

FOSSIL SEEDS FROM THE PLIOCENE OF MENORCA AND EIVISSA (BALEARIC ISLANDS, WESTERN MEDITERRANEAN)

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Abstract

The presence of *Cneorum tricoccon* and *Crataegus monogyna* during the Pliocene of Menorca, and of *Cneorum tricoccon* and *Pistacia lentiscus* during the Pliocene of Eivissa is documented from fossil seeds obtained in karstic deposits. We compare the size of abundant fossil *Cneorum* seeds from Menorca with those obtained from the only extant population in this island. The finding of such *Cneorum* seeds demonstrates the wider distribution of this species in the past in Menorca, before the disappearance of its main disperser, the endemic lizard *Podarcis lilfordi* (Lacertidae).

Resum

Es documenta la presència de *Cneorum tricoccon* i de *Crataegus monogyna* al Pliocè de Menorca, i de *Cneorum tricoccon* i de *Pistacia lentiscus* al Pliocè d'Eivissa a partir de les llavors fòssils obtingudes a dipòsits càrstics. Es compara la mida dels fòssils de *Cneorum tricoccon* amb la de les llavors de la població actual de l'illa de Menorca. La presència d'aquestes llavors fòssils de *Cneorum* a Menorca demostra la seva major distribució en el passat, abans de la desaparició del seu principal dispersor, la sargantana balear *Podarcis lilfordi* (Lacertidae).

Introduction

The vegetal macrofossil record of the Balearic Islands has received little attention compared to the animal component, mainly mammals, reptiles and birds (e.g., ALCOVER *et al.*, 1981; BOUR, 1985; AGUSTÍ and MOYÀ-SOLÀ, 1990; ALCOVER and McMINN, 1992; SONDAAR *et al.*, 1995; SEGUÍ, 1999; BOVER, 2004; KÖHLER & MOYÀ-SOLÀ, 2004; QUINTANA *et al.*, 2004; QUINTANA, 2005). Until the last decade, most information on palaeobotany of these islands came from old studies, mostly performed in Mallorca, on material coming from Oligocene and early Miocene (Burdigalian) deposits, which allowed the description of several new plant species (e.g., DEPAPE and FALLOT, 1928; ARENES, 1951; ARENES and DEPAPE, 1954; BAUZÀ, 1956; COLOM, 1982; RAMOS & ÀLVAREZ, 1989-90; HABLY & FERNÁNDEZ MARRON, 1998). The Triassic flora of Mallorca was also examined several decades ago by

BAUZÀ (1971) whereas another study dealt with the vascular flora of the Primary (BOURROUILH, 1973; LLOMPART *et al.*, 1979). From Menorca, the only studies that mention the presence of vegetal macrofossils (*Cneorum tricoccon* seeds) are QUINTANA (1998a,b) and QUINTANA *et al.* (2004) who found them in a couple of deposits of the north-eastern coast (deposits 11 and 28 of QUINTANA, 1998a). More recent information about the vegetational history of Mallorca and Menorca derives from palynological studies performed during the last decade (e.g., YLL *et al.*, 1999, and references therein).

In this paper, we present data on fossil seeds that have been obtained in two karstic deposits attributed to Pliocene, one in Menorca and another in Eivissa, representing the first fossil record of Neogene seeds in the Balearic Islands. In the first case, the finding of a large number of seeds from the same species (*C. tricoccon*) allowed to compare their dimensions with those from current seeds collected at the only extant population in the island, in Cala Mesquida. Such fossil seeds evidence that this shrub has become extinct from areas where it used to live in the past. In the case of Eivissa, fossil seeds could also be identified from material obtained in a cave; the material here consists only of several fragments and one entire seed.

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Material and methods

The material from Menorca described in this paper has been obtained from a karstic site in Punta Nati (Ciutadella), at the northwest of the island (deposit 11). Two other deposits containing fossil seeds are known in the island (deposit 28 of Racó des Pi and na Macaret; see Fig. 1). The fossil seeds appear associated to different elements of the so-called “the giant leporid fauna”, considered from the Pliocene. This fauna consists in a highly peculiar vertebrate assemblage consisting in two terrestrial mammals (an undescribed giant leporid and a giant dormouse, *Muscardinus cyclopeus*), a bat (*Rhinolophus cf. grivensis*), a giant tortoise (*Cheirogaster gymnesica*), a lizard (*Podarcis* sp.), an undetermined gecko, several snakes (*Vipera natiensis*, *Vipera* sp. and an undetermined colubrid), an amphisbaenid (*Blanus* sp.), a discoglossid (*Latonía* sp.) and different birds (such as *Pterodromoides minoricensis*, *Scolopax carmesinae*, *Camusia quintanae*, *Tyto balearica*, *Athene* sp. and *Corvus* sp.). This fauna was obtained after acid acetic treatment of the blocks obtained in the deposits, but the fossil seeds were obtained through physical methods.

The fossil seeds from Eivissa were collected in the cave of Ca na Reia, located in Puig des Guixer (Santa Eulària des Riu), at the northeast of the island and at an altitude of 120 a.s.l. This cave consists of a number of small cavities surrounding a collapsed large cavity. Currently, the main cave consists in an opened hall of 13 x 7 x 6 m. The emergent sediment thickness is c. 3 m and its length is c. 2 m. Detailed information on this cave and its topography can be obtained from TRIAS (1982). The obtained vertebrate fauna consists on two dormice (*Eliomys* (*Eivissia*) *canarreiensis* and *Eliomys* sp.), bats, a giant tortoise (*Cheirogaster* sp.), a lizard (*Podarcis pit-yusensis* or its direct ancestor), and several species of birds (among them, *Puffinus nestori*). This fauna has been attributed to the Pliocene. The materials were obtained without any special treatment of the sediment.

The materials from Eivissa are curated in the collection “Museu de la Naturalesa de les Illes Balears”, in Palma de Mallorca, whereas those from Menorca are

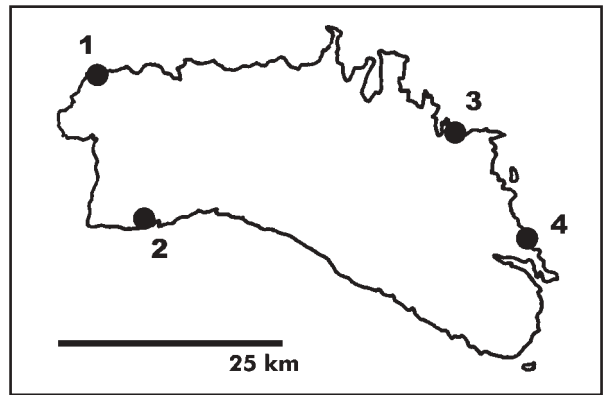


Figure 1. Map of Menorca showing the localities where fossil seeds have been found and the only extant population of *Cneorum tricoccon* in the island. 1. Punta Nati. 2. Racó des Pi. 3. Na Macaret. 4. Cala Mesquida.

Figura 1. Mapa de Menorca amb les localitats on s'han trobat llavors fòssils i la localitat on s'ha trobat l'única població vivent de *Cneorum tricoccon* de l'illa. 1. Punta Nati. 2. Racó des Pi. 3. Na Macaret. 4. Cala Mesquida.

deposited in the private collection of Josep Quintana.

One of the objectives of the study was to compare the wall structure and the dimensions of *C. tricoccon* seeds between fossil and current material. We examined the seed wall structure by means of a dissecting scope and measured seed diameter and length to the nearest 0.01 mm of all seeds by means of a digital caliper.

Systematic palaeontology

Family Cneoraceae Link, 1831

Genus *Cneorum* L., 1753

***Cneorum tricoccon* L., 1753**

Catalan common name: Olivella or escanyacabres.

Material: 55 seeds obtained in Punta Nati locality 11 (Menorca). Several fragments of seeds obtained in cova de Ca na Reia (Eivissa). The species is also present in

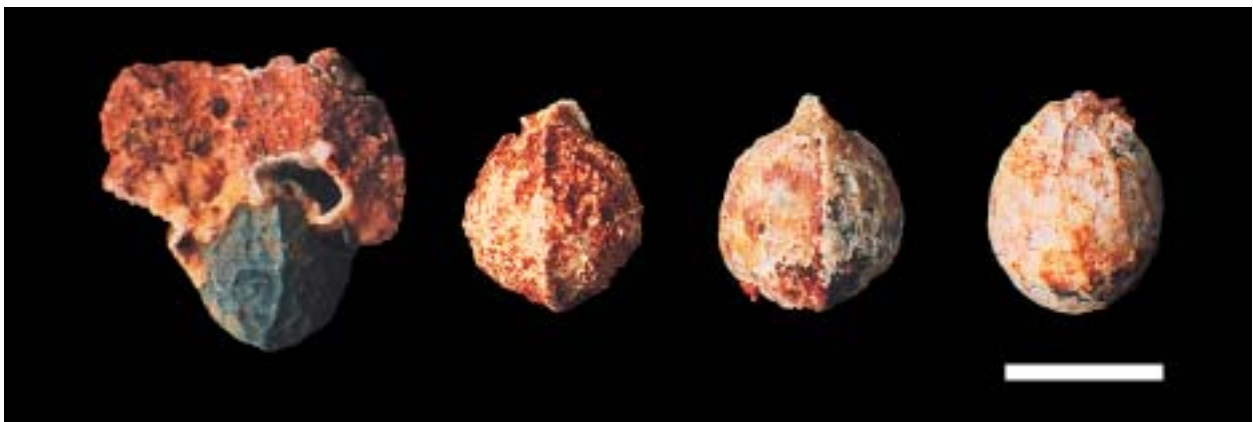


Figure 2. Fossil seeds of *Cneorum tricoccon* collected at the karstic deposits from Menorca, after Quintana et al. (2004). Scale bar, 5 mm.

Figura 2. Llavors de *Cneorum tricoccon* de Menorca col·lectades als jaciments càrstics de Menorca, segons Quintana et al. (2004). Escala, 5 mm.

the deposit of Racó des Pi (south of Ciutadella; Quintana 198a; Quintana et al., 2004) and in na Macaret (Quintana, 1998b). See Figs. 2 and 3.

Comments: Fossil seeds of *C. tricocon* measure, on average, 5.44 ± 0.68 mm and 4.71 ± 0.62 mm ($x \pm sd$; $n = 55$) in length and diameter, respectively. Both measures were found to be somewhat higher than those obtained from seeds collected at Cala Mesquida in the fruiting season of 2002 (4.43 ± 0.50 mm and 4.00 ± 0.52 mm, respectively, $n = 414$; Fig. 3A, B), the differences being highly significant (one-way ANOVAs, after logarithmically transforming both parameters: $F_{1,467}=150.38$ and $F_{1,467}=71.83$, respectively, $P < 0.001$). Such difference in size, however, might partly be due to the layer of calcium carbonate -often thicker

than 1 mm- that sometimes cover the fossil seeds. Anyway, the size of fossil seeds fall within the range (6.8-2.72 mm in length and 1.92-5.51 mm in diameter; $n = 5781$ seeds; Traveset, unpublished data) of those found in other populations of *C. tricocon* in the Balearic Islands and are known to vary from year to year depending upon environmental conditions (RIERA et al., 2002).

Finally, some *Cneorum tricocon* seed fragments were identified from Cova de Ca na Reia (e.g., Fig. 3C) together with an entire seed of *Pistacia lentiscus*.

Family Rosaceae Juss., 1789

Genus *Crataegus* L., 1753

Crataegus monogyna Jacq., 1775

Catalan common name: Cirerer de pastor, arç blanc

Material: A complete seed obtained in Punta Nati locality 11 (Calas Pou). See Fig. 4.

Comments: *Crataegus monogyna* is a tree with irregular leaves that currently spreads over humid areas in the Balearic Islands.

The size of the *Crataegus monogyna* fossil seed is 6.37 mm in length and 4.71 mm in diameter, which also falls within the range of those collected nowadays (mean \pm sd: 6.62 ± 0.82 mm; range: 5.1-8.3 mm for seed length, and 4.89 ± 0.65 , 3.86-6.12 for seed diameter; $n = 50$ seeds).

Family Anacardiaceae Lindl., 1830

Genus *Pistacia*

Pistacia lentiscus L., 1753

Catalan common name: Mata.

Material: One seed, collected in Cova de Ca na Reia, Eivissa.

Comments: The entire seed of *Pistacia lentiscus* (Anacardiaceae) is of a similar size to those collected nowadays (Fig. 5).

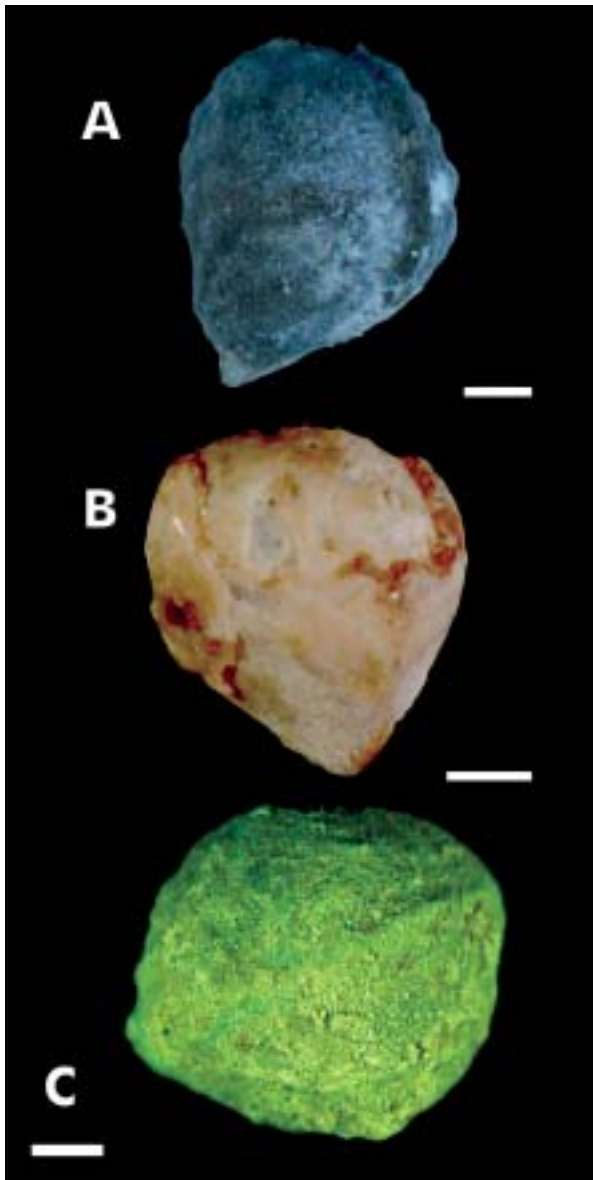


Figure 3. Actual (A: Cala Mesquida) and fossil seeds (B: Punta Nati) of *Cneorum tricocon* from Menorca and Eivissa (C: Cova de Ca na Reia). Scale bar, 1 mm.

Figura 3. Llavors actual (A: Cala Mesquida) i fòssil (B: Punta Nati) de *Cneorum tricocon* de Menorca i d' Eivissa (C: Cova de Ca na Reia). Escala, 1 mm.

Discussion

The best sample of fossil seeds was obtained from a deposit of the North of Ciutadella. A total of 68 seeds were gathered at Punta Nati locality 11 (Calas Pou). The large majority of them (55; 81%) has been classified as *Cneorum tricocon* L. (Cneoraceae); they are very well preserved and the characteristic seed shape and coat structure facilitates their identification (see Figs. 2-3). The rest of specimens cannot be attributed with certainty to any species except for one seed that we identify as *Crataegus monogyna* (Rosaceae) (Fig. 4). The unidentified specimens from Calas Pou probably belong, mainly or totally, to *Cneorum tricocon*.

Cneorum tricocon is a perennial shrub, often shorter than 1 m, which belongs to a Mediterranean flora evolved during the early Tertiary under tropical conditions (RAVEN, 1973) and it thus represents a relict spe-

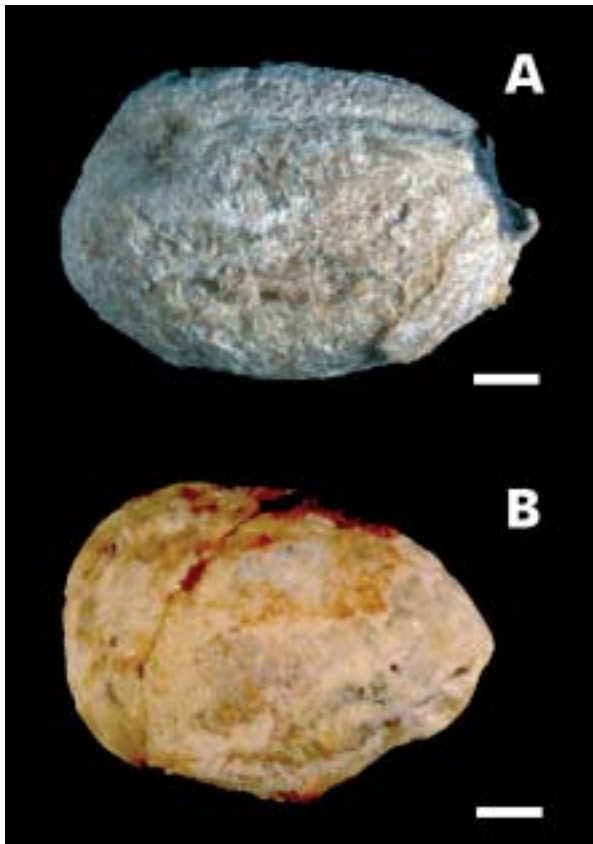


Figure 4. Actual (A) and fossil (B) seeds of *Crataegus monogyna*. Scale bar, 1 mm.

Figura 4. Llavors de *Crataegus monogyna* de Menorca: (A) actual, i (B) fòssil. Escala, 1 mm.

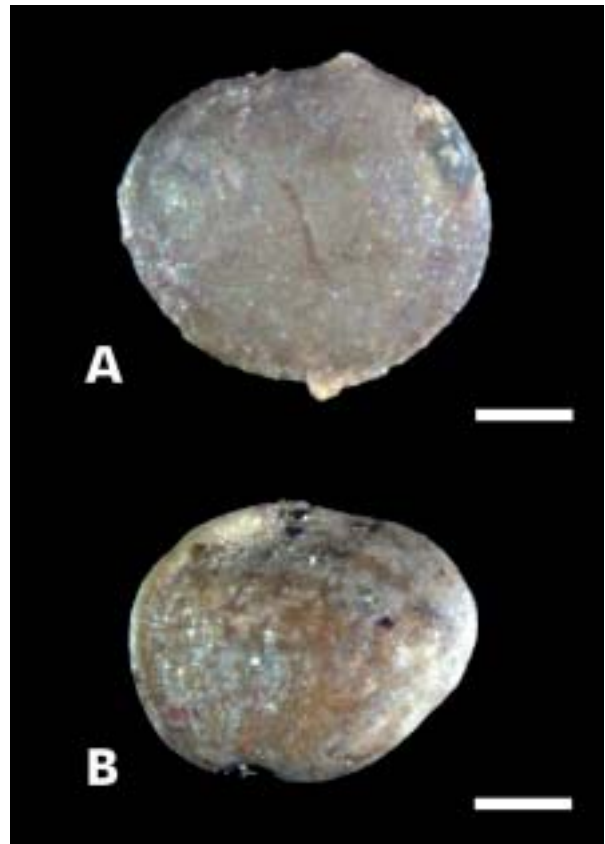


Figure 5. Actual (A) and fossil (B) seeds of *Pistacia lentiscus* from Eivissa. Scale bar, 1 mm.

Figura 5. Llavors de *Pistacia lentiscus* d' Eivissa: (A) actual i (B) fòssil. Escala, 1 mm.

cies. It has a disjunct distribution in the western Mediterranean basin. It is common in the Balearic Islands, having been recorded on 14 islands and islets (Traveset & Riera, unpubl. data), and has small populations in the southeastern Iberian Peninsula, southeastern France, southwestern Sardinia and northwestern Italy (BOLÓS, 1958; and Traveset, unpub. data). It usually inhabits coastal maquis or shrublands, usually in calcareous soils. In the Balearics, the species has also colonized the interior of the large islands; in Mallorca is often found in the understory of oak forests (*Quercus ilex* L.) up to an altitude of around 1000 m a.s.l. (TRAVERSESET, 1995, 2002). The fruit consists of three cocci that are easily separated from each other, and each coccus contains two one-seeded compartments. Information on its reproductive biology can be obtained in TRAVESET (1995 a,b).

Crataegus monogyna is rather common both in Menorca and Mallorca (BONAFÉ, 1979), and thus the finding of the fossil seed of this species is not unexpected. *C. monogyna* is currently distributed throughout Menorca, mostly in the central part (Pere Fraga, pers. com.) and is also abundant at Serra de Tramuntana in Mallorca. It is usually found in shady habitats, often near temporary streams. Its fruits are consumed usually by birds (Traveset, pers. obs.), although pine martens *Martes martes* probably contribute also to the dispersal of this plant.

The fossil seeds of *C. tricocon*, obtained in palaeontological deposits from Menorca (QUINTANA, 1998; QUINTANA *et al.*, 2004, and the present study) and located in sites where the plant is not currently present, are the only evidence that demonstrates the more widespread distribution that this species had in this island. The shrinking of the populations of this species can be related to the disappearance of its main native disperser from Menorca, the endemic lizard *Podarcis lilfordi* (Lacertidae), as it seems to have happened with other plant species such as the endemic and threatened shrub *Daphne rodriguezii* (TRAVERSESET & RIERA, 2005). According to the fossil record, *P. lilfordi* began vanishing from the larger Balearic Islands, Mallorca and Menorca, about c. 2000 years ago, presumably after the human introductions of predators such as weasels (*Mustela nivalis*) (see ALCOVER, 1989; PLEGUEZUELOS *et al.*, 2002 and references therein). This lizard persists only in the small islands around the two larger ones and it is an important seed disperser for a number of plant species (PÉREZ-MELLADO & TRAVESET, 1999).

In Mallorca, pine martens (*Martes martes*) appear to play an important role at present for the distribution of *C. tricocon* as they consume large quantities of fruits and effectively disperse its seeds in that island (RIERA *et al.*, 2002; TRAVESET, 2002). In Menorca, in contrast, pine martens are not as frugivorous as in Mallorca

(CLEVENGER, 1993) and most fruits of *C. tricoccon* remain undispersed (RIERA *et al.*, 2002).

In the Pityusic Islands, the healthiest populations of *C. tricoccon* are found in Formentera and in the islets south of Eivissa (TRAVERSESET & RIERA, unpub. data), where they have a strong interaction with the other endemic lizard species of the Balearics, *P. pityusensis*. The abundance of lizards in the larger island (Eivissa) appears to have decreased in the last years (Riera, pers. com.) which may well have affected the populations of this plant in the island.

The *Pistacia lentiscus* seed found in Cova de Ca na Reia is not surprising considering that this species is also very ancient, from the early Tertiary (RAVEN, 1973), and quite common in many habitats in all the Balearics (BONAFÉ, 1979).

Finally, the presence of *Cneorum tricoccon* in the Pliocene deposits of the Balearic Islands confirms the antiquity of the presence of this species in the Balearics. In our knowledge, these findings represent the first fossil documentation of the species, and it is highly consistent with the interpretation of its belonging to the subtropical flora that was once spread in the Balearics, before the start of the glaciations.

Acknowledgements

This paper is included in our Research Projects BOS2001-0610 and CGL2004-04612/BTE of the Dirección General de Investigación, Ministerio de Educación y Ciencia (Madrid). We thank Javier Tomás for his assistance with photographs of seeds under the scope and the Jardí Botànic de Sóller for letting us consult their seed collection.

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