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The first occurrence of rock partridge *Alectoris graeca* (Meisner 1804) in Sicily and its palaeobiogeographical significance

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Abstract – In this paper, the presence of rock partridge *Alectoris graeca* (Meisner 1804) in Sicily from the Late Pleistocene is presented and discussed. This presence is testify by the finding of a fossil remain from the Zà Minica Cave (Carini, Palermo). This cave contains fossiliferous sediments previously attributed to the late Middle Pleistocene/Late Pleistocene *Elephas mnaidriensis* Faunal Complex of the Sicilian biochronological scheme. After the excavations carried out by the writer the fossiliferous sediments filling the cave can be attributed to the Late Pleistocene Pianetti/San Teodoro Faunal Complex after the presence of the non endemic micromammal *Microtus* (*Terricola*) sp. together with endemic macromammals, such as *Elephas* sp.. During the excavations, a bone of *Alectoris graeca* was found and it represents the oldest Sicilian occurrence of this species. The Galliformes are absent in isolated islands or were introduced by man, so the presence of *Alectoris graeca* in Sicily indicates the end of the strong endemic condition of the islandlasted all the Pleistocene, testified by at least three different Faunal Complexes with endemic birds and mammals, and the start of the modern biogeographical setting of the island. Moreover the concordance between the palaeontological data with the mDNA analyses on the time-span of isolation of the Sicilian *Alectoris graeca* is discussed.

Riassunto – *Primo rinvenimento di coturnice* Alectoris graeca (Meisner 1804) *in Sicilia e significato paleobiogeografico*. In questo lavoro viene descritta la presenza della coturnice *Alectoris graeca* (Meisner 1804) in Sicilia a partire dal Pleistocene superiore. La presenza di questa specie è testimoniata dal ritrovamento di un resto fossile nei sedimenti pleistocenici della grotta della Zà Minica (Carini, Palermo). Questa grotta contiene dei sedimenti fossiliferi attribuiti storicamente al Complesso Faunistico a *Elephas mnaidriensis*, unità dello schema biocronologico siciliano risalente alla fase finale del Pleistocene medio al passaggio con il Pleistocene superiore. In seguito alle ricerche dello scrivente, i sedimenti della grotta della Zà Minica possono essere attribuiti al Complesso Faunistico di Pianetti/San Teodoro risalente al Pleistocene superiore, grazie al ritrovamento del micromammifero non endemico *Microtus* (*Terricola*) sp. insieme a macromammiferi endemici, come *Elephas* sp.. Durante le ricerche è stato rinvenuto un osso attribuito a *Alectoris graeca* che rappresenta la più antica testimonianza di questa specie sull'isola. I Galliformes sono assenti in contesti di endemismo insulare tranne quando vengono introdotti dall'uomo; quindi la presenza di *Alectoris graeca* in Sicilia indica la fine delle condizioni di forte endemismo che hanno caratterizzato l'isola per tutto il Pleistocene, testimoniato in almeno tre dei cinque Complessi Faunistici dalla presenza di mammiferi e uccelli endemici, e l'inizio del moderno assetto biogeografico dell'isola. Inoltre viene discussa la concordanza dei dati paleontologici con quelli ottenuti dalle analisi del mDNA sulla durata dell'isolamento della forma siciliana di *Alectoris graeca*.

The fossil avifauna of Sicily is known mainly for few studies on bird remains from archaeological sites, where only extant species and continental-like bird associations are listed (Tyrberg 1998), for preliminary analyses of Middle Pleistocene birds from Contrada Fusco and Spinagallo Cave (Siracusa, South-Eastern Sicily) (Cassoli and Tagliacozzo 1996, Pavia 1999, 2001) and for the description of the new endemic taxa *Athene trinacriae*, *Tyto mourerchauvireae* and *Aegolius martae* (Pavia and Mourer-Chauviré 2002; Pavia 2004, 2007). In the 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, after the isolation of Sicily during Middle and early Late Pleistocene. These authors thought that the island isolation was not enough to generate endemic bird species. In the last two centuries, many Sicilian localities with fossil vertebrate assemblages have been found and excavated (Bonfiglio and Burgio 1992). The rich fossil record of Sicily allowed the construction of a fairly detailed biochronological frame that is dated by correlation of vertebrate bearing deposits with marine deposits and with ancient shorelines. These analyses (Bonfiglio *et al*. 2001, 2002, Di Maggio *et al*. 1999) arranged the Pleistocene vertebrates into five phases or Faunal Complex-

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es (FC), which are characterized by the occurrence of different taxa showing, on average, a decreasing degree of endemism. Four of these FC mainly include endemic fossil mammals, 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*. 2002), except for the oldest one, the Monte Pellegrino FC, which contains only endemic small mammals and reptiles (Burgio and Fiore 1988). The analysis of some Sicilian fossil bird assemblages (Pavia 2000) provided 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*. (2002). 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).

The faunal composition of the five different Faunal Complexes give also fairly precise information of the palaeogeography of Sicily during the Quaternary; in fact, the different FC dated from the Early Pleistocene to the Late Pleistocene-Holocene. The palaeogeography of Sicily, as well as its relationships with peninsular Italy, underwent several important changes from the Early Pleistocene to the Late Middle Pleistocene (Bonfiglio *et al*. 2002). At the time corresponding to the Monte Pellegrino FC and to the *Elephas falconeri* FC, Sicily was a well isolated island with a impoverished terrestrial vertebrate communities, characterized by strongly endemic mammal species, and with some endemic bird species (Bonfiglio *et al*. 2002, Pavia 2007). Starting from the *Elephas mnaidriensis* FC to the Castello FC, the faunal composition is more similar to that of the southern Italian peninsula and the endemism becomes more and more moderate, being absent in the youngest assemblages. During the Late Middle Pleistocene and the Late Pleistocene, vertebrate dispersals from peninsular Italy through southern Calabria were conditioned by two palaeogeographic barriers, working as a filtering barrier that affect the dispersals in the various phase of the population, and determined the differences between the various Faunal Complexes (Bonfiglio *et al*. 2002).

The occurrence of *Alectoris graeca* in the Late Pleistocene Pianetti/San Teodoro FC has been already preliminarily signalled by the author in Bonfiglio *et al*. (2002). In this paper, this recovery is described in details for the first time and its biogegraphical significance is discussed.

The fossil locality

One of the former locality of the *Elephas mnaidriensis* FC is the Zà Minica Cave, located in the North-western Sicily, in the municipality of Carini, close to Palermo (Fig. 1). The cave was excavated in late Jurassic-early Cretaceous limestone by the sea, as testified by a notch, and hereafter modelled by karstic activity, as testified by some stalactites and surface concretions. Its maximum length is 32

Figure 1. Map of Italy with the position of the Zà Minica Cave (Carini, Palermo). – *Localizzazione della Grotta Zà Minica (Carini, Palermo).*

meters and the maximum width is 9 meters. Originally it was full of Pleistocene sediments, but at the beginnings of the '80 of the last century the owner removed most of the deposits, except for a small part in the North side of the cavity (Fig. 2). Two small sample collections have been carried out in the remnant sediment by the writer in 1999 and 2002 (Fig. 2), mainly in order to find out fossil bird remains, unknown in the Zà Minica Cave at that time. In fact, the vertebrate remains already known from this locality were only macromammals and indicate that the faunal association is to be assigned to the *Elephas mnaidriensis* FC (Fiore 1999). The Pleistocene deposit still preserved is probably more than two meters thick and the outcropping portion is separable in at least three levels. From the top, the first one, 20 to 30 cm thick, is constituted by fine sand with no fossil remains (Layer 1 in Fig. 2); the second, 60 to 100 cm thick, is made by brown clayey-sand matrix with frequent calcite incrustations, it contains numerous hyena coprolites and frequent bone remains, most of them fragmented (Layer 2 in Fig. 2); the third level, exposed for 60 cm, is constituted by reddish sandy-clay with less coprolites and bone remains (Layer 3 in Fig. 2). During the excavations, fossil vertebrates remains have been found in both the fossiliferous levels, in particular remains of *Cervus elaphus siciliae Elephas* sp. (Fig. 3, B), (Fig. 3, A), *Sus scrofa*, *Bos primigenius siciliae*, *Crocuta crocuta* and *Canis lupus* have been found. Washing and sieving the sediments collected at that time also revealed the presence of Anura indet., Reptilia indet., Chiroptera indet. and *Microtus* (*Terricola*) sp. (Fig. 3, C-E). Together with mammals, few bird remains, belonging to *Alectoris graeca*,

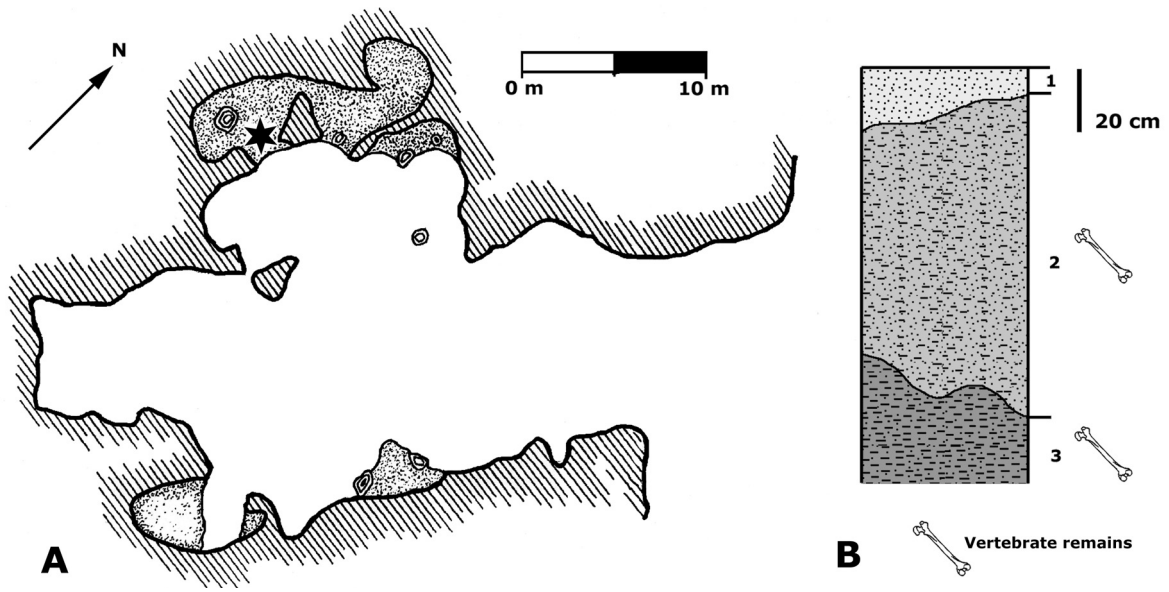

Figure 2. A) Floor plan of the Zà Minica Cave (from Fiore 1999, modified) with the position of the excavation described in the text (Star). B) Schematic log of the Pleistocene sediments outcropping in the Zà Minica Cave; for the description of the different layer, see text. – *A) Planimetria della Grotta Zà Minica (da Fiore 1999, modificato) con la posizione degli scavi descritta nel testo (stella). B) Sezione schematica dei sedimenti affioranti nella Grotta Zà Minica; vedi testo per la descrizione dei differenti livelli.*

Rallus aquaticus, *Columba livia/oenas*, *Athene noctua*, *Garrulus glandarius* and Passeriformes indet. have been found. The whole fossil vertebrate assemblage, in particular the presence of non-endemic micromammals together with endemic macromammals, allows researchers to assign the Zà Minica fossil vertebrate association to the Late Pleistocene Pianetti/San Teodoro FC (Bonfiglio *et al*. 1997, 2002) and not to the late Middle Pleistocene/Late Pleistocene *Elephas mnaidriensis* FC as previously stated (Burgio *et al*. 2002, Fiore 1999). In fact, even if the dispersal history of the ground vole *Microtus* in Sicily is complex, with probably two different dispersal events (Bonfiglio et al. 1997), its first occurrence is dated to the Pianetti/San Teodoro FC.

MATERIALS AND METHODS

Comparisons have been made with recent skeletal material stored in the Dipartimento di Scienze della Terra of the University of Torino (Marco Pavia Osteological Collection (MPOC)), in the Museo Civico di Storia Naturale of Carmagnola and in the Université Claude Bernard Lyon 1, Villeurbanne, France. The material is kept in the Museo di Geologia e Paleontologia of the University of Torino (PU). The osteological terminology is from Baumel and Witmer (1993) and Kraft (1972).

Order Galliformes Temminck, 1820
Family Phasianidae Vigors, 1825
Genus *Alectoris* Kaup, 1829
Alectoris graeca (Meisner, 1804)

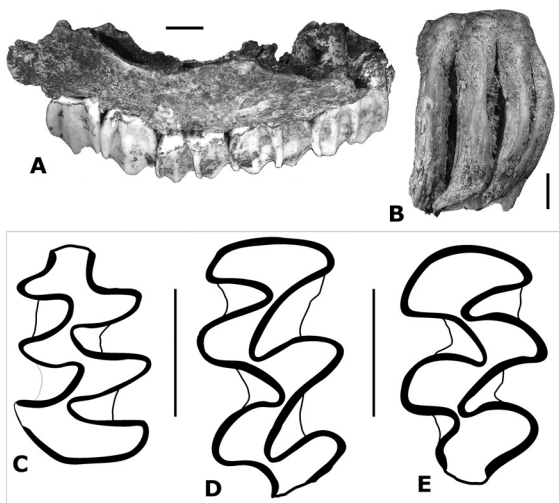

Figure 3. Mammal remains from Zà Minica Cave: A) *Cervus elaphus siciliae* fragmented left maxilla PU 103040; B) *Elephas* sp. fragmented molar of a young individual PU 103041; C) *Microtus* (*Terricola*) sp. lower left second molar PU 101754; D) *Microtus* (*Terricola*) sp. upper left first molar PU 101755; E) *Microtus* (*Terricola*) sp. upper left second molar PU 101756. The scale bars of figs A-B represent 1 cm; the scale bars of figs C-E represent 1 mm. – *Resti di mammiferi rinvenuti nella Grotta Zà Minica: A)* Cervus elaphus siciliae *frammento di mascella sinistra PU 103040; B)* Elephas *sp. frammento di molare di un individuo giovane PU 103041; C)* Microtus (Terricola) *sp. secondo molare inferiore sinistro PU 101754; D)* Microtus (Terricola) *sp. primo molare superiore sinistro PU 101755; E)* Microtus (Terricola) *sp. secondo molare superiore sinistro PU 101756. Il riferimento di scala delle figure A-B è pari ad 1 cm; per le figure C-E 1 mm.*

Material – A distal fragment of furcula PU 103027 (Fig. 4) collected at the Zà Minica cave, particularly in the Layer 2 of the exposed outcrop (Fig. 2).

Description and comparisons – The furcula is normally not well representative in term of taxonomical identification, but in the case of the Galliformes it presents a wide apophysis furculae, ventrally well developed. In the fossil remain from Zà Minica this part is preserved and so it can be clearly assigned to the Galliformes.

The dimension of the fossil remain allows to associate it to the medium-sized Galliformes, genus *Alectoris*, *Perdix* and *Bonasa*, because *Coturnix* is too small and the other genera are bigger (Kraft 1972). The morphological features fit well with those of the genus *Alectoris*, because in the other two genera the hypocleidium is more developed ventrally (*Bonasa*) or caudally (*Perdix*). More in detail, the shape of the Zà Minica fragment is more similar to *Alectoris graeca* than to *A. rufa* in having heavier structures at the edges of the hypocleidium. The other *Alectoris* species have been excluded because not native of the Italian avifauna, but present only after human introduction, including *Alectoris barbara*, which is absent in all the Plio-Pleistocene fossil localities of Sardinia (Abbazzi *et al*. 2004, Louchart 2002, Mourer-Chauviré *et al*. 2001).

CONCLUSIONS

The biochronological setting of the various Sicilian fossil vertebrate associations are mainly based on the mammal components of these associations (Bonfiglio *et al*. 2002), because fossil avifauna and herpetofauna were relatively unknown until recent times (Delfino 2006, Mourer-Chauviré *et al*. 2001). Fossil bird taxa, mainly the endemic ones, usually confirm the endemic characteristic of a certain island vertebrate association, especially those with mammal remains. In fact, in the continental islands or in the intermediate-type islands recently described (Louchart 2005; Pavia 2007), where birds and mammals occur together, the percentage of endemic bird taxa in respect to the whole bird association is lower than in the mammal one, in which normally attains the 100%, with the nearly absence of non endemic forms (Caloi and Palombo 1989; Mourer-Chauviré *et al*. 2001).

In addition, some bird groups, such as the Galliformes, play a different role in defining the degree of isolation of a certain island, as they indicate the absence of insular conditions or an important human colonisation. In fact, the Galliformes were absent from all the isolated Mediterranean islands during the Pleistocene (Alcover *et al*. 1992; Mourer-Chauviré *et al*. 2001), with the exception of *Coturnix coturnix*, due to its migratory habits and long distance flying ability.

For this reason, the finding of *Alectoris graeca* in the Late Pleistocene Sicilian Pianetti/San Teodoro FC indicates the end of the strong insular endemic condition of Sicily, although it has been found together with endemic macromammals, such as *Elephas* sp., *Cervus elaphus siciliae* and *Bos primigenius siciliae*. These latters were survivors from the earlier *Elephas mnaidriensis* FC and indicate a still difficult connection of Sicily with the mainland, at least for some large mammals. More in general, the Pianetti/San Teodoro FC, dated to a cold phase of the Late Pleistocene, is characterized by extinction events of endemic mammals (the dwarf hippo *Hippopotamus pentlandi*, the endemic glirids *Leithia* and *Maltamys* and the endemic shrew *Crocidura esuae*) and by the dispersal from the Italian mainland of the extinct *Equus hydruntinus* and of small mammals still present in Sicily (*Microtus* (*Terricola*), *Crocidura*, *Apodemus sylvaticus*, *Erinaceus europaeus*) (Bonfiglio *et al*. 2002). *Alectoris graeca* has also been found in different localities of the Late Pleistocene Castello FC and other Holocene localities, none of them with endemic macromammals (Bonfiglio *et al*. 2002, Pavia 2000).

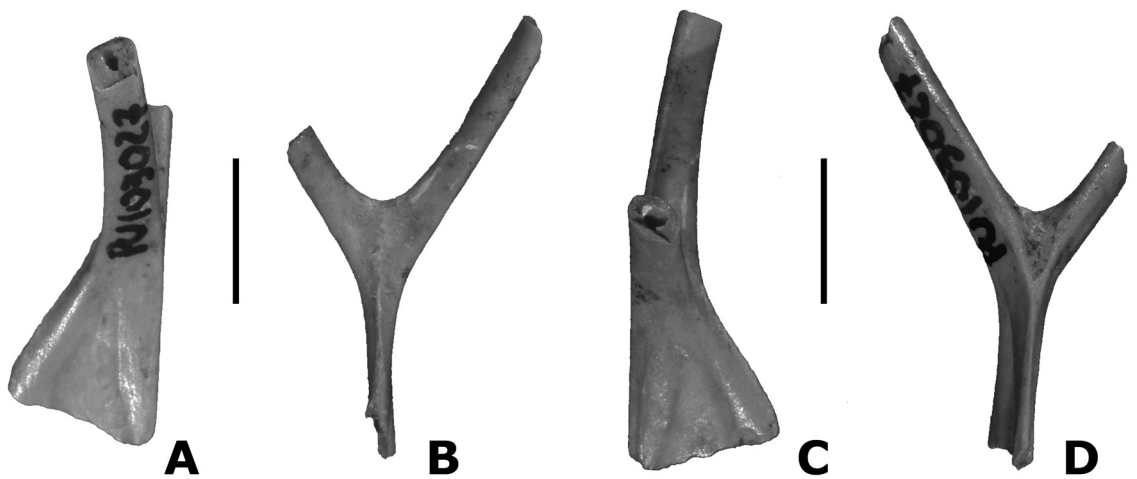

Figure 4. Fragmented furcula PU 103027 of *Alectoris graeca* from Zà Minica Cave: A) right view; B) caudal view; C) left view; D) cranial view. The scale bars represent 0.5 cm. – *Frammento di furcula PU 103027 di* Alectoris graeca *dalla Grotta Zà Minica: A) lato destro; B) visione caudale; C) lato sinistro; D) visione frontale. Il riferimento di scala è pari a 0.5 cm.*

A recent study (Randi *et al*. 2003) reconstructed the phylogeography of *Alectoris graeca* using the mDNA; concerning the Sicilian rock partridge *Alectoris graeca whitakeri*, the authors suggest an isolation dated from more than 100.000 years ago and thus its validity as a well separated taxon. The palaeontological data here presented seem to confirm the long-time isolation of Sicilian *Alectoris graeca*, although a little bit more recent than that proposed by Randi *et al*. (2003). In fact, the Pianetti/San Teodoro FC could be dated to a first cold phase of the Late Pleistocene around 80.000 years ago (Bonfiglio *et al*. 2002). A recent radiometric dating carried out with the $^{230}Th/^{234}U$ in the San Teodoro Cave yelded an age of 32.000 ± 4000 yr (Bonfiglio *et al* 2006). This chronological datum can be considered as a first contribute to a firmer chronological assessment of the Pianetti/San Teodoro FC and also an "ante-quam" dating for the dispersal events characterising this FC. Other palaeontological data indicate other dispersal events in the late glacial phase of the Late Pleistocene around 25.000 years ago and in the Holocene (Bonfiglio *et al*. 2002), in which the birds were not involved (Pavia 2000), and thus no influence to the local evolution of *Alectoris graeca* can be observed after those dispersal events.

The faunal compositions of the two last Faunal Complexes (Pianetti/San Teodoro FC and Castello FC), reinforced by the recovery of *Alectoris graeca* in the Zà Minica cave, may testify that the starting point of the modern biogeographical setting of Sicily dates to a first phase of the Late Pleistocene. At present, Sicily is still slightly isolated, with some endemic vertebrate taxa such as *Discoglossus pictus*, *Crocidura sicula* and, among birds, *Aegithalos caudatus siculus*, *Passer hispaniolensis maltae* and *Alectoris graeca withakeri*, which evolved locally after the first dispersal event. At the same time, Sicily suffers the lacking of some other species widely distributed in Southern Italy, such as *Rana italica, Podarcis muralis, Crocidura leucodon*, *Martes foina* and, among breeding birds, *Accipiter gentilis*, *Dendrocopos minor*, *Picus viridis*, *Prunella modularis*, *Phylloscopus sibilatrix* as well as *Sturnus vulgaris*, locally replaced by the Mediterranean species *Sturnus unicolor*. Thus, this pattern indicates the present-day absence of terrestrial interchange between Sicily and the southern Italian peninsula.

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