2** represent 2 mm; the scale bars **3** and **4** represent 10 mm.

Fig. 3.**1–4.** Restes de Gliridae ne montrant pas des traces de digestion. *Leithia melitensis* (Adams, 1863) de la Grotte Marasà. **1**, maxillaire droite (PU 100046), vue occlusale; **3**, mandibule droite (PU 100047), vue linguale; **4**, humérus gauche (PU 100048), vue antérieure. *Maltamys wiedincitensis* (Zammit Maempel et De Bruijn, 1982) de la Grotte de Spinagallo. **2**, tibia droit, partie distale (PU 100049), vue antérieure. Les exemplaires **3** et **4** ont été blanchis au chlorure d'ammonium. L'échelle graphique **1** et **2** représente 2 mm; l'échelle graphique **3** et **4** représente 10 mm.

while the dimensional range and the mean dimensions of the prey species are comparable to those observed in other Strigiformes with a body size similar to *T. mourerchauvireae* nov. sp., such as *Bubo bubo* and *Nyctea scandiaca* (Cramp, 1985). The macro- and microscopic analyses, aimed at detecting what kind of modifications due to predation occurred on skeletal remains, revealed that the long bones and cranial remains found in the Sicilian cave deposits are often almost complete and their surfaces show very few traces of modification and digestion. According to Andrews (1990), the pattern of modifications observed in the Sicilian fossil assemblages fits well with the one of the genus *Tyto* thus indicating, together with the dimension of the preys, the main role of *T. mourerchauvireae* nov. sp. as accumulator of small and medium size vertebrate remains in the Sicilian karst localities of the "*Elephas falconeri* FC".

Such evidence confirms the importance of taphonomic analyses aimed at selecting, from fossil assemblages, information useful for reconstructing the palaeoenvironmental conditions of the fossil locality. The validity of the model proposed by Andrews (1990), and successfully applied in some other continental localities by different authors (Fernández-Jalvo, 1995, 1996; Fernández-Jalvo and Andrews, 1992; Fernández-Jalvo et al., 1998) has been confirmed also in insular condition, such as the Sicilian cave deposits. On islands, the strigiforms often represent the only predators at the top of the food chain (Alcover and Mc Minn, 1994) and thus are probably the most important agent of bone accumulation. An understanding of the predator and its role in the fossil assemblages is useful for palaeoecological and palaeoenvironmental reconstructions, even if the endemic animals sometimes are synecologically different from their continental relatives. For this reason, this model could be transferred to other fossil assemblages, such as the late Miocene vertebrates found in several fissure fillings of the Gargano area (Freudenthal, 1976) in which the high number of nocturnal raptors, some of big body size (Ballmann, 1973, 1976), may have played an important role in the formation of the very rich small mammal fossil assemblages.

Acknowledgements

I would like to thank Prof. U. Nicosia and Dr. R. Manni for the possibility to study the Spinagallo material; I am very grateful to the late Dr. E. Burgio for the loan of the material from the Luparello and Marasà caves and for his invaluable suggestions. Prof. T. Kotsakis is thanked for his comments on the manuscript and for the long discussions on the Sicilian palaeontology, Dr. N. Minciotti for the revision of the English version, and Dr. G. Mayr and Dr. D.W. Steadman for their useful suggestions. A special thank to Prof. G. Pavia for his invaluable suggestions and for the help in the realization of the photographs. The SEM images were taken with the help of Dr. L. Martire. This work was supported by grants MURST COFIN 2003 to Prof. L. Bonfiglio.

References

Alcover, J.A., Florit, F., Mourer-Chauviré, C., Weesie, P.D.M., 1992. The avifaunas of the isolated Mediterranean islands during the Middle and Late Pleistocene. In: Campbell Jr. K.E. (Ed.), Papers in Avian Palaeontology Honouring Pierce Brodkorb. Natural History Museum of Los Angeles County, Science Series 36, pp. 273–284.

Alcover, J.A., Mc Minn, M., 1994. Predators of vertebrates on islands. Bioscience 44, 12–18.

Andrews, P., 1990. Owls, caves and fossils: predation, preservation and accumulation of small mammal bones in caves, with analysis of the Pleistocene cave faunas from Westbury, sub-Mendip, Somerset. UK Natural History Museum Publications, London.

Andrews, P., 1992. Reconstructing past environments. In: Jones, S., Martin, R., Pilbeam, D. (Eds.), The Cambridge Encyclopaedia of Human Evolution. Cambridge University Press, Cambridge, pp. 191–195.

Azzaroli, A., 1982. Insularity and its effects on terrestrial vertebrates: evolutionary and biogeographical aspects. In: Montanaro Gallitelli, E. (Ed.), Palaeontology, Essential of Historical Geology. Mucchi, Modena, pp. 193–213.

Ballmann, P., 1973. Fossile Vögel aus dem Neogen der Halbinsel Gargano. (Italien). Scripta Geologica 17, 1–75.

Ballmann, P., 1976. Fossile Vögel aus dem Neogen der Halbinsel Gargano (Italien), zweiter Teil. Scripta Geologica 38, 1–59.

Baumel, J.J., Witmer, L.M., 1993. Osteologia. In: Baumel, J.J., King, A.S., Beazile, J.E., Evans, H.E., Van den Berge, J.C. (Eds.), Handbook of Avian Anatomy: Nomina Anatomica Avium. Publications of the Nuttall Ornithological Club 23, pp. 45–132.

Bocheński, Z., 1997a. List of European fossil bird species. Acta zoologica cracoviensia 40, 293–333.

Bocheński, Z.M., 1997b. Preliminary taphonomic studies on damage to bird bones by Snowy Owls *Nyctea scandiaca*, with comments on the survival of bones in palaeontological sites. Acta zoologica cracoviensia 40, 279–292.

Bocheński, Z.M., Tomek, T., 1997. Preservation of bird bones: erosion versus digestion by owls. International Journal of Osteoarchaeology 7, 372–387.

Bonfiglio, L., Burgio, E., 1992. Significato paleoambientale e cronologico delle mammalofaune pleistoceniche della Sicilia in relazione all'evoluzione paleogeografica. Il Quaternario 5, 223–234.

Bonfiglio, L., Insacco, G., 1992. Palaeoenvironmental, palaeontologic and stratigraphic significance of vertebrate remains in Pleistocene limnic and alluvial deposits from southeastern Sicily. Palaeogeography, Palaeoclimatology, Palaeoecology, 95, 195–208.

Bonfiglio, L., Insacco, G., Marra, A.C., 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, 97–122.

Bonfiglio, L., Mangano, G., Marra, A.C., Masini, F., 2001. A new Late Pleistocene vertebrate faunal complex from Sicily (S. Teodoro Cave, North-Eastern Sicily, Italy). In: Rook, L., Torre, D. (Eds.), Neogene and Quaternary continental stratigraphy and mammal evolution. Papers in honour of Prof. Augusto Azzaroli's outstanding contribution in Geology and Palaeontology. Bollettino della Società Paleontologica Italiana 40, pp. 149–158.

Bonfiglio, L., Mangano, G., Marra, A.C., Masini, F., Pavia, M., Petruso, D., 2002. Pleistocene Calabrian and Sicilian bioprovinces. In: Monegatti, P., Cecca, F., Raffi, S. (Eds.), International Conference "Paleobiogeography and Paleoecology 2001", Piacenza and Casetll'Arquato 2001. Geobios MS 24, pp. 29–39.

Burgio, E., Costanza, M., 1999. La collezione vertebratologica della grotta del Luparello (Palermo). Naturalista siciliano S. IV 23, 359–379.

Burgio, E., Fiore, M., 1988a. La fauna vertebratologica dei depositi continentali di Monte Pellegrino (Palermo). Naturalista Siciliano S. IV 12, 9–18.

Burgio, E., Fiore, M., 1988b. *Nesolutra trinacriae* sp. nov., lontra quaternaria della Sicilia. Bollettino della Società Paleontologica Italiana 27, 259–275.

Cassoli, P.F., Tagliacozzo, A., 1996. L'Avifauna. In: Basile, B., Chilardi, S. (Eds.), Siracusa, le ossa dei Giganti, lo scavo paleontologico di Contrada Fusco. Arnaldo Lombardi, Siracusa, pp. 61–67.

Cheneval, J., 2000. L'avifaune de Sansan. In: Ginsburg, L. (Ed.), La faune miocène de Sansan et son environnement. Mémoire du Muséum National de Histoire naturel 183, pp. 321–388.

Cramp, S., 1985. The Birds of the Western Palearctic, vol. IV. Oxford University Press, Oxford, New York.

Del Hoyo, J., Elliott, A., Sargatal, J., 1999. Handbook of the Birds of the World. vol. 5. Barn-Owls to Hummingbirds. Lynx Edicions, Barcelona.

Di Maggio, C., Incandela, A., Masini, F., Petruso, D., Renda, P., Simonelli, C. et al., 1999. Oscillazioni eustatiche, biocronologia dei depositi continentali quaternari e neotettonica nella Sicilia Nord-occidentale (Penisola di S. Vito Lo Capo–Trapani). Il Quaternario 12, 25–49.

Esu, D., Kotsakis, T., Burgio, E., 1986. I vertebrati e molluschi continentali pleistocenici della Grotta di Poggio Schinaldo (Palermo, Sicilia). Bollettino della Società Geologica Italiana 105, 233–241.

Fernández-Jalvo, Y., 1995. Small mammal taphonomy at La Trinchera de Atapuerca (Burgos, Spain). A remarkable example of taphonomic criteria used for stratigraphic correlations and palaeoenvironment interpretations. Palaeogeography, Palaeoclimatology, Palaeoecology 114, 167–195.

Fernández-Jalvo, Y., 1996. Small mammal taphonomy and the middle Pleistocene environments of Dolina, northern Spain. Quaternary International 33, 21–34.

Fernández-Jalvo, Y., Andrews, P., 1992. Small mammal taphonomy of Gran Dolina, Atapuerca (Burgos), Spain. Journal of Archaeological Sciences 19, 407–428.

Fernández-Jalvo, Y., Denys, C., Andrews, P., Williams, T., Dauphin, Y., Humphrey, L., 1998. Taphonomy and palaeoecology of Olduvai Bed-I (Pleistocene, Tanzania). Journal of Human Evolution 34, 137–172.

Freudenthal, M., 1976. Rodent stratigraphy of some Miocene fissure fillings in Gargano (prov. Foggia, Italy). Scripta Geologica 37, 1–23.

Kotsakis, T., 1977. I resti di anfibi e rettili pleistocenici della grotta di Spinagallo (Siracusa, Sicilia). Geologica Romana 16, 211–229.

Kotsakis, T., 1984. *Crocidura esui* sp. nov. (Soricidae, Insectivora) du Pléistocène de Spinagallo (Sicile orientale, Italie). Geologica Romana 23, 51–64.

Kotsakis, T., Petronio, C., 1980. I chirotteri del Pleistocene superiore della grotta di Spinagallo (Siracusa, Sicilia). Bollettino del Servizio Geologico d'Italia 101, 49–76.

Langer, G., 1980. Vergleichend Morphologische Untersuchungen an Einzelknochen in Mitteleuropa vorkommender mittelgroßer Eulenarten. PhD Dissertation, University of München (unpublished).

Louchart, A., 2002. Les oiseaux du Pléistocène de Corse et de quelques localités sardes. Écologie, évolution, biogéographie et extinctions. Documents des Laboratoires de Géologie de Lyon 155, 1–287.

Lydekker, R., 1891. Catalogue of the fossil birds in the British Museum (Natural History), British Museum (Natural History), London.

Mlíkovský, J., 1996. Tertiary avian faunas of Europe. In: Mlíkovský, J. (Ed.). Tertiary Avian Localities of Europe. Acta Universitatis Carolinae (Geologica) 39, 619–647.

Mlíkovský, J., 1998. A new barn owl (Aves: Strigidae) from the early Miocene of Germany, with comments on the fossil history of the Tytoninae. Journal für Ornithologie 139, 247–261.

Mourer-Chauviré, C., 1975. Les oiseaux du Pléistocène moyen et supérieur de France. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon 64, 1–624.

Mourer-Chauviré, C., 1987. Les Strigiformes (Aves) des Phosphorites du Quercy (France): systématique, biostratigraphie et paléobiogéographie. In: Mourer-Chauviré, C. (Ed.), L'évolution des oiseaux d'après le témoignage des fossiles. Table Ronde internationale du CNRS, Lyon-Villeurbanne, 18-21 septembre 1985. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon 99, pp. 89–135.

Mourer-Chauviré, C., 2001. The systematic position of the genus *Basityto* Mlíkovský, 1998 (Aves: Gruiformes: Gruidae). Proceedings of the Biological Society of Washington 114, pp. 964–971.

Mourer-Chauviré, C., Alcover, J.A., Moya, S., Pons, J., 1980. Une nouvelle forme insulaire d'Effraie géante, *Tyto balearica* sp. nov. (Aves, Strigiformes), du Plio-Pléistocène des Baléares. Geobios 13, 803–811.

Mourer-Chauviré, C., Louchart, A., Pavia, M., Segui, B., 2001. Les avifaunes du Pléistocène moyen et supérieur des îles méditerranéennes. Bulletin de la Société des Sciences historiques et naturelles de la Corse 696–697, pp. 223–244.

Pavia, M., 1999. The Middle Pleistocene Avifauna of Spinagallo Cave (Sicily, Italy): preliminary report. In: Olson, S.L. (Ed.), Avian Palaeontology at the Close of the 20th Century, Proceedings of the Fourth International Meeting of the Society of Avian Palaeontology and Evolution, Washington, DC, June 4–June 7, 1996. Smithsonian Contributions to Paleobiology 89, pp. 125–127.

Pavia, M., 2000. Le avifaune pleistoceniche dell'Italia meridionale. PhD Dissertation, University of Torino (unpublished).

Pavia, M., 2001. The Middle Pleistocene fossil avifauna from the "*Elephas mnaidriensis* Faunal Complex" of Sicily (Italy): preliminary results. Cavarretta, G., Gioia, P., Mussi, M., Palombo, M.R. (Eds.), The World of Elephants, Proceedings of the First International Congress, Consiglio Nazionale per le Ricerche, Roma, pp. 497–501.

Pavia, M., Mourer-Chauviré, C., 2002. An overview on the genus *Athene* in the Pleistocene Mediterranean Islands with the description of *Athene trinacriae* n. sp. (Aves, Strigiformes). In: Zhou, Z., Zhang, F. (Eds.), Proceedings of the Fifth Symposium of the Society of Avian Paleontology and Evolution. Beijing Science Press, Beijing, pp. 13–27.

Peters, D.S., 1992. A new species of owl (Aves: Strigiformes) from the middle Eocene Messel oil shale. In: Campbell Jr. K.E. (Ed.), Papers in Avian Palaeontology honouring Pierce Brodkorb. Natural History Museum of Los Angeles County, Science Series 36, pp. 161–169.

Petronio, C., 1970. I roditori pleistocenici della grotta di Spinagallo (Siracusa). Geologica Romana 9, 149–194.

Sanchez-Marco, A., 2001. Strigiformes from the Neogene of Spain. Ibis 143, pp. 313–316.

Sibley, C.G., Ahlquist, E., 1990. Phylogeny and Classification of Birds. A Study in Molecular Evolution. Yale University Press, New Haven and London.

Steadman, D.W., Hilgartner, W.B., 1999. A new species of extinct barn owl (Aves: *Tyto*) from Barbuda, Lesser Antilles. In: Olson, S.L. (Ed.), Avian Palaeontology at the Close of the 20th Century, Proceedings of the Fourth International Meeting of the Society of Avian Palaeontology and Evolution, Washington, DC, June 4–June 7, 1996. Smithsonian Contributions to Paleobiology 89, pp. 75–82.

Tyrberg, T., 1998. Pleistocene Birds of the Palearctic: A Catalogue. Publications of the Nuttall Ornithological Club 27, 1–720.