The late Miocene/early Pliocene vertebrate fauna from Mallorca (Balearic Islands, Western Mediterranean): an update

Journal:	*Integrative Zoology*
Manuscript ID:	INZ-2013-01-003.R1
Manuscript Type:	Original Article
Keywords:	Mallorca, late Miocene, early Pliocene, new fauna, paleobiogeography
Specialty:	Paleontology, Evolution

ABSTRACT

The vertebrate fossil record from the Balearic Islands (western Mediterranean) has been widely improved in the last decade, especially in Mallorca and Menorca. In Menorca, the Pliocene terrestrial fauna was updated by the discovery and description of the large-sized leporid *Nuralagus* and several reptiles and an amphibian. In Mallorca, paleontological exploration yielded two deposits with a late Miocene/early Pliocene chronology, Caló den Rafelino (CdR) and Na Burguesa-1 (NB-1). Up to four new mammalian taxa and two new reptiles have been identified for the Caló den Rafelino deposit so far, whereas the faunal assemblage from the recently discovered deposit (April 2012) of Na Burguesa-1 is currently composed of, at least, six terrestrial mammals, eight reptiles and an amphibian. Its faunal composition and some primitive characteristics of the obtained taxa suggest that the chronology of this deposit is slightly earlier than the Caló den Rafelino. The terrestrial vertebrates recorded in these two Mallorcan deposits are changing the view of the paleofaunal assemblage previously known for the Plio-Pleistocene of the island. Morphological characteristics displayed by some of the taxa suggest that these faunas would be at the beginning of an isolated evolution. In this paper we present a preliminary report on the fossils recovered from Na Burguesa-1 deposit, as well as some unpublished material from Caló den Rafelino, and we analyze the whole fauna from both Mallorcan deposits, focusing in taxonomical and paleobiogeographical aspects.

Keywords : Mallorca, late Miocene, early Pliocene, new fauna, paleobiogeography

INTRODUCTION

The Balearic Islands are an archipelago located at the Western Mediterranean Sea. It is compound of two sub-archipelagos, the Gymnesic Islands (Mallorca, Menorca and surrounding islets) and the Pityusic Islands (Eivissa, Formentera and surrounding islets) (Fig. 1). Although these islands are geographically close to each other, remarkable differences in their Pliocene and Pleistocene fossil record exist.

Two different insular episodes can be identified in the Miocene to Holocene fossil record of the Balearic Islands (e.g., Alcover *et al.* 1981; Moyà-Solà *et al.* 1999; Bover *et al.* 2008). A first episode has been related to the Langhian-Serravalian regression (middle Miocene). It has been only recorded in Mallorca and Menorca. The two main Mallorcan sites representatives of this episode (Santa Margalida and Sant Llorenç) yielded remains of a lagomorph (*Gymnesicolagus gelaberti* Mein & Adrover, 1982) and three glirids (*Carbomys sacaresi* Mein & Adrover, 1982, *Margaritamys llulli* Mein & Adrover, 1982 and *Peridyromys ordinasi* Mein & Adrover, 1982) (Mein & Adrover 1982; Adrover *et al.* 1985). Other taxa found in pre-Messinian deposits (Cova des Coll and Cova de Cala Varques B; Gràcia *et al.* 1997, 2000) are a large terrestrial tortoise (Testudinidae), and a brackish soft-shell turtle (*Trionyx* sp.) (Bover *et al.* 2008). A related fauna, also belonging to this episode, was recovered from the Menorcan deposits of Punta Nati-2 and Es Cul de sa Ferrada, with *G.* aff. *gelaberti*, *Margaritamys adroveri* Quintana & Agustí, 2007, an undetermined viperid, an undetermined great-sized tortoise, one or more small-sized reptiles, and a bird (Bailon *et al.* 2002; Quintana & Agustí 2007).

The second episode started at the Messinian Salinity Crisis (MSC) and spreads over all the Plio-Pleistocene. Until the end of the 90's its record of terrestrial vertebrates was mainly represented in Mallorca and Menorca by three mammalian

evolutionary lineages: a bovid (*Myotragus*), a glirid (*Hypnomys*) and a soricid (*Nesiotites*), together with a lacertid of the genus *Podarcis* (early Pleistocene to Holocene), and the amphibians *Alytes* (early Pleistocene to Holocene) and *Discoglossus* (early Pleistocene) (Alcover *et al.* 1981; Bover *et al.* 2008). The fossil record of the three mammalian lineages was remarkably complete throughout the Pliocene to Holocene on Mallorca and throughout the early Pleistocene to Holocene on Menorca (see Alcover *et al.* 1981; Agustí & Moyà-Solà 1990; Moyà-Solà *et al.* 1999; Bover *et al.* 2008 for further detail on the fauna). Additionally, a peculiar Pliocene fauna was known from Menorca, composed of the glirid *Muscardinus cyclopeus* Agustí, Moyà-Solà, Pons-Moyà, 1982, the bat *Rhinolophus* cf. *grivensis* Depéret, 1892 and the giant tortoise *Cheirogaster gymnesica* (Bate, 1914) (Bate 1914; Pons-Moyà *et al.* 1981; Agustí *et al.* 1982).

In Eivissa, a distinctive faunal succession was observed. The earliest fauna recorded comes from the deposit of Ses Fontanelles. It includes two bovids (a caprine and an antilopine), two rodents (the gerbillid *Debruijnimys* sp. and the glirid *Eliomys* sp.), a leporid (identified as *Hypolagus* sp. by Quintana *et al.* 2010), an insectivore, a lizard, and a tortoise (Moyà-Solà *et al.* 1984, 1999; Agustí & Moyà-Solà 1990). It was attributed to the late Miocene (Messinian)/early Pliocene (Moyà-Solà *et al.* 1999; Bover *et al.* 2008). A single deposit from the late Pliocene/early Pleistocene of Eivissa is known, Cova de Ca Na Reia, containing two glirids (*Eivissia canarreiensis* Alcover & Agustí, 1985 and *Hypnomys* sp.), a tortoise (*Cheirogaster* sp.), a lizard (*Podarcis* sp.), bats and birds (Kotsakis 1981; Alcover & Agustí 1985; Bour 1985; Alcover 1989). Remains of giant tortoises are also known from other early-middle Pleistocene deposits from Eivissa and Formentera (Bover *et al.* 2008). Finally, the late Pleistocene-Holocene deposits from the Pityusic Islands yielded birds, bats and a

lizard (*Podarcis pityusensis* Boscá, 1883), but no other fossil terrestrial vertebrates have been ever recorded from them (Florit *et al.* 1989).

The discovery of Pliocene deposits in Mallorca and Menorca during the last fifteen years improved substantially the knowledge on the paleofauna of the second faunal episode, and it shed light to the stock that arrived to the islands during MSC, an event that has been situated between 5.6 and 5.32 Ma ago (Clauzon *et al.* 1996; Gautier *et al.* 1994; Krijgsman *et al.* 1999). In Menorca, several deposits in the Northwest coast of the island, in Punta Nati (municipality of Ciutadella, Quintana 1998), yielded a Pliocene fauna coeval to *Muscardinus cyclopeus*, *Rhinolophus* cf. *grivensis* and *Cheirogaster gymnesica*. It includes *Nuralagus rex* Quintana, Moyà-Solà, Köhler, 2011, *Vipera natiensis* Bailon, Garcia-Porta, Quintana, 2002, *Vipera* sp., *Coluber* sp., Gekkonidae indet., *Podarcis* aff. *lilfordi*, *Blanus* sp., *Latonia* sp. (Bailon 2004; Bailon *et al.* 2002, 2005; Garcia-Porta *et al.* 2002; Quintana *et al.* 2005, 2011), and several bird species (such as *Pterodromoides minoricensis* Seguí, Quintana, Fornós, Alcover, 2001, *Scolopax carmesinae* Seguí, 1999, *Camusia quintanai* Seguí, 2002, *Tyto balearica* Mourer-Chauviré, Alcover, Moyà-Solà, Pons-Moyà, 1980, *Athene* sp., *Corvus* sp. and an unidentified passeriform; Seguí 1998, 1999, 2002; Seguí *et al.* 2001).

The early Pliocene fauna from Mallorca started to be known within the last decade (Bover *et al.* 2007). In this paper we present an overview of the Mallorcan vertebrate fauna from the late Miocene/early Pliocene interval based on the findings from two sites, Caló den Rafelino (Manacor) and Na Burguesa-1 (Palma). As the work on the Na Burguesa-1 breccia is now in progress, we only can present here a few preliminary data on this site, based on the first extracted and identified bones.

MATERIAL AND METHODS

DEPOSITS

Caló den Rafelino (from now on CdR)

This deposit (Fig. 1.b) is located at the eastern coast of Mallorca, at the North of Caló den Rafelino (from where it takes its name) and at the South of Cala Morlanda, in the municipality of Manacor. It was discovered by Josep Quintana and Pere Bover in the spring of 2004 and it was excavated the same year.

The deposit, located at 5 meters above sea level, consists of consolidated red silts of karstic origin which are the floor sediment of a collapsed cave in the Upper Miocene limestone of the so-called Reef Complex (Pomar *et al.* 1990; Gómez-Pujol *et al.* 2007) of late Tortonian-Messinian chronology (Bizon *et al.* 1973). Just a small portion of the sediments (around 1 m^2 at the North-East extreme of the cave sediments) has yielded fossil remains while the rest of the sediment seems to be sterile. The thickness of these red silts is unknown but the structure of the fossil cave and its proximity to the sea (around 6 m, and 5 m above sea level) suggest that it is not very large.

The chronology of the deposit has been indirectly estimated. It postdates the upper Miocene limestone and characters of some of the taxa, more primitive than those of the fauna present in the later early Pliocene deposit of Cala Morlanda (Moyà-Solà & Pons-Moyà 1982; Pons-Moyà 1990), suggest that it should be considered as an early Pliocene deposit, but a Messinian chronology cannot be completely discarded.

The bones obtained from this breccia were mainly broken, worn and eroded.

Na Burguesa-1 (from now on NB-1)

It was discovered on April 2012 by the Mallorcan speleologists Damià Vicens, Damià Crespí and Antelm Ginard from the Speleo Club Mallorca (SCM). The deposit (Fig 1.a) is located at 160 meters above sea level and close to the road from the neighborhood of Génova to the Mirador de Na Burguesa, at the municipality of Palma. The original location of the breccia has not been found, as the findings are blocks extracted from the original site and used to facilitate the access to a small house, but it is probably close or under a small construction of the Mallorcan Water Company (EMAYA) built in the slope of the mountain.

The breccia is constituted by brown-red silts and, geologically, it was in a cave or fissure excavated in the Lower Lias sediments present in the area. The obtained fauna is related to that from CdR and both can be considered as chronologically close, being CdR slightly more recent than NB-1. Further study of the fauna will shed more light on the NB-1 deposit chronology. After obtaining the permits from the Mallorcan Government, several large blocks have been recovered and the bones are being extracted. The obtained bones are in better condition than those from CdR.

BONE EXTRACTION

The obtained breccias from CdR and NB-1 were treated or are currently being treated (NB-1) with acetic acid to extract the bones. Cycles of consolidation of the bones with Paraloid-B67 (5%), treatment with acetic acid (10%, 48 h), and fresh water immersion (7 days) have been used. The breccia from NB-1 is much richer than the CdR one.

GEOLOGICAL NOMENCLATURE

In this paper we use the nomenclature for the Pliocene and Pleistocene presented by Gibbard *et al.* (2010), following the IUGS updated chronology of the base of the Quaternary.

MEASUREMENTS/NOMENCLATURE

Teeth nomenclature: lowercase letters ('m' for molar, 'p' for premolar) for lower teeth and uppercase letters for upper teeth.

Measurements of reptile bones were taken with an electronic digital calliper (accuracy 0.01 mm) on bone projections using a camera lucida.

SYSTEMATIC PALEONTOLOGY

In this section, a complete list of the fauna so far obtained from Caló den Rafelino (CdR) is presented. For Na Burguesa (NB-1), just some preliminary remarks on the fauna of the deposit will be furnished because it is currently being processed, and additional taxa could be obtained. Furthermore, only a small sample of amphibians/reptiles from NB-1 has been currently analysed.

FISHES

Several fish teeth have been recovered from the CdR deposit. The taxonomical composition of this fish fauna is being currently studied (Vicens & Bover in prep.). The presence of fish teeth in a mainly terrestrial faunal deposit is intriguing. Their incorporation at the site deposition may be related to some bioaccumulator agent (such as some seabird).

BIRDS

A single bird bone (proximal fragment of a humerus) has been obtained from the CdR (unidentified bird), whereas bird bones are also present in NB-1.

AMPHIBIANS

Order Anura Fischer von Waldheim, 1813

Family Bufonidae (?) Gray, 1825

Material: 1 sacral vertebra (NB-1).

The vertebra is procoelous and it bears an anterior cotyle and two clearly separated posterior condyles. The sacral processes are only moderately widened antero-porteriorly. The centrum is relatively short and, in dorsal view, a small pit occurs at the base of each sacral process. This combination of characters suggests referral to the Bufonidae (see, e.g., Sanchiz 1977; Bailon & Hossini 1990; Bailon 1999), but such an attribution cannot be made without reservation. If recovery of further material shows that assignment to the Bufonidae is accurate, then this anuran would be the first fossil record of the family in the Balearic Islands, as the presence of the extant species *Bufo balearicus* (Boettger, 1880) in these islands is the consequence of a recent human introduction (Hemmer *et al.* 1981; Pinya & Carretero 2011).

REPTILES

Order Chelonii Linnaeus, 1758

Material: 2 terminal phalanges (IMEDEA 90102, 90103) (CdR), 1 phalange and shell plates (NB-1).

Two terminal phalanges probably belonging to a large-sized terrestrial tortoise (Testudinidae) have been recovered from CdR. A phalange and shell fragments of a tortoise have been obtained from NB-1.

Order Squamata Opell, 1811

Family Gekkonidae Gray, 1825

Material: 1 fragment of right dentary (NB-1).

The presence of a Meckel's groove entirely surrounded by the dentary and of numerous pleurodont, cylindrical and monocuspid teeth allows the attribution of this dentary to the Gekkonidae. However, a more precise identification is not possible. Bailon *et al.* (2005) described remains of gekkonids from the Pliocene of Menorca.

Family Lacertidae Batsch, 1788

Lacertidae, new genus and species

Material: 1 left fragmented dentary (IMEDEA 90107), 1 right dentary fragment (IMEDEA 90109), 2 left maxilla fragments (IMEDEA 90105, 90106), 1 caudal vertebra (IMEDEA 90260) (CdR).

Remains of a large-sized lacertid were recovered from the CdR deposit. This lizard displays short and robust dentaries having a thick lateral wall, a reduced number of tooth positions (13) and amblyodont teeth. It has been proposed as a new genus and species (Bailon *et al.* submitted).

Lacertidae, unidentified genus and species

Material: 1 left fragmentary maxillary (NB-1).

The presence of cylindrical, pleurodont and bicuspid teeth, with a well developed central cusp and a small anterior cusp, permits attribution of this maxilla to the Lacertidae (Barahona & Barbadillo 1997). This family is known in the Balearic Islands since the middle Miocene of Menorca (Bailon 2004).

Family Scincidae Gray, 1825

cf. *Chalcides* Laurenti, 1768.

Material: 1 right dentary (NB-1) (Fig. 2.g).

The dentary, comprised of two fragments, has an approximate length of 4.7 mm, thus belonging to a small-sized individual. In medial view, Meckel's canal is open throughout the dentary, but in its anterior half it narrows and it is located medio-ventrally. The mandibular symphysis is reduced. The subdental table, the ventral margin of the bone and the dental crest are slighltly curved and they give an elongated appearance to the dentary. In laterat view, six dental foramina can be observed and, postero-dorsally, there is no coronoid impression on the lateral wall of the dentary. Teeth are pleurodont, monocuspid, cylindrical and they have blunt apexes. Medially, each apex displays a series of small vertical ridges. The dentary has 19 teeth. The morphology of this dentary fits into the general morphological pattern observed in the small-sized individuals of *Chalcides* (Barbadillo 1989; Bailon 2000; Blain *et al.* 2007, 2008; Blain 2009).

In the fossil record of the Balearic Islands, Boulenger (in Bate 1918) mentioned *Chalcides* sp. from a currently unknown deposit from Menorca. Thus, the identification of *Chalcides* in NB-1 deposit could confirm the presence of skinks on these islands during the late Miocene/early Pliocene interval.

Family Anguidae Gray, 1825

Dopasia Gray, 1853

Material: 1 trunk vertebra, IMEDEA 90115 (CdR, Fig. 2.a-c); 1 fragment of dentary, 1 trunk vertebra, 3 caudal vertebrae and 2 osteoderms (NB-1, Fig. 2.d).

A medium-sized vertebra (centrum length = 4.3 mm) from CdR displays a characteristic anguid morphology and it is tentatively attributed to *Dopasia*. It is procoelous, depressed, moderately elongated and its cotyle and condyle are dorso-ventrally flattened. The ventral surface of the centrum is sub-triangular and slightly convex in transverse section; the lateral margins of the centrum diverge anteriorly and are slightly concave laterally. The neural spine, partially broken, is moderately robust in its posterior half. No zygosphene-zygantrum, precondylar constriction and haemal keel can be observed on the vertebra.

When compared with the different anguids known from the Neogene of mainland Europe, the CdR vertebra displays size and morphological characteristics observed in *Dopasia* (*sensu* Augé 2005, i.e., European species formerly included in *Ophisaurus* s.l. and *Pseudopus* excluded), but a more precise attribution cannot be done. In *Anguis*, the lateral margins of the centrum are mainly parallel and vertebrae are slightly smaller, whereas in *Pseudopus* the size of the vertebrae is greater and the lateral margins of the centrum are markedly more divergent than in the CdR vertebra (Estes 1983; Roček 1984; Bailon 1989, 1991; Augé 2005; Blain 2009; Delfino *et al.* 2011).

To our knowledge, this is the first record of a member of the Anguidae in the Balearic Islands. In islands, *Dopasia* was only known from the late Pliocene (MN16) of Sardinia (Delfino *et al.* 2011), whereas in the European continent the genus has been recorded from the Oligocene to the early Pleistocene (Augé 2005; Blain 2009;

Blain & Bailon 2010). Today, the genus is restricted to Asia. No extant anguids currently live in the Balearic Islands.

The material obtained from NB-1 deposit confirms the presence of *Dopasia* (*sensu* Augé 2005), in the Mallorcan Pliocene. The studied dentary fragment displays a tooth that is subpleurodont, slightly hook-shaped and unicuspid; the apex lacks ridges and it is directed postero-medially. The trunk vertebra is procoelous, with dorsoventrally depressed cotyle and condyle. Its centrum is subtriangular, with a smooth ventral surface that is slightly convex in transverse section, and with slightly concave and anteriorly divergent lateral margins. The caudal vertebrae display two pairs of transverse processes, each being partly subdivided longitudinally by an autotomic septum and, in the posterior third of the vertebra, haemapophyses fused to the centrum. The osteoderms are simple, with a smooth basal area and with an external area displaying vermicular ornamentation. One of the osteoderms has lateral margins that are slightly bevelled and a longitudinal keel typical of the medio-dorsal osteoderms. All these characteristics allow the attribution of this fossil material to *Dopasia* and also to differentiate it from the other anguids known for the European fossil record (Estes 1983; Roček 1984; Bailon 1989, 1991; Augé 2005; Blain 2009).

Infraorder Scolecophidia Dumeril & Bibron, 1844

Material: 1 vertebral trunk (NB-1) (Fig. 2.e-f)

The vertebra is very small with a centrum length slightly longer than 1mm. It is dorso-ventrally compressed and with a simple morphology typical of this group of snakes (flattened neural arch, without neural spine and posterior medial notch; narrow centrum without haemal keel; dorso-ventrally flattened cotyle and condyle; well

developed subcentral foramina, but paracotylar foramina absent; prezygapophyseal processes present and synapophyses not divided) (Rage 1984; McDowell 1987).

Within this group of snakes, the morphology of the vertebrae is highly homogeneous and the taxonomical identification, even at family level, is particularly difficult. Scolecophidia have been recorded in the early Paleocene from Hainin (Belgium; Vidal *et al.* 2009), and in the early Pleistocene of the Illes Medes (Spain; Bailon 1991). The vertebra from NB-1 deposit is the first and sole record of this group in the Balearic Islands. *Typhlops vermicularis* Merrem, 1820 is the only known extant Scolecophidia in Europe (Montenegro, Greece, Albania, Macedonia and Bulgaria; Gasc *et al.* 1997).

Family Colubridae Opell, 1811

"Colubrinae" type

Material: 2 vertebral trunks (IMEDEA 90114 and 90261), 3 fragments of centra (IMEDEA 90267, 90269 and 90270) (CdR); 1 vertebral trunk (NB-1).

The vertebrae from CdR belong to small-sized individuals, with a centrum length less than 4 mm. The vertebrae are slightly longer than wide; their neural spine and posterior notch are well developed. They display rounded cotyle and condyle; paracotylar foramina are present and the centrum is subtriangular and bears a well marked off haemal keel. These characteristics allow the attribution of these vertebrae to a Colubridae of "colubrinae" type (*sensu* Szyndlar 1991). The preservation of the vertebrae (partly fragmented and eroded) does not allow further identification.

The sole vertebra from NB-1 studied here is from a medium-sized individual (centrum length = 4.5mm). It is slightly longer than wide (ratio centrun length / interzygapophyseal width = 1.3) and it does not display a hypapophysis. These two

characters allow to refer this vertebra to a colubrid of "Colubrinae" type (*sensu* Szyndlar 1991). The centrum is narrow, with well-defined subcentral ridges and a well developed haemal keel. The zygapophyses are rectangular and arranged on the horizontal plane. The prezygapophyseal processes are cylindrical, blunt and shorter than the prezygapophyses. The cotyle and condyle are small and rounded. The diapophyses are located more posteriorly than the parapophyses. In posterior view, the neural arch is vaulted, its dorsal edges being slightly convex. Together with the vertebrae from CdR, the colubrid from NB-1 deposit displays a vertebral morphology similar to that of the material described from the Menorcan Pliocene, and attributed to "*Coluber*" sp. [*Coluber dolnicensis* Szyndlar, 1987-*C. pouchetii* (Rochebrune, 1880) group] (Bailon *et al*. 2005), therefore they probably represents the same taxon.

Family Viperidae Laurenti, 1768

Vipera Laurenti, 1768 **(Oriental Vipers Complex)**

Material: 1 middle trunk vertebra (IMEDEA 90113), 1 cervical vertebra (IMEDEA 90116) (CdR). Tentatively, 2 vertebrae from NB-1.

Bailon *et al.* (2010) studied two vertebrae of a large snake obtained from the CdR deposit. The combination of characters such as straight hypapophysis, posteriorly depressed neural arches, zygapophyseal articular facets inclined dorsally, parapophyseal processes directed antero-ventrally, large condyles and cotyles, relatively short centrum and condyle ventrally attached to the hypapophysis basis allowed these authors to assign these vertebrae to a member of the Viperidae, more specifically to the 'Oriental Vipers Complex' (according to the classification suggested by Szyndlar & Rage 1999). Based on the size of the centrum, a body length close or even greater than 200 cm was estimated for this viper; it may be considered

the largest European viper belonging to this complex. Two viperid vertebrae obtained in NB-1 could belong to the same or to a related taxon.

cf. *Vipera natiensis* Bailon, Garcia Porta & Quintana, 2002

Material: 1 anterior trunkal vertebra or cervical vertebra (IMEDEA 90264) (CdR).

The vertebra belongs to a small-sized individual, with a centrum slightly longer than 2 mm. In posterior view, the neural arch is dorsoventrally flattened. The articular surfaces of the zygapophyses are inclined latero-dorsally, and the prezygapophyseal processes are short and blunt. The vertebral centrum is markedly convex ventrally in transverse section; it bears a hypapophysis and its subcentral ridges are somewhat indistinct. These characters suggest that this vertebra could belong to a viper close to *Vipera natiensis* that was described by Bailon *et al.* (2002) from the Pliocene of Menorca.

MAMMALS

Order Eulipotyphla Waddell, Okada & Hasegawa, 1999

Family Soricidae Fischer von Waldheim, 1817

Subfamily Soricinae Fischer von Waldheim, 1817

Nesiotites rafelinensis Rofes, Bover, Cuenca-Bescós & Alcover, 2012

Material: 1 incomplete left mandible with p4, m1, m2, and m3 (IMEDEA 91950) (CdR).

The material obtained from CdR was used by Rofes *et al.* (2012) to describe a new species of *Nesiotites*, *N. rafelinensis*. Although the species is based on a single mandible, it displays enough diagnostic features to be distinguished from the other remaining *Nesiotites* species. A combination of characters as teeth size, mandible size,

absence of accessory cusps on the oblique crest of the first and second lower molars, inconspicuous cuspule and lingual crest on the lingual basin of the p4, broad and pronounced buccal and lingual cingula of the lower teeth, slightly undulated buccal cingulum and slightly forward placement of the mental foramen allowed the description of *N. rafelinensis* as a new species. Thus, this species combines primitive dental traits with a relatively large size.

Soricinae unidentified

Material: 2 fragmented skulls, 2 mandibles, and some postcranial bones (NB-1).

The insectivore remains are here provisionally attributed to *Nesiotites/Asoriculus* (Fig. 3.a). The absence of accessory cusps in m1-m2, the almost straight buccal cingulum, and the forward position of the mental foramen are typical of both groups (i.e., *Nesiotites rafelinensis* and *Asoriculus gibberodon* Petényi, 1864).

Order Rodentia Bowdich, 1821

Family Cricetidae Fischer von Waldheim, 1817

Tragomys macpheei Agustí, Bover & Alcover, 2012

Material: 1 right m1 (IMEDEA 90614, holotype), 17 cheek teeth, 2 incisors, 3 mandible fragments, 2 maxillae fragments, 9 fragments of postcranial long bones, 1 calcaneum, and 1 astragalus [See Agustí *et al.* (2012) for an extensive list of material] (CdR).

Agustí *et al.* (2012) recently described a new genus and a new species of Cricetidae based on the material obtained from CdR, *Tragomys macpheei*. It displays a large size, and a distinctive selenodont pattern and hypsodont teeth.

Cricetinae unidentified

Material: Currently, circa 200 bones, complete or fragmented, including 10 mandibles, 3 maxillae, complete femora, humerus, radius, tibia, a partial skull, etc, representing most of the elements of the skeleton (NB-1).

Remains of a large-sized cricetine with slightly selenodont and hypsodont dentition have been recovered in the NB-1 (Fig. 3.b). Most probably, it corresponds to the putative ancestor of *Tragomys macpheei*.

Family Muridae Illiger, 1811

Muridae unidentified

Material: 3 mandibles, 1 maxillar, 1 humerus and 1 femur (NB-1).

Another slightly hypsodont small rodent has been recorded in NB-1 deposit (Fig. 3.c). The absence of the anterior accessory cusp (tma) and the poorly marked stephanodonty in the teeth studied allows the attribution of these remains to a derived species of *Occitanomys* or *Castillomys*, but additional analysis is needed to go further in the identification.

Family Gliridae Thomas, 1897

***Hypnomys* sp.**

Material: 1 m1 (IMEDEA 90622) and 1 M1 (IMEDEA 90623) (CdR).

In addition to *Tragomys macpheei*, a second rodent species is present at CdR. This second species corresponds to a very early member of the dormice genus *Hypnomys*. Since the scanty material does not permit to make inferences about its specific identity, we will refer to as *Hypnomys* sp. (Fig. 4). In the upper first molar, a

continuous endoloph connects anteroloph, protoloph, metaloph and posteroloph (Fig. 4.b). The anterior centroloph is labially fused to the protoloph. The paracone is not individualized as a cusp, nor is the metacone. An anterior extra-ridge is present between the protoloph and the anterior centroloph. The posterior centroloph is fused to the metaloph. The lingual ends of the anterior and posterior centrolophs are fused. It presents three roots, two labials and one very wide lingual one. In this way, *Hypnomys* sp. from CdR looks very much as the oldest species of the *Hypnomys* described from Mallorca and Menorca, such as *Hypnomys waldreni* Reumer, 1979, *Hypnomys onicensis* (Reumer, 1994) and *Hypnomys eliomyoides* Agustí, 1980 (Reumer 1979, 1981; Agustí 1980). However, it differs from these old *Hypnomys* species by the still *Eliomys*-like, narrow M1 and m1. Its dimensions (first m1: 1.82 x 1.96 mm; first M1: 1.62 x 1.64 mm) are also lower than those of other *Hypnomys* species, and closer to those of the late Miocene *Eliomys*, such as *E. intermedius* Friant, 1953 and *E. truci* Mein & Michaux, 1970. However, the dormouse from CdR differs significantly from *Eliomys* since the upper molar presents much less prominent labial cusps, as it is also the case in *Hypnomys*.

***Eliomys*/*Hypnomys* sp.**

Material: Abundant material, including currently c. 300 bones representing most of the elements of the skeleton (NB-1).

The glirid present in NB-1 (Fig. 3.d) displays small size. It most probably represents the ancestor of, or an ancestral species inside, the *Hypnomys* lineage.

Order Lagomorpha Brandt, 1855

Family Leporidae Gray, 1821

Hypolagus balearicus Quintana, Bover, Alcover, Agustí & Bailon, 2010

Material: 1 left p3 (IMEDEA 90123, Holotype), 10 cheek teeth, 1 incisor, 5 postcranial bones [See Quintana *et al.* (2010) for an extensive list of material] (CdR). Twenty juvenile bones (NB-1) are here tentatively attributed to *Hypolagus*, as cf. *Hypolagus*.

The first record of *Hypolagus* in the Balearic Islands was reported by Quintana *et al.* (2010). These authors described a new species, *H. balearicus*, based on tooth characteristics and some postcranial features. The p3 of *H. balearicus* displays a small size, trapezoidal outline, with a shallow and well-marked anteroflexid, shallow protoflexid, deep hypoflexid and lack of paraflexid. All these characteristics allow the differentiation of the Mallorca species from the other species of *Hypolagus*. Additionally, more robust postcranial bones were also observed in this species. The presence of *Hypolagus* in the Balearic Islands represents one of the westernmost European records of the genus. The fossils obtained in NB-1 (Fig. 3.e) include complete bones of juveniles that are here tentatively attributed to *Hypolagus*.

Order Artiodactyla Owen, 1848

Family Bovidae Gray, 1821

Myotragus palomboi Bover, Quintana & Alcover, 2010

Material: 1 right metatarsal (IMEDEA 90140, Holotype), 4 cheek teeth, 2 incisiforms, 12 postcranial bones [See Bover *et al.* (2010) for an extensive list of material] (CdR); 2 bones and one tooth of a juvenile bovid (NB-1) are here tentatively attributed to *Myotragus*, as cf. *Myotragus* (Fig. 3.f).

The earliest representative of *Myotragus*, *M. palomboi*, was described by Bover *et al.* (2010). It displays relevant similarities that allow its attribution to

Myotragus, but there are remarkable differences between *M. palomboi* and the former earliest species of *Myotragus*, *M. pepgonellae* Moyà-Solà & Pons-Moyà, 1982. The CdR *Myotragus* has a larger p2, not hypsodont nor ever-growing incisors with more rectangular wear surface and with enamel surrounding the whole crown (and not elongated incisors as the other *Myotragus* species), and a lower robustness index of the studied postcranial bones than in *M. pepgonellae*. Specifically, the metatarsal bone is longer than the other representatives of the genus and its morphology seems to be intermediate between *M. pepgonellae* and the putative mainland ancestors *Aragoral* and *Norbertia*.

DISCUSSION

Insular environments are characterized by unbalanced faunas with a reduced number of endemic species displaying morphological traits that follow well-described patterns (the so-called "insularity syndrome"). The faunal record of the two Mallorcan deposits here presented partially agrees with this insular pattern. So far, in none of these deposits carnivores have been obtained and the number of recorded species is reduced (5 mammals and 6 reptiles in CdR and 6 mammals, at least 8 reptiles and 1 amphibian in NB-1).

Morphological traits observed in some taxa suggest that the fauna from CdR and NB-1 would be in a first stage of its isolated evolution. The species of the fauna from CdR displays more derived characters than that from NB-1. In this sense, the large size of *Tragomys*, the reduction of premolar size observed in *M. palomboi* (a progressive loss of teeth has been considered as an insular evolutionary effect in the *Myotragus* lineage, Alcover *et al.* 1981) and the characteristic selenodont teeth pattern of *T. macpheei* points out to be at the beginning of an isolated evolution. The glirid,

the soricid and the murid are only slightly modified, suggesting also a proximity to the isolation event. On the other hand, although *Hypolagus balearicus* displays a relatively smaller size of the p3 when compared to other species of *Hypolagus*, the scarce postcranial bones available do not allow determining whether insular evolutionary effects occurred in the species.

According to Bailon *et al.* (2010), the large size of *Vipera* sp. ('Oriental Vipers Complex') from CdR cannot be explained in terms of insular evolution itself but also as the result of a co-evolutionary process between this group of snakes and the size of the preys. Additionally, as the mainland ancestor of this snake is unknown no definitive inferences on dwarfism or gigantism can be done. The same accounts for the remaining reptiles and for the amphibian.

The faunal composition of NB-1 and CdR represents a faunal assemblage that could be related to the colonization pattern. It has been widely accepted that the arrival of the faunal stock recorded for the Plio-Pleistocene in the Balearic Islands occurred during the MSC (Agustí *et al.* 2006; van der Made *et al.* 2006: Bover *et al.* 2008 and references therein), around 5.6-5.32 Ma ago (Clauzon *et al.* 1996; Gautier *et al.* 1994; Krijgsman *et al.* 1999). While the founder stock of terrestrial vertebrates was initially thought to be composed in Mallorca of the ancestors of *Myotragus*, *Hypnomys*, and *Nesiotites* lineages together with a reptile (*Podarcis*) and two amphibians (*Alytes* and *Discoglossus*), the discovery of the two deposits studied in this paper allows reporting a different scenario, and additionally it sheds light in the understanding of the late Miocene/early Pliocene faunal assemblage from the Eivissan deposit of Ses Fontanelles.

In Fig. 5, a schematic view of the faunal succession of terrestrial vertebrates from the Balearic Islands throughout late Miocene/early Pliocene to Holocene is

presented. Although further analysis of the NB-1 fauna is needed, if we roughly compare the taxonomical groups (rather than taxa at genus/species level) recorded in the several Pliocene deposits from these islands, the Mallorcan deposits of NB-1 and CdR share five species or close relatives of the six mammals and at least four reptiles (a tortoise, *Dopasia*, *Vipera* sp. OVC, and a colubrine), and it seems adequate to consider them as deeply related. Additionally, also four of the mammalian taxa and probably two reptiles are shared by the Mallorcan and Eivissan deposits, suggesting that the fauna from Ses Fontanelles is also related to the same colonizer stock. The differences in taxa composition may be related to an insufficient fossil record or/and to taphonomical reasons. Nevertheless, a more extensive study of the Mallorcan and Eivissan Pliocene fauna is needed in order to confirm the relationship between these deposits.

On the other hand, a clear relationship cannot be established between the late Miocene/early Pliocene Mallorcan fauna and the Pliocene (*sensu lato*) Menorcan one. The mammals present in the Pliocene deposits from Menorca, *Nuralagus rex* and *Muscardinus cyclopeus*, can be clearly distinguished from the lagomorph and glirid, respectively, present in NB-1, CdR and Ses Fontanelles deposits, and although some of the reptiles could be similar (Gekkonidae, small Lacertidae) or may even be the same taxa (*Vipera natiensis*, Colubrinae), further discoveries and analyses are needed to definitively establish or reject a relationship among these faunas.

The knowledge on the Pliocene vertebrate fauna from Mallorca has been improved thanks to the discovery of the deposits of NB-1 and CdR (Fig. 5). More species than previously thought arrived to the Balearic Islands during the MSC. At least six mammals and eight reptiles colonized Mallorca at this period. Most of them became extinct during the Pliocene. In Mallorca, just three mammalian species have

been recorded in the later early Pliocene deposits (*Myotragus pepgonellae*, *Hypnomys* sp. and *Nesiotites* sp., Moyà-Solà & Pons-Moyà 1982; Pons-Moyà 1990). Remains of a *Vipera* related to *V. natiensis* (Bailon & Bover unpublished) and of *Podarcis* have been recovered in the late Pliocene deposit of Crulls de Cap Farrutx (in addition to the three mammalian lineages with the species *M. antiquus* Pons-Moyà, 1977, *H. waldreni*, and *N. ponsi* Reumer, 1979).

The presence of a remarkable number of reptiles in the Messinian-early Pliocene fossil record of the Balearic Islands seems to agree with the subtropical climate conditions, as recorded over the Mediterranean area (see Fauquette *et al.* 1999; Jiménez-Moreno *et al.* 2010 and references therein). Although an increase in hypsodonty has been recorded in insular species and it is considered as part of an 'island syndrome' (e.g., Jordana *et al.* 2012) the very hypsodont dentition of *Myotragus palomboi* and the hypsodont and selenodont dentition of *Tragomys macpheei* might point out to the consumption of sclerophyll plants. The amblyodont dentition of the Lacertidae nov. gen. et sp. from CdR could have also been an important selective advantage to feed on particularly hard shell molluscs in the warm and dry climate during the earlier early Pliocene, as the shell of molluscs is known to be harder and wider in arid conditions (Sacchi & Testard 1971).

The absence of carnivores in this fauna leaves the large *Vipera* sp. ('Oriental Vipers Complex'), together with birds of prey, as a main predator for the Mallorcan Pliocene fauna.

REFERENCES

Adrover R, Agustí J, Moyà-Solà S, Pons-Moyà J (1985). Nueva localidad de micromamíferos insulares del Mioceno medio en las proximidades de San Lorenzo en la isla de Mallorca. *Paleontologia i Evolució* **18**, 121–9.

Agustí J (1980). *Hypnomys eliomyoides* n. sp., nuevo glírido (Rodentia, Mammalia) del Pleistoceno de Menorca (Islas Baleares). *Endins* **7**, 49–52.

Agustí, J, Bover P, Alcover JA (2012). A new genus of endemic cricetid (Mammalia, Rodentia) from the late Neogene of Mallorca (Balearic Islands, Spain). *Journal of Vertebrate Paleontology* **32**, 722–6.

Agustí J, Garcés M, Krijgsman W (2006). Evidence for African–Iberian exchanges during the Messinian in the Spanish mammalian record. *Palaeogeography, Palaeoclimatology, Palaeoecology* **238**, 5–14.

Agustí J, Moyà-Solà S (1990). Neogene-Quaternary Mammalian faunas of the Balearics. In: Azzaroli A, ed. *International Symposium "Biogeographical aspects of insularity". Atti dei Convegni dei Lincei* **85**. Accademia Nazionale dei Linzei, Roma, pp. 459–68.

Agustí J, Moyà-Solà S, Pons-Moyà J (1982). Une espèce géante de *Muscardinus* Kaup, 1829 (Gliridae, Rodentia, Mammalia) dans le gisement karstique de Cala Es Pou (Miocène supérieur de Minorque, Baléares). *Geobios* **15**, 783–9.

Alcover JA (1989). Les aus fòssils de la cova de ca na Reia. *Endins* **14–15**, 95–100.

Alcover JA, Agustí J (1985). *Eivissia canarreiensis* n. gen., n. sp., nou glírid del Pleistocè de les Pitiüses. *Endins* **10–11**, 51–6.

Alcover JA, Moyà-Solà S, Pons-Moyà J (1981). *Les quimeres del passat. Els vertebrats fòssils del Plio-Quaternari de les Balears i Pitiüses. Monografies Científiques* **1**. Editorial Moll, Palma de Mallorca.

Augé M (2005). *Evolution des lézards du Paléogène en Europe*. *Mémoires du Muséum National d'Histoire Naturelle* **192**. Publications Scientifiques du Muséum, Paris.

Bailon S (1989). Les Amphibiens et les Reptiles du Pliocène supérieur de Balaruc II (Hérault, France). *Palaeovertebrata* **19**, 7–28.

Bailon S (1991). Les amphibiens et les reptiles du Pliocène et du Quaternaire de France et Espagne: mise en place et évolution des faunes (PhD thesis). Université de Paris-7, Paris, France.

Bailon S (1999). Clés de détermination ostéologique des amphibiens anoures de France. In: Desse J, Desse-Berset N, eds. *Fiches d'ostéologie animale pour l'Archéologie, Série C : varia*. Centre de Recherches Archéologiques-CNRS, Valbonne, pp. 1–38.

Bailon S (2000). Amphibiens et reptiles du Pliocène terminal d'Ahl al Oughlam (Casablanca, Maroc). *Geodiversitas* **22**, 539–58.

Bailon S (2004). Fossil records of Lacertidae in Mediterranean islands: the state of the art. In: Pérez-Mellado V, Riera N, Perera A, eds. *Proceedings of the Fourth International Symposium of the Lacertids of the Mediterranean Basin*. Institut Menorquí d'Estudis, Maó, pp. 37–62.

Bailon S, Hossini S (1990). Les plus ancien Bufonidae (Amphibia, Anura) d'Europe: les espèces du Miocène français. *Annales de Paléontologie (Vertébré-Invertébré)* **76**, 121–32.

Bailon S, Bover P, Quintana J, Alcover JA (2010). First fossil record of *Vipera* Laurenti 1768 "Oriental vipers complex" (Serpentes: Viperidae) from the Early Pliocene of the Western Mediterranean islands. *Comptes Rendus Palevol* **9**, 147–54.

Bailon S, Garcia-Porta J, Quintana J (2002). Première découverte de Viperidae (Reptilia, Serpentes) dans les Îles Baléares (Espagne): des vipères du Néogène de Minorque. Description d'une nouvelle espèce du Pliocène. *Comptes Rendus Palevol* **1**, 227–34.

Bailon S, Quintana J, Garcia Porta J (2005). Primer registro fósil de las familias Gekkonidae (Lacertilia) y Colubridae (Serpentes) en el Plioceno de Punta Nati (Menorca, Islas Baleares). In: Alcover JA, Bover P, eds. *Proceedings of the International Symposium "Insular Vertebrate Evolution: The Palaeontological Approach". Monografies de la Societat d'Història Natural de les Balears* **12**. Societat d'Història Natural de les Balears, Palma de Mallorca, pp. 27–32.

Barahona F, Barbadillo LJ (1997). Identification of some Iberian lacertids using skull characters. *Revista Española de Herpetología* **11**, 47–62.

Barbadillo LJ (1989). Los Reptilia (Sauria y Amphisbaenia) de los yacimientos Plio-Pleistocénicos de la Cuenca de Guadix-Baza. In: Alberdi MT, Bonadonna FB, eds. *Geología y Paleontología de la Cuenca de Guadix-Baza. Trabajos Neogeno/Quaternario* **11**. Museo Nacional de Ciencias Naturales, Madrid, pp. 151–65.

Bate DMA (1914). A gigantic land tortoise from the Pleistocene of Menorca, *Geological Magazine* **6**, 100–7.

Bate DMA (1918). On a new genus of extinct muscardine rodent from the Balearic Islands. *Proceedings of the Zoological Society of London* **1918**, 209–22.

Bizon G, Bizon JJ, Bourrouilh R, Massa D (1973). Présence aux iles Baléares (Méditerranée Occidentale) de sédiments "messiniens" déposés dans une mer ouverte, à salinité normale. *Comptes Rendus de l'Académie des Sciences Naturelles de Paris* **277**, 985–988.

Blain HA (2009). Contribution de la paléoherpétofaune (Amphibia & Squamata) à la connaissance de l'évolution du climat et du paysage du Pliocène supérieur au Pléistocène moyen d'Espagne. *Treballs del Museu de Geologia de Barcelona* **16**, 39–170.

Blain HA, Bailon S (2010). Anfibios y escamosos del Pleistoceno Inferior de Barranco León y de Fuente Nueva 3 (Orce, Andalucía, España). In: Toro I, Martínez-Navarro B, Agustí J, eds. *Ocupaciones humanas en el Pleistoceno Inferior y Medio de la Cuenca de Guadix-Baza*. Junta de Andalucía, Consejería de Cultura, Sevilla, pp. 165–83.

Blain HA, Bailon S, Agustí J (2007). Anurans and squamate reptiles from the final Early Pleistocene of Almenara-Casablanca-3 (Castellón, East of Spain). Systematic, climatic and environmental considerations. *Geodiversitas* **29**, 269–95.

Blain HA, Bailon S, Agustí J (2008). Amphibians and squamate reptiles from the latest early Pleistocene of Cueva Victoria (Murcia, southeastern Spain, SW Mediterranean): Paleobiogeographic and paleoclimatic implications. *Geologica Acta* **6**, 345–61.

Bour R (1985). Una nova tortuga terrestre del Pleistocè d'Eivissa: la tortuga de la cova de ca na Reia. *Endins* **10–11**, 57–62.

Bover P, Alcover JA (2000). La identitat taxonomica de *Myotragus binigausensis* Moyà-Solà i Pons-Moyà 1980. *Endins* **23**, 83–8.

Bover P, Quintana J, Agustí J, Bailon S, Alcover JA (2007). Caló den Rafelino: an early Pliocene site in Mallorca, Western Mediterranean. In: *Libro de resúmenes del VII Simposio Internacional de Zoología*. Topes de Collantes, Sancti Spiritus, Cuba, pp. 119.

669 Bover P, Quintana J, Alcover JA (2008). Three islands, three worlds: Paleogeography
670 and evolution of the vertebrate fauna from the Balearic Islands. *Quaternary*
671 *International* **182**, 135–44.
672 Bover P, Quintana J, Alcover JA (2010). A new species of *Myotragus* Bate, 1909
673 (Artyodactyla, Caprinae) from the Early Pliocene of Mallorca (Balearic
674 Islands, western Mediterranean). *Geological Magazine* **147**, 871–85.
675 Clauzon G, Suc JP, Gautier F, Berger A, Loutre MF (1996). Alternate interpretation
676 of the Messinian salinity crisis: controversy resolved? *Geology* **24**, 363–6.
677 Delfino M, Bailon S, Pitruzzella G (2011). The Late Pliocene amphibians and reptiles
678 from "Capo Mannu D1 Local Fauna" (Mandriola, Sardinia, Italy).
679 *Geodiversitas* **33**, 357–82.
680 Estes R (1983). Sauria terrestria, Amphisbaenia. In: Kuhn O, Wellnhofer P, eds.
681 *Handbuch der Paläoherpetologie 10A*. G. Fischer Verlag, Stuttgart & New
682 York, pp. 1–249.
683 Fauquette S, Suc JP, Guiot J, *et al.* (1999). Climate and biomes in the West
684 Mediterranean area during the Pliocene. *Palaeogeography,*
685 *Palaeoclimatology, Palaeoecology* **152**, 15–36.
686 Florit X, Mourer-Chauviré C, Alcover JA (1989). Els ocells pleistocènics d'es Pouàs,
687 Eivissa. Nota preliminar. *Butlletí de la Institució Catalana d'Història Natural*
688 *(Secció Geologia 5)* **56**, 35–46.
689 Garcia-Porta J, Quintana J, Bailon S (2002). Primer hallazgo de *Blanus* sp
690 (Amphisbaenia, Reptilia) en el Neógeno balear. *Revista Española de*
691 *Herpetología* **16**, 19–28.
692 Gasc JP, Cabela A, Crnobrnja-Isailovic J, *et al.* (1997). *Atlas of amphibians and*
693 *reptiles in Europe*. *Collection Patrimoines Naturels* **29**. Societas Europaea

Herpetologica, Muséum National d'Histoire Naturelle & Service du Patrimone Naturel, Paris.

Gautier F, Clauzon G, Suc JP, Cravatte J, Violantini D (1994). Âge et durée de la crise de salinité messinienne. *Comptes Rendus de l'Académie des Sciences Naturelles de Paris, Serie II* **318**, 1103–9.

Gibbard PL, Head MJ, Walker MJC, The Subcomission on Quaternary Stratigraphy (2010). Formal ratification of the Quaternary System/Period and the Pleistocene Series/Epoch with a base at 2.58 Ma. *Journal of Quaternary Science* **25**, 96–102.

Gómez-Pujol L, Balaguer P, Fornós JJ (2007). El litoral de Mallorca: síntesis geomórfica. In: Fornós JJ, Ginés J, Gómez-Pujol L, eds. *Geomorfología litoral: Migjorn y Llevant de Mallorca*. *Monografies de la Societat d'Història Natural de les Balears* **15**. Societat d'Història Natural de les Balears, Palma de Mallorca, pp. 39–59.

Gràcia F, Clamor B, Lavergne JJ (2000). Les coves de cala Varques (Manacor, Mallorca). *Endins* **23**, 41–57.

Gràcia F, Watkinson P, Monserrat T, Clarke O, Landreth R (1997). Les coves de la zona de Ses Partions (Felanitx, Mallorca). *Endins* **21**, 5–36.

Hemmer H, Kadel B, Kadel K (1981). The Balearic toad (*Bufo viridis balearicus* (Boettger, 1881)), human Bronze Age culture, and Mediterranean biogeography. *Amphibia-Reptilia* **2**, 217–30.

Jiménez-Moreno G, Fauquette S, Suc JP (2010). Miocene to Pliocene vegetation reconstruction and climate estimates in the Iberian Peninsula from pollen data. *Review of Palaeobotany and Palynology* **162**, 403–15.

718 Jordana X, Marín-Moratalla N, DeMiguel D, Kaiser TM, Köhler M (2012). Evidence
719 of correlated evolution of hypsodonty and exceptional longevity in endemic
720 insular mammals. *Proceedings of the Royal Society B* **279**, 3339–3346.
721 Kotsakis T (1981). La lucertole (Lacertidae, Squamata) del Pliocene, Pleistocene e
722 Olocene delle baleari. *Bolletí de la Societat d'Història Natural de les Balears*
723 **25**, 135–50.
724 Krijgsman W, Hilgen FJ, Raffi I, Sierro FJ, Wilson DS (1999). Chronology, causes
725 and progression of the Messinian Salinity Crisis. *Nature* **400**, 652–5.
726 McDowell SB (1987). Systematics. In: Seigel RA, Collins JT, Novak SS, eds. *Snakes:*
727 *ecology and evolutionary biology.* Macmillan, New York, pp. 3–50.
728 Mein P, Adrover R (1982). Une faunule de mammifères insulaires dans el Miocène
729 moyen de Majorque (Îles Baléares). *Geobios Mémoire Spécial* **6**, 451–63.
730 Moyà-Solà S, Pons-Moyà J (1982). *Myotragus pepgonellae* nov. sp., un primitivo
731 representante del género *Myotragus* Bate, 1909 (Bovidae, Mammalia) en la
732 isla de Mallorca (Baleares). *Acta Geologica Hispanica* **17**, 77–87.
733 Moyà-Solà S, Köhler M, Alba D, Pons-Moyà J (2007). El significado de *Myotragus*
734 *batei y M. binigausensis* en la evolución del género *Myotragus* (Bovidae,
735 Mammalia) en las Islas Baleares. In: Pons GX, Vicens D, eds. *Geomorfologia*
736 *Litoral i Quaternari. Homenatge a Joan Cuerda Barceló*. *Monografies de la*
737 *Societat d'Historia Natural de les Balears*, **14**. SHNB, Palma de Mallorca, pp.
738 155–80.
739 Moyà-Solà S, Pons-Moyà J, Alcover JA, Agustí J (1984). La fauna de vertebrados
740 neógeno-cuaternaria de Eivissa (Pitiuses). Nota preliminar. *Acta Geologica*
741 *Hispanica* **19**, 33–5.

Moyà-Solà S, Quintana J, Alcover JA, Köhler M (1999). Endemic island faunas of the Mediterranean Miocene. In: Rössner GE, Heissig K, eds. *The Miocene land mammals of Europe*. Pfeil, Munchen, pp. 435–42.

Pinya S, Carretero MA (2011). The Balearic herpetofauna: a species update and a review on the evidence. *Acta Herpetologica* **6**, 59–80.

Pomar L, Rodríguez-Perea A, Sabat F, Fornós JJ (1990). Neogene stratigraphy of Mallorca Island. *Paleontologia i Evolució* **2**, 271–320.

Pons-Monjo G, Moyà-Solà S, Furió M (2012). New data on the origin of *Nesiotites* (Soricidae, Mammalia) in Menorca (Balearic Islands, Spain). *Comptes Rendus Palevol* **11**, 393–401.

Pons-Moyà J (1990). Estratigrafía y fauna del yacimiento kárstico de Cala Morlanda (Manacor, Mallorca). *Endins* **16**, 59–62.

Pons-Moyà, J, Moyà-Solà S, Alcover JA, Agustí J (1981). La fauna de Mamíferos de los yacimientos menorquines con *Geochelone gymnesica* (Bate, 1914). *Acta Geologica Hispanica* **16**, 129–30.

Quintana J (1998). Aproximación a los yacimientos de vertebrados del Mio-Pleistoceno de la isla de Menorca. *Bolletí de la Societat d'Història Natural de les Balears* **41**, 101–17.

Quintana J, Agustí J (2007). Los mamíferos insulares del Mioceno medio y superior de Menorca (islas Baleares, Mediterráneo occidental). *Geobios* **40**, 677–87.

Quintana J, Alcover JA, Moyà-Solà S, Sanchiz B (2005). Presence of *Latonia* (Anura, Discoglosidae) in the Insular Pliocene of Minorca (Balearic Islands). In: Alcover JA, Bover P, eds. *Proceedings of the International Symposium "Insular Vertebrate Evolution: The Palaeontological Approach"*.

Monografies de la Societat d'Història Natural de les Balears **12**. Societat d'Història Natural de les Balears, Palma de Mallorca, pp. 293–6.

Quintana J, Bover P, Alcover JA, Agustí J, Bailon S (2010). Presence of *Hypolagus* Dice, 1917 (Mammalia, Lagomorpha) in the Neogene of the Balearic Islands (Western Mediterranean): Description of *Hypolagus balearicus* nov. sp. *Geobios* **43**, 555–67.

Quintana J, Moyà-Solà S, Köhler M (2011). *Nuralagus rex*, gen. et sp. nov., an endemic insular giant rabbit from the Neogene of Minorca (Balearic Islands, Spain). *Journal of Vertebrate Paleontology* **31**, 231–40.

Rage JC (1984). *Serpentes. Handbuch der Paläoherpetologie, Part II*. Gustav Fischer Verlag, Stuttgart - NewYork.

Reumer JWF (1979). On two new micromammals from the Pleistocene of Mallorca. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Series B* **82**, 473–82.

Reumer JWF (1981). The Pleistocene small mammals from Sa Pedrera de S´Ònix, Majorca (Gliridae, Soricidae). *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Series B* **84**, 3–11.

Reumer JWF (1982). Some remarks on the fossil vertebrates from Menorca, Spain. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Series B* **85**, 77–87.

Roček Z (1984). Lizards (Reptilia: Sauria) from the lower Miocene locality Dolnice (Bohemia, Czechoslovakia). *Rozpravy Ceskoslovenske akademie ved Rada Matematickych a Prirodnich* **94**, 1–69.

789 Rofes J, Bover P, Cuenca-Bescós G, Alcover JA (2012). *Nesiotites rafelinensis* sp.
790 nov., the earliest shrew (Mammalia, Soricidae) from the Balearic Islands,
791 Spain. *Palaeontologia Electronica* **15**, 8A.
792 Sacchi CF, Testard P (1971). *Ecologie animale*. Doin, Paris.
793 Sanchiz B (1977). La Familia Bufonidae (Amphibia, Anura) en el Terciario Europeo.
794 *Trabajos Neogeno/Quaternario* **8**, 75–111.
795 Seguí B (1998). Els ocells fòssils de Mallorca i Menorca. Successió estratigràfica
796 d'aus en els rebliments càrstics de les Gimnèsies (PhD thesis). Universitat de
797 les Illes Balears, Palma de Mallorca, Spain.
798 Seguí B (1999). A late Tertiary woodcock from Minorca, Balearic Islands, Western
799 Mediterranean. *Condor* **101**, 909–15.
800 Seguí B (2002). A new genus of crane (Aves: Gruiformes) from the late Tertiary of
801 the Balearic Islands, Western Mediterranean. *Ibis* **144**, 411–22.
802 Seguí B, Quintana J, Fornós JJ, Alcover JA (2001). A new fulmarine petrel (Aves:
803 Procellariiformes) from the upper Miocene of the Western Mediterranean.
804 *Palaeontology* **44**, 933–48.
805 Szyndlar Z (1991). A review of Neogene and Quaternary snakes of Central and
806 Eastern Europe. Part I: Scolecophidia, Boidae, Colubrinae. *Estudios*
807 *Geológicos* **47**, 103–26.
808 Szyndlar Z, Rage JC (1999). Oldest fossil vipers (Serpentes: Viperidae) from the old
809 World. *Kaupia* **8**, 9–20.
810 van der Made J, Morales J, Montoya P (2006). Late Miocene turnover in the Spanish
811 mammal record in relation to palaeoclimate and the Messinian salinity crisis.
812 *Palaeogeography, Palaeoclimatology, Palaeoecology* **238**, 228–46.

Vidal N, Rage JC, Couloux A, Hedges SB (2009). Snakes (Serpentes). In: Hedges SB, Kumar S, eds. *The Timetree of Life*. Oxford University Press, Oxford, pp. 390–7.

FIGURE LEGENDS

Figure 1 Map and location (top) of the late Miocene/early Pliocene interval deposits presented in this paper and Pliocene Balearic deposits mentioned in the text: (a) View of the Na Burguesa-1 (NB-1) deposit. (b) View of the Caló den Rafelino (CdR) deposit. Abbreviations: CdR = Caló den Rafelino, CF = Crull de Cap Farrutx, CM = Cala Morlanda, NB-1 = Na Burguesa-1, PN = Punta Nati, SF = Ses Fontanelles.

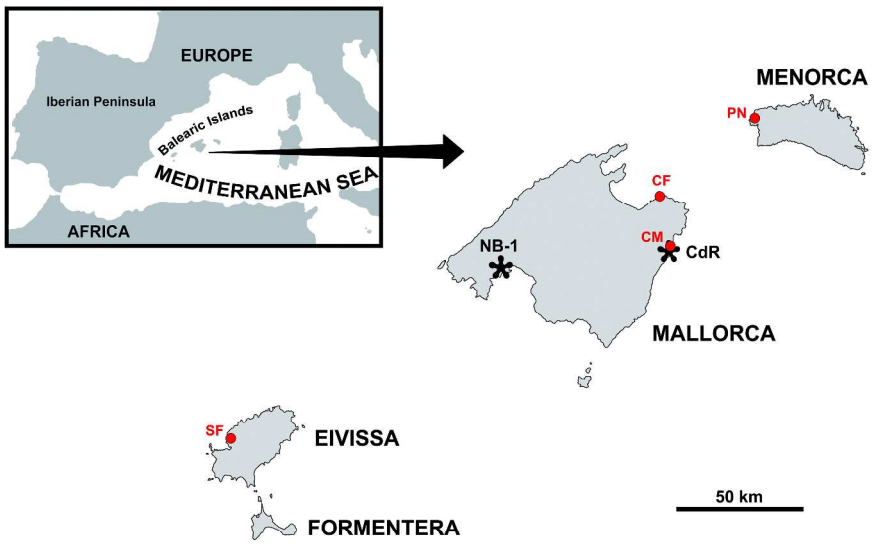
Figure 2 Several reptiles from the Mallorcan late Miocene/early Pliocene deposits: (a-c) Dorsal vertebra of *Dopasia* sp. from CdR (IMEDEA 90115) in dorsal (a), anterior (b) and ventral (c) views: (d) Osteoderm in dorsal view *Dopasia* sp. from NB-1: (e-f) Dorsal vertebra of Scolecophidia from NB-1 in dorsal (e) and ventral (f) views: (g) Right dentary of Scindidae cf. *Chalcides* from NB-1 in medial view. Scale bars equal 1 mm.

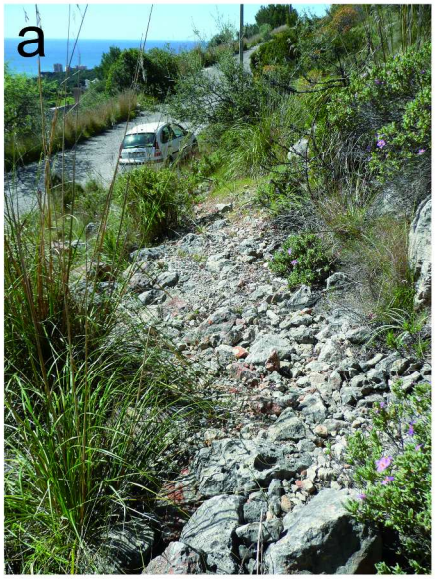
Figure 3 Mammalian species obtained in NB-1: (a) Soricinae indet., jaw, lingual view, (b) Cricetinae indet., jaw, lingual view, (c) Muridae indet., jaw, lingual view, (d) *Eliomys*/*Hypnomys*, jaw, lingual view, (e) cf. *Hypolagus*, femur, frontal view, (f) cf. *Myotragus*, proximal epiphysis of a right femur, frontal view. Scale bars equal 1 cm.

Figure 4 Occlusal view of the two teeth of *Hypnomys* sp. retrieved from the Caló den Rafelino (CdR) deposit: (a) IMEDEA 90622, left m1, (b) IMEDEA 90623, left M1. Scale bar equals 1 mm.

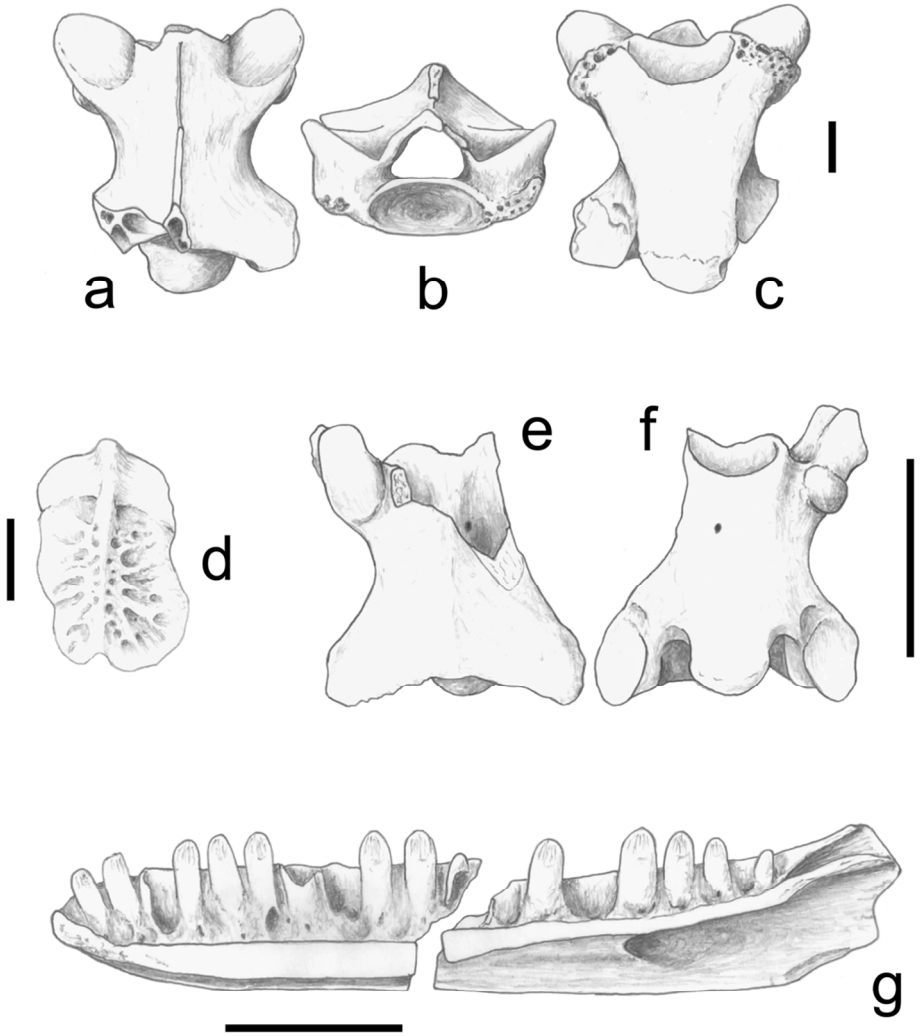
Figure 5 Diagram of the late Miocene/early Pliocene to Holocene vertebrate terrestrial fauna from the Balearic Islands. (*) The taxonomical identity of the described species from Menorca *Myotragus binigausensis* Moyà-Solà & Pons-Moyà, 1980, *Hypnomys eliomyoides* Agustí, 1980 and *Nesiotites meloussae* Pons-Moyà & Moyà-Solà, 1980 is unclear and it is under discussion (Reumer 1982; Bover &

Alcover 2000; Moyà-Solà *et al.* 2007; Pons-Monjo *et al.* 2012). Here we consider these species as being synonymous of the Mallorcan coetaneous taxa, following Bover *et al.* (2008). Gray arrows indicate contacts between Mallorca and Menorca during Quaternary glaciations.

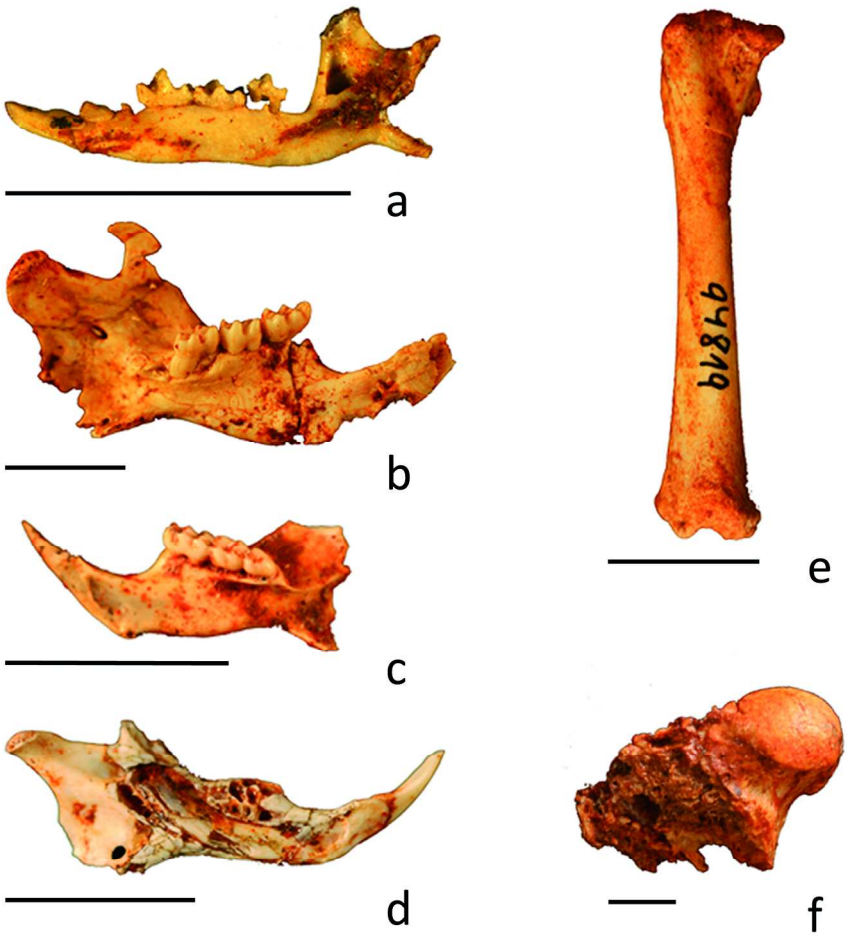

EUROPE
Iberian Peninsula
Balearic Islands
MEDITERRANEAN SEA
AFRICA
MENORCA
PN
CF
CM
CdR
NB-1
MALLORCA
SF
EIVISSA
FORMENTERA
50 km

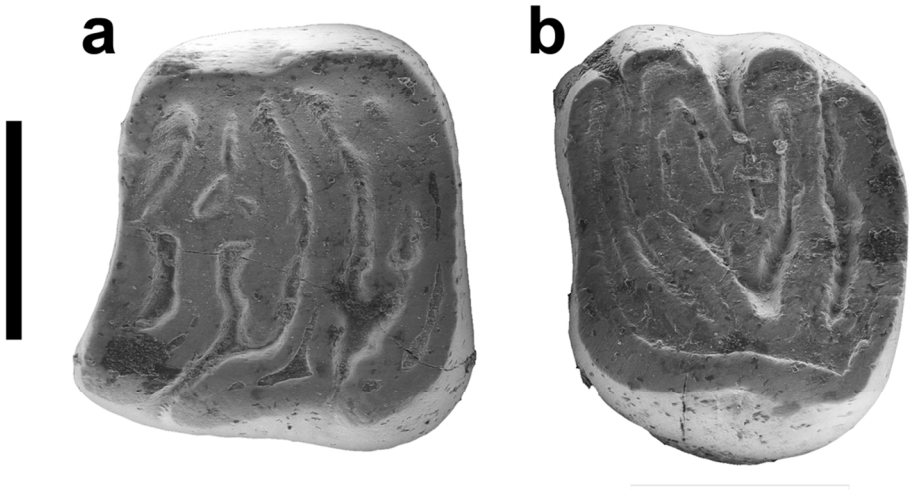

a


b

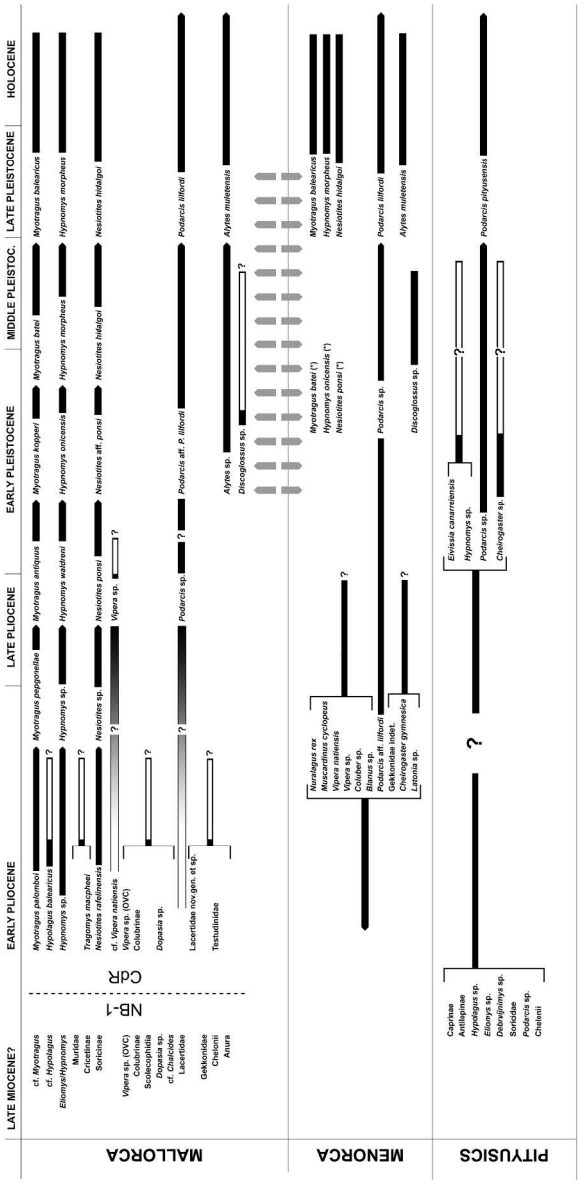


109x122mm (300 x 300 DPI)


a
b
c
d
e
f



109x54mm (300 x 300 DPI)



322x618mm (300 x 300 DPI)