

Original article

# Systematics, biostratigraphy and evolutionary pattern of the Oligo-Miocene marine mammals from the Maltese Islands<sup>☆</sup>

*Systématique, biostratigraphie et évolution des mammifères marins de l'Oligo-Miocène des îles maltaises*

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## Abstract

An overview of the upper Oligocene-upper Miocene marine sediments outcropping in the Maltese Islands provides a detailed stratigraphical setting of several marine mammal assemblages. The studied fossil material collected within the entire sequence, is now kept in the National Museum of Natural History of Mdina (Malta). Nannoplankton analysis of some selected sections, where mammal remains have been discovered, is also undertaken. The fossil marine mammals, consisting mostly of isolated ear bones and teeth, are referred to cetaceans (both mysticetes and odontocetes), sirenians, and pinnipeds. The cetacean record evidences an evolutionary pattern that agrees with the Oligo-Miocene general trend, characterized by the progressive rarefaction and disappearance of archaic families (squalodontids, waipatiids, and, maybe, mammalodontids), and by the appearance and diversification of the extant families represented within younger strata (kogiids, pontoporiids and ziphiids). Pontoporiids, waipatiids, and tentatively mammalodontids are here reported for the first time in the Mediterranean, while the kogiid record represents the only sure Miocene evidence of this family in the Mediterranean. The geographical distribution of the mammalodontids and the waipatiids, based on the Maltese and extra-Mediterranean records, supports an open communication between the Proto-Mediterranean and the Indo-Pacific during the late Oligocene. Sirenians are represented by several dugongid pachyosteosclerotic rib fragments, collected from upper Oligocene through upper Miocene sediments. Pinnipeds are represented by a femur fragment from the Serravallian, referred to an indeterminate monachine, a phocid subfamily already reported from the Mio-Pliocene of the Mediterranean.

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**Keywords:** Malta; Oligocene; Miocene; Cetacea; Sirenia; Pinnipedia

## Résumé

Une vue d'ensemble des sédiments marins de l'Oligocène supérieur-Miocène supérieur affleurant dans les îles maltaises, complétée par une analyse du nannoplancton de quelques coupes sélectionnées, fournit un cadre stratigraphique détaillé pour plusieurs assemblages de mammifères marins, connus sur la base de restes fossiles collectés tout au long de la séquence et conservés au Muséum National d'Histoire Naturelle de Mdina (Malte). Les restes de mammifères marins, consistant principalement en os de l'oreille et dents isolés, sont rapportés aux cétacés (mysticètes et odontocètes), siréniens et pinnipèdes. Le registre des cétacés montre une évolution des faunes en accord avec la tendance générale pour l'Oligo-Miocène, caractérisée par la rarefaction progressive et la disparition des familles archaïques (squalodontidés, waipatiidés et, peut-être,

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mammalodontidés) et par l'apparition et l'augmentation de la diversité des familles modernes, présentes dans les strates les plus récentes (kogiidés, pontoporiidés et ziphiidés). Les signalements de pontoporiidés, mammalodontidés et waipatiidés sont les premiers pour la Méditerranée, alors que l'identification d'un kogiidé est la seule preuve tangible de la présence de cette famille dans le Miocène de Méditerranée. Sur la base des identifications maltaises et extra-méditerranéennes, la distribution géographique des mammalodontidés et des waipatiidés soutient l'hypothèse d'une voie de communication entre la Proto-Méditerranée et la région indo-pacifique au cours de l'Oligocène supérieur. Le registre des siréniens consiste principalement en plusieurs fragments de côtes pachyostéosclosées de dugongidé, collectées en continu dans les sédiments de l'Oligocène supérieur au Miocène supérieur. Les pinnipèdes sont représentés par un fragment de fémur, daté du Serravallien, rapporté à un monachiné indéterminé, une sous-famille de phocidés déjà signalée dans le Mio-Pliocène de Méditerranée.

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*Mots clés* : Malte ; Oligocène ; Miocène ; Cétacé ; Sirénien ; Pinnipède

## 1. Introduction

The Maltese archipelago, situated in the central Mediterranean about 90 km south of Sicily and 300 km east of Tunisia, is composed of a mid-Cenozoic succession of marine limestones and marls which range in age from the late Oligocene to the late Miocene. Superficial terrestrial Quaternary deposits of Pleistocene to Holocene age also occur (Jacobs et al., 1996; Foresi et al., 2002, 2008; John et al., 2003; Föllmi et al., 2007).

In the marine sediments, both invertebrate and vertebrate remains are relatively frequent and marine mammals, here described, have been discovered in more or less all the stratigraphical levels of the lithological sequence (Gatt, 2006a, 2006b). Previous works on these fossil marine mammals include the famous “*La vana speculazione disingannata dal senso*” where the Italian Agostino Scilla described and illustrated for the first time in the history of science a fossil whale (Scilla, 1670). This specimen, consisting of a mandible fragment with three teeth *in situ*, which probably came from one of the phosphorite conglomerate beds within the Globigerina Limestone Formation, is still preserved in the Woodwardian collection at the Sedgwick Museum in Cambridge, England. Originally referred to a seal (*Phocodon scillae* Agassiz, 1841), this fossil was rightly assigned to a squalodontid odontocete in most of the successive works (Fabiani, 1949; Rothausen, 1968).

Other works on Maltese fossil marine mammals were published in the second half of the 19<sup>th</sup> Century (Adams, 1866, 1870, 1879; Lydekker, 1887; Cooke, 1892a, 1892b, 1893, 1895). The fossils examined by these authors consisted of fragmentary and generally undiagnostic remains: cetacean specimens were referred to *Delphinus*, *Hoplocetus* and *Zeuglodon*; sirenian specimens to *Halitherium*; while pinniped specimens were referred to *Phoca* and some of them to the new species *Phoca rugosidens* Owen (in Adams, 1879). Other fragmentary cetacean remains were described more recently by Menesini (1972): an isolated tooth attributed to *Squalodon* sp. and a fragmentary periotic and tympanic bulla assigned tentatively to odontocetes. The latter mentioned ear bone remains were respectively referred to a possible kentriodontid and to an indeterminate ziphiid by Bianucci and Landini (2002). Fragmentary sirenian remains were also recorded by Zammit-Maempel (1982) and an indeterminate fossil pinniped was recorded but not described by Koretsky (2001). More recently, an overall history and stratigraphic distribution of

Maltese Cenozoic mammals, including new records of marine mammals, was discussed by Gatt (2006a, 2006b).

The aim of this work is to describe specimens of Maltese fossil marine mammals kept in the collections of the National Museum of Natural History of Malta. Unlike the case of previously published material, the stratigraphical provenance of most of these fossils is well known and reported below. Although these fossils are all represented by fragmentary remains (mainly ear bones, teeth and ribs), they provide general but important information on the structure of the fossil marine mammal fauna from the southern Mediterranean Basin and its evolution spanning from the late Oligocene to the late Miocene.

## 2. Material and methods

### 2.1. Marine mammal specimens

All Maltese fossil marine mammals here described are kept in the collections of the National Museum of Natural History, Malta; most have been recently collected and donated to the Museum by the Maltese authors contributing to the present work. Other fossil marine mammals collected in the past from the Maltese Islands and kept in the Natural History Museum of London, were examined for comparison but not described in detail in this work, since their exact stratigraphical provenance is unknown.

**Institutional acronyms:** IGF, Museo di Geologia e Paleontologia, Università di Firenze, Italy; KÜH, Krahuletz Museum, Eggenburg collection, Eggenburg, Austria; MGPUP, Museo di Geologia e Paleontologia, Università di Padova, Italy; NHM, Natural History Museum, London, England; NMNH, National Museum of Natural History, Mdina, Malta; NMV P, Museum Victoria Palaeontology Collection, Melbourne, Australia.

### 2.2. Calcareous nannofossil analysis

Eight sections in the upper part of the Maltese stratigraphical sequence were sampled in order to analyse their calcareous nannofossils and to obtain a relative age of the fossils found in these sediments (Table S1). Matrix adhering to some important specimens (part of the old collections at the National Museum of Natural History, Mdina), were analysed for calcareous nannofossils to determine their stratigraphic position (Tables S2 and S3).

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