

Chemosymbiotic bivalves from Miocene methane-seep carbonates in Italy

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Abstract.—Eleven species of chemosymbiotic bivalves are reported from middle to late Miocene methane seep deposits ('Calcarei a *Lucina*') in the Italian Apennines, including seven new species and one new genus. The new species are *Bathymodiolus* (s.l.) *moroniae* and *B.* (s.l.) *miomediterraneus* among the Bathymodiolinae and *Archivesica aharoni*, *A. apenninica*, *A. strigarum*, and '*Pliocardia*' *italica* among the Vesicomylidae; specimens from the middle Miocene of Deruta are reported as *Archivesica* aff. *aharoni*. *Samiolus iohannesbaptistae* new genus new species is introduced for an unusual mytilid with a commarginally ribbed surface, which might be the first non-bathymodiolin mytilid obligate to the seep environment. The two large lucinid species from which these deposits derived their informal name 'Calcarei a *Lucina*' are identified as *Meganodontia hoernea* (Des Moulins, 1868) and *Lucinoma perusina* (Sacco, 1901). With *Chanellaxinus* sp., we report the first thyasirid from a Neogene deep-water seep deposit in Italy and the first fossil occurrence of this genus.

Introduction

Limestone deposits yielding large lucinid bivalves have been known for centuries from the Miocene deposits in Italy, and were termed 'Calcarei a *Lucina*' (Manzoni, 1876; Coppi, 1877; Scabelli, 1880; Sacco, 1901; Di Stefano, 1903). Due to their isolated occurrence in deep-water sediments and the large bivalves preserved in them, they were considered to have been transported from shallow water (Ricci Lucchi and Veggiani, 1967). This view changed after the first discovery of faunal communities at methane seeps in the deep Gulf of Mexico with similarly large bivalves (Paull et al., 1984) and the recognition that methane seep carbonates can be identified based on their distinctive, light carbon isotope signature (Hovland et al., 1987). The 'Calcarei a *Lucina*' deposits throughout Italy are now considered as ancient deep-water methane seep deposits (Clari et al., 1988; Conti et al., 1993; Terzi, 1993; Aharon and Sen Gupta, 1994; Berti et al., 1994; Ricci Lucchi and Vai, 1994; Taviani, 1994; Terzi et al., 1994; Peckmann et al., 1999; Clari et al., 2004b; Conti et al., 2004, 2010). Despite this wealth of geologic literature on these deposits, modern studies on the macrofauna are relatively rare (Moroni, 1966; Taviani, 1994, 2011, 2014; Taviani et al., 2011). The purpose of the present contribution is to provide a revision of the major taxa of chemosymbiotic bivalves of the 'Calcarei a *Lucina*' deposits, with exclusion of solemyids.

Materials and methods

Specimens were coated with ammonium chloride for photography. The material is from twelve seep deposits of middle to late Miocene age (Fig. 1) associated with deep-water hemipelagic marls or turbidites, mostly ascribed to the Marnoso-arenacea

Formation. Their geological and stratigraphic context is described in various publications (Vai et al., 1997; Conti and Fontana, 1999; Clari et al., 2004b; Taviani, 2011). A short description of the localities is provided in the Appendix.

Repositories and institutional abbreviations.—MGGC: Museo Geologico Giovanni Capellini, University of Bologna; MSF: Museo Civico di Scienze Naturali, Faenza; MZB: Museo dell'Evoluzione (formerly Zoologia), University of Bologna; MRSN: Museo Regionale di Scienze Naturali, Torino (managing the Bellardi and Sacco collection, property of the Turin University).

Systematic paleontology

Class Bivalvia Linnaeus, 1758
Subclass Pteriomorpha Beurlen, 1944
Order Mytilida Férussac, 1822
Family Mytilidae Rafinesque, 1815
Genus *Bathymodiolus* Kenk and Wilson, 1985

Type species.—*Bathymodiolus thermophilus* Kenk and Wilson, 1985, Recent, Galapagos Rift Zone, by original designation.

Remarks.—Molecular phylogenetic studies have shown that species currently classified as *Bathymodiolus* belong to at least two clades within the bathymodiolins (Gustafson et al., 1998; Jones et al., 2006; Lorion et al., 2010, 2013; Thubaut et al., 2013), of which those related to *B. childressi* may be placed in a separate genus. This species group is often referred to as the '*childressi* clade' and it is recommended to use "*Bathymodiolus*" only in quotation marks for these species until the taxonomic uncertainties