



Barnea (Anchomasa) parva (Pennant, 1777) (Pholadidae, Bivalvia) in the Pleistocene sediments of northern Latium (central Italy)

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KEY WORDS - *Pholadidae, Systematics, Biogeography, Palaeoecology, Mediterranean Sea, Pleistocene.*

ABSTRACT - The study considers the occurrence of *Barnea (Anchomasa) parva* (Pennant, 1777) in a Pleistocene deposit cropping out in the Tarquinia area (northern Latium, Italy) and ascribed to the Marine Isotope Stage 7 (MIS 7). The finding represents the first quotation of the species in the Pleistocene and also in the fossil record of the Mediterranean region. The systematics, ecology and biogeographical distribution of *B. (A.) parva* are discussed in detail. The present-day distribution of *B. (A.) parva* is characterised by its highest frequency in the Boreal and northern Lusitanian regions decreasing progressively towards lower latitudes. The planktonic stage of the larval development, the adaptation to a wide variety of substrata and the absence of evident geographical barriers suggest that the seawater temperature is one of the most important factors limiting the southward dispersal of the species. The palaeoecological analysis of the associated mollusc fauna revealed that the deposit formed in the upper part of the infralittoral zone, which is consistent with the ecological data known for *B. (A.) parva*. That consistency and the good state of preservation of the specimens strongly suggest that they probably underwent only limited displacement, allowing the extraction of the valves from their borings.

All the above suggests that the occurrence of *B. (A.) parva* in Pleistocene proximal sediments of the Tarquinia area would correspond to an event of dispersal during a time relatively cooler than today. However, the MIS 7 was, in general, a warm stage having maximum temperatures slightly higher than today. The available data are insufficient to clear up that contradiction. As a matter of speculation, one can presume that the species reached the Tarquinia area during the rise of temperatures at the beginning of MIS 7 or during one of its stadial-interstadial transitions.

RIASSUNTO - [*Barnea (Anchomasa) parva* (Pennant, 1777) (Pholadidae, Bivalvia) nei sedimenti pleistocenici del Lazio settentrionale (Italia centrale)] - Il lavoro analizza il ritrovamento di *Barnea (Anchomasa) parva* (Pennant, 1777), specie tipo del sottogenere *B. (Anchomasa)* Leach, 1872, in un deposito pleistocenico affiorante nei dintorni di Tarquinia (Lazio settentrionale) attribuito dagli autori (Bartolini et al., 1984) allo Stadio Isotopico Marino 7 (MIS 7). Per comprendere il significato di tale ritrovamento, sono state esaminate in dettaglio la sistematica, la documentazione fossile, l'ecologia e la distribuzione biogeografica della specie.

La distribuzione attuale di *B. (A.) parva* è concentrata lungo le coste atlantiche dell'Inghilterra e della Francia. La frequenza della specie diminuisce bruscamente nella parte meridionale della regione lusitanica. Nel Mediterraneo, la specie è stata documentata soltanto in una località delle coste dell'Algeria (Pallary, 1900). Per quanto riguarda l'ecologia, *B. (A.) parva* è un filtratore perforante substrati di varia natura e durezza, comprendenti argille compatte, arenarie, sedimenti organici e, raramente, anche resti di legno in decomposizione. La specie vive a profondità che non superano poche decine di metri e sviluppa uno stadio planctonico, seppur breve, durante la crescita larvale. Allo stato fossile, *B. (A.) parva* è nota in sedimenti del Pliocene Inferiore e Medio del Belgio, nel Pliocene Medio dell'Olanda e nel Pliocene Medio e Superiore dell'Inghilterra. Il suo ritrovamento nel Pleistocene del Lazio settentrionale rappresenta, quindi, la prima segnalazione della specie nella documentazione fossile concernente l'area mediterranea e, più in generale, in sedimenti di tale intervallo. La presenza di una fase larvale planctonica, la capacità di adattamento ad un ampio spettro di substrati e l'assenza di evidenti barriere geografiche che ne limitano l'attuale distribuzione sembrano indicare una certa sensibilità della specie alla temperatura come elemento principale di contrasto alla sua dispersione verso sud.

L'analisi del campione da cui provengono gli esemplari di *B. (A.) parva* ha permesso di riconoscere 34 specie di molluschi, tutti oggi viventi nelle comunità dell'area mediterranea. L'analisi bionomica ha evidenziato la chiara dominanza di specie appartenenti a biocenosi di SGCF e di fondi vegetati, e l'elevata frequenza di specie comuni in aree subcostiere. Unitamente alle informazioni sedimentologiche e di facies disponibili, l'analisi paleoecologica indica che il deposito si è formato in una depressione del substrato nella parte alta del piano infralittorale. Questa interpretazione è conforme a quanto noto sull'ecologia di *B. (A.) parva*. Viene, quindi, escluso un consistente trasporto o la rielaborazione degli esemplari, come anche testimoniato dall'ottimo stato di conservazione del materiale, sebbene sia molto probabile un relativo spiazzamento.

Nel complesso dei dati suesposti, la presenza di *B. (A.) parva* nei sedimenti pleistocenici prossimali di Tarquinia, un'area molto distante dal limite della distribuzione attuale e molto più meridionale rispetto alla sua zona focale, potrebbe corrispondere ad un evento di dispersione durante una fase climatica relativamente più fredda rispetto alle condizioni attuali. Tuttavia, tale interpretazione contrasta con il carattere climatico noto per il MIS 7, uno stadio caldo nel suo complesso, sebbene piuttosto articolato, con temperature massime leggermente più elevate di quelle attuali. I dati disponibili non consentono di risolvere tale contraddizione. Si può presumere, in via del tutto ipotetica, che la specie abbia raggiunto l'area tirrenica centrale durante la risalita delle temperature all'inizio del MIS 7 oppure durante uno dei passaggi stadiale-interstadiale noti per tale stadio.

INTRODUCTION

During the 1980's, the Pleistocene deposits of northern Latium and southern Tuscany (central Italy) were the subjects of intensive studies (see references in Bosi et al., 1990; Messina et al., 1990) directed to investigate the coastline changes in Pleistocene times. In some of

these studies (e.g. Bartolini & Bosi, 1983), M.A. Conti (Department of Earth Sciences, University "La Sapienza", Rome, Italy) contributed to the palaeoecological analysis of some outcrops. She also made supplementary samplings. The macrobenthonic content of some of those samples was recently re-analysed. This resulted in the identification of specimens of *Barnea (Anchomasa)*

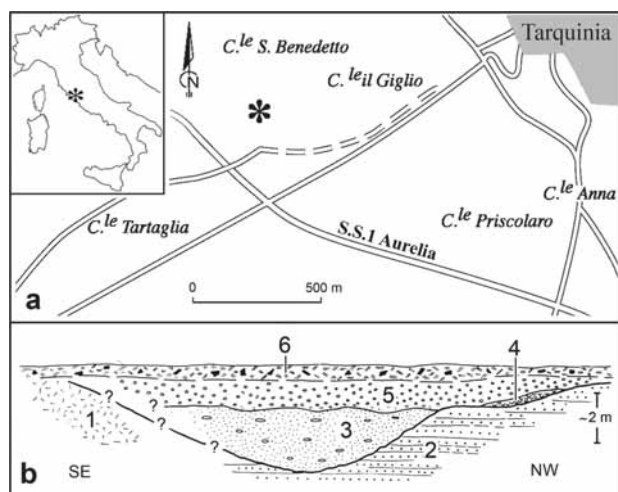


Fig. 1 - Geographical location and stratigraphical setting of the Giglio section. a - Map showing the geographical location of the outcrop (now inaccessible). b - stratigraphical section (from Bartolini & Bosi, 1983, fig. 4). 1) Pliocene bedrock, 2) pumices, 3) pebbly-sand, 4) coarse grained sandstone, 5) loam with sedimentary and volcanic gravels, 6) soil. The material studied here comes from Bed 3.

parva (Pennant, 1777), type species of the subgenus *Barnea* (*Anchomasa*) Leach, 1852. Today, the species mainly lives in the Lusitanian and Boreal areas (Fig. 4). The finding in the Tarquinia area testifies that, during the Pleistocene, *B. (A.) parva* reached the eastern coasts of the Tyrrhenian Sea.

GEOGRAPHICAL AND STRATIGRAPHICAL SETTING

The specimens of *B. (A.) parva*, were found in Bed 3 of the "Giglio" section of Bartolini & Bosi (1983), SW of the town of Tarquinia (northern Latium, Italy; Fig. 1), 28 m above sea level. The section, which was exposed along a small artificial escarpment, no longer crops out.

According to Bartolini & Bosi (1983) Bed 3 consists of a pebbly sand, which lies on an erosive surface irregularly cutting the Pliocene substrate and a middle Pleistocene pumiceous deposit. Past authors supported contrasting opinions about the age of that bed. Bartolini & Bosi (1983) tentatively correlated it to the sediments that, in the same area, contain *Strombus bubonius* Lamarck, 1822 (= *Strombus latus* Gmelin, 1791). Such an interpretation was maintained by Palieri & Sposato (1988). Bartolini et al. (1984), however, estimated the age of the bed to approximately 200 ka on the basis of the aminoacid racemization dating method and correlated it to the Marine Isotope Stage 7 (MIS 7) of Shackleton & Opdyke (1973) (see also Bosi & Palieri, 1990). Hearty & Dai Pra (1986) supported that interpretation and calculated the elevation of about +30 m as the maximum for the marine ingression in the Tarquinia area during the MIS 7.

SYSTEMATICS

The higher classification here adopted is that generally accepted by the majority of authors (e.g. Turner, 1954,

1969; Vokes, 1980; Hoagland & Turner, 1981; Kelly, 1988; Kennedy, 1993; Amler, 1999). In the descriptive part, the morphological terms are those defined by Turner (1954, 1969) with the emendation made by Kelly (1988) suggesting the term "prora" as a replacement for "anterior beak".

The material is deposited at the Palaeontological Museum of the Department of Earth Sciences, University of Rome "La Sapienza", collection N.S.8.

Superfamily Pholadoidea Lamarck, 1809
Family Pholadidae Lamarck, 1809
Subfamily Pholadinae Lamarck, 1809

Genus *Barnea* Leach in Risso, 1826
Subgenus *Anchomasa* Leach, 1852

Type species - *Anchomasa pennantiana* Leach, 1852
(a junior synonym of *Pholas parva* Pennant, 1777).

Remarks - The genus *Barnea* Leach in Risso, 1826 has shells characterised by the simple umbonal reflection, i.e. not septate, a single dorsal accessory plate (the protoplax), the absence of the umbonal-ventral sulcus (Turner, 1954, 1969) and relatively thin apophyses (Pacaud, 1998). *Barnea* (*Anchomasa*) Leach, 1852 differs from *Barnea* s.s. in having prominent prora due to the concavity of the anteroventral edge and, consequently, a wide pedal gape (Turner, 1954, 1969; see also Beu, 2006 for a short synthesis).

B. (Anchomasa) shows similarities with *Cyrtopleuroopsis* Pacaud, 1998 in the general shape and ornament. However, Pacaud's genus distinguishes in having wide, spoon-shaped apophyses. *Nipponopholas* Okamoto & Habe, 1987 is also similar in shape to *Barnea* (*Anchomasa*) but differs in the absence of protoplax, in the presence of mesoplax, and in the very wide condrophore (Okamoto & Habe, 1987).

Barnea (Anchomasa) parva (Pennant, 1777) Fig. 2a-d

- 1777 *Pholas parvus* PENNANT, p. 77, Pl. 40, fig. 13 [not seen, *fide* Pennant (1812)].
- 1812 *Pholas parva* Pennant - PENNANT, p. 157, Pl. 43, fig. 1.
- 1818 *Pholas dactyloides* LAMARCK, p. 445.
- 1822 *Pholas tuberculata* TURTON, p. 5, Pl. 1, figs. 7, 8.
- 1827 *Pholas parva* Pennant - BROWN, Pl. 9, figs. 10, 11.
- 1839 *Pholas ligamentina* DESHAYES, p. 80, Pl. 3, figs. 11, 12.
- 1846 *Pholas parvus* Pennant - MONTAGU, p. 10, Pl. 1 figs. 1, 1a.
- 1852 *Anchomasa pennantiana* LEACH, p. 253.
- 1853 *Pholas parva* Pennant - FORBES & HANLEY, p. 111, Pl. 2, fig. 2, Pl. 4, figs. 1, 2.
- 1855 *Pholas parva* Pennant - SOWERBY, p. 487, Pl. 104, figs. 31, 32.
- 1862 *Barnea parva* Pennant - CHENU, p. 5, fig. 19.
- 1862 *Zirfaea callosa* Lamarck - CHENU, p. 6, figs. 24, 25.
- 1865 *Pholas parva* Pennant - JEFFREYS, p. 109.
- 1865 *Pholas parva* var. *quadrangula* JEFFREYS, p. 110.
- 1867 *Pholas parva* Pennant - WEINKAUFF, p. 8.
- 1869 *Pholas parva* Pennant - JEFFREYS, p. 193, Pl. 52, fig. 3.
- 1874 *Pholas parva* Pennant - WOOD, p. 164, Pl. 10, figs. 24a, b.
- 1878-81 *Pholas crispata* var. *parva* Pennant - NYST, p. 248, Pl. 27, figs. 11a-e.

- 1886 *Pholas parva* Pennant - LOCARD, p. 367.
 1887 *Pholas parva* Pennant - SOWERBY, Pl. 1, fig. 10.
 1888 *Pholas (Barnea) parva* Pennant - KOBELT, p. 301.
 1892 *Pholas parva* Pennant - LOCARD, p. 246.
 1892 *Pholas duboisi* Locard - LOCARD, p. 246.
 1900 *Pholas (Barnea) parva* var. *major* PALLARY, p. 413, fig. 19.
 1954 *Barnea (Anchomasa) parva* (Pennant) - TURNER, p. 23, Pl. 8, figs.10-12, Pl. 9.
 1966 *Barnea (Anchomasa) parva* (Pennant) - GLIBERT & VAN DE POEL, p. 17.
 1966 *Barnea parva* (Pennant) - TEBBLE, p. 181, fig. 96B.
 1969 *Barnea (Anchomasa) parva* (Pennant) - NORDSIECK, p. 152, Pl. 22, fig. 87.01
 1969 *Barnea (Anchomasa) parva* var. *duboisi* (Locard) - NORDSIECK, p. 152.
 1969 *Barnea (Anchomasa) parva* (Pennant) - TURNER, p. N708, figs. E170,1a, b.
 1976 *Barnea parva* (Pennant) - PARENZAN, p. 381, fig. 360.
 1984 *Barnea (Anchomasa) parva* (Pennant) - JANSSEN ET AL., p.157, Pl. 91, figs. 228a, b.
 1990 *Barnea (Anchomasa) parva* (Pennant) - SABELLI et al., p. 99, p. 335.
 1998 *Barnea (Anchomasa) parva* (Pennant) - PACAUD, figs. 31, 32.

Material - One well preserved left valve (MACB311), and one incomplete right valve (MACB312).

Dimensions (mm) - Abbreviations: L = length of shell from posterior end to the extremity of prora; H = maximum height of shell orthogonal to the length; I = inflation of single valve; La = length of anterior part from the extremity of prora to the umbo, measured parallel

to the length of valve. Lp = length of posterior part from umbo to posterior end, measured parallel to the length of valve. The asterisk (*) indicates partial measurements of incomplete specimen.

	L	H	I	La	Lp
MACB311	21.7	13.6	5.7	8.3	13.4
MACB312	18.5*	13.0*	-	8.4	-

Description - Shell equivalve, medium sized, with wide gapes at the extremities. Prora prominent. Posterior margin rounded. Umbo anterior. Umbonal reflection simple, thin at its margin, adherent to the shell surface, free in its anterior part and extended almost to the end of prora. Pedal gape wide and with oval outline. Protoplax not preserved. Ornament composed of commarginal and radial ribs. Concentric ribs numerous (about forty), laminated on anterior part of shell, especially near to margin, and fully crenulated. They attenuate on the disc and even more on the posterior slope, where they become dense striae. Radial ribs prominent on anterior slope, made by radial alignment and imbrications of crenulations of commarginal ribs, well spaced on central part of the anterior area, dense and thin near to the umbonal reflection. Radial ribs becoming slightly denser and abruptly attenuating, together with commarginal ribs, along the umbonal-ventral line. On disc, only feeble, well-spaced crenulations of concentric ribs are present, which are scarcely to not aligned in radial direction. Crenulations and radial ribs absent on posterior slope.

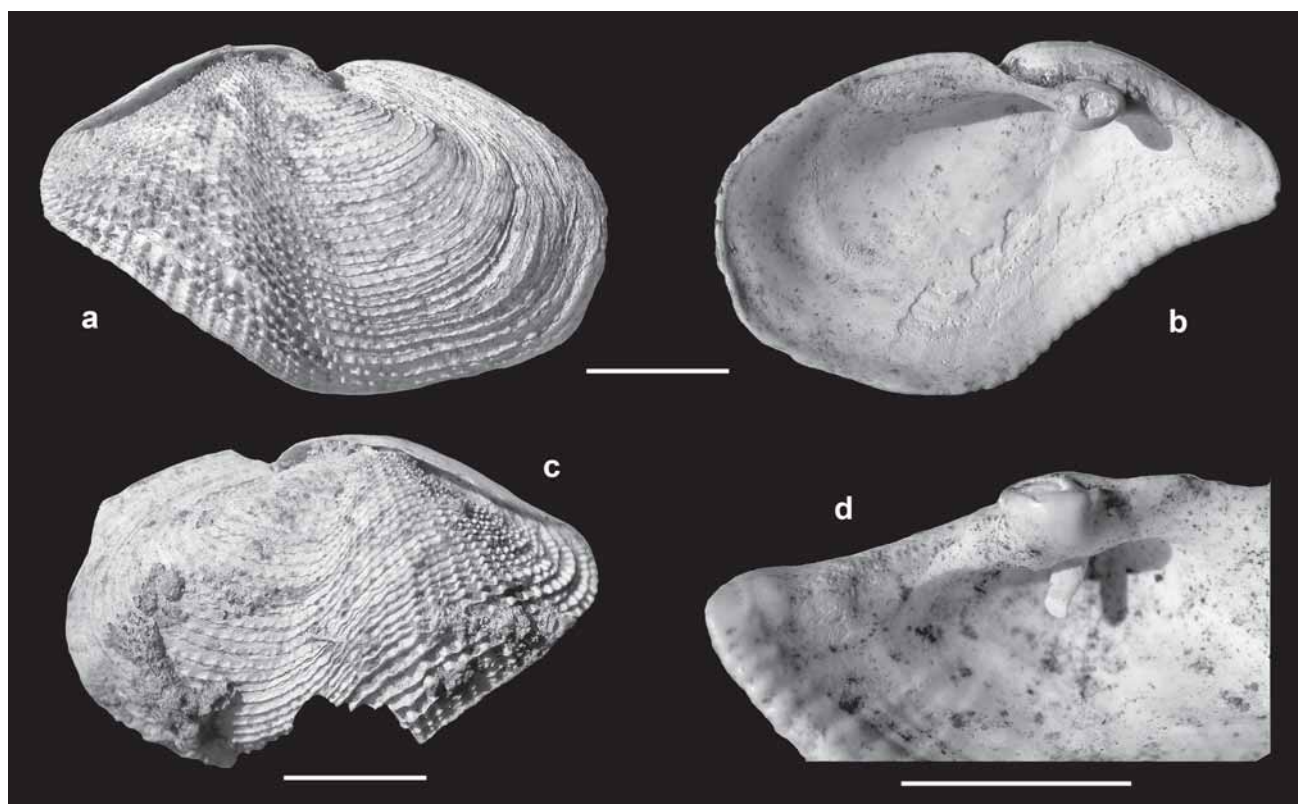


Fig. 2 - *Barnea (Anchomasa) parva* (Pennant, 1777). a, b - specimen MACB311, left valve; c - specimen MACB312, incomplete right valve; d - detail of the inner dorsal region of the specimen MACB312 showing the apophysis partly preserved. Scale bar = 5 mm.

Posterior adductor scar elliptical and elongated besides postero-dorsal margin. Anterior adductor scar, pallial line and sinus not visible. Apophysis relatively thin but solid, slightly inclined in anterior direction and with trapezoidal cross section. Radial ribs forming marginal crenulations on the edge of pedal gape, and slight and short inner radial sulci.

Remarks - The specimens differ from the typical shells ascribed by other authors (see synonymy for references) to *Barnea (Anchomasa) parva* (Pennant, 1777) in the less elongated outline due to its more rounded posterior margin. This difference is not sufficient alone to keep separate the specimens at species level, especially considering that the relatively high specific variability is an expected feature in bivalves which are capable of boring substrates of different hardness (Pinn et al., 2005 and references therein).

Simple plots (Fig. 3), based on the literature data, express graphically the variability of *B. (A.) parva* and show the position occupied by the material here described. The ratio between the length and the height of the shell (Fig. 3a) represents the degree of elongation of the valve. It is based on sources listed in the synonymy reporting the absolute measurements of the parameters involved and on sources containing indications on the magnification of the illustrations. Although the data are rather few, a close correlation can be recognized which would indicate a regular allometric growth to be characteristic for the species. In this respect, Pinn et al. (2005) found a linear correlation between size and age of individuals in living populations of southern England.

The relationship between the degree of elongation of the valve and the position of the umbo (Lp/La ratio) is shown in Fig. 3b. This diagram is exclusively based on ratios of biometric parameters and the illustrations given by authors, which are lacking absolute measurements in text and indications on magnification of the illustration, become also contributory to the data set.

The dispersion resulting from the diagram reflects the relatively wide range of variability in the position of umbo. One can only perceive a tendency of the umbo to assume a more anterior position with the increase of the

degree of valve elongation. In both the diagrams, the slight displacement of the specimens here described reflects their more globose shell with respect to the mean.

The specimen described by Pallary (1900) as *Pholas (Barnea) parva* var. *major* Pallary, 1900, which represents the only documented quotation of the species in the Mediterranean region, falls at the margins of field of distribution of the parameters shown in Fig. 3. This is mainly due to its size that is bigger in respect to the typical specimens of Pennant's species. It also exhibits a finer radial ornament. Both these differences fall within the species variability.

Fossil record - The fossil record concerning *B. (A.) parva* is rather limited. The species is quoted in the Middle and Late Pliocene of England (Wood, 1874; Glibert & Van de Poel, 1966) in Early and Middle Pliocene of Belgium (Nyst, 1878-81; Glibert, 1963) and in Middle Pliocene of the Netherlands (Janssen et al., 1984). The finding of *B. (A.) parva* in the Pleistocene sediments of Tarquinia represents the first fossil quotation of the species in the Mediterranean region and also in the Pleistocene worldwide.

ECOLOGY AND BIOGEOGRAPHY OF *BARNEA (ANCHOMASA) PARVA*

Ecology - *B. (A.) parva* is a filter-feeding bivalve adapted for boring into substrata of different hardness. According to Turner (1954), the species bores into soft sandstone, stiff clay and decaying waterlogged wood. Jeffreys (1865) pointed out its presence also in peat deposits and Forbes & Hanley (1853) found it in red sandstone. Tebble (1966) listed a variety of substrata, such as slate, lignite, chalk, marl, and red sandstone. Pinn et al. (2005) analysed living populations of some localities of southern England boring in chalk and clay substrata. They found that *B. (A.) parva* occurs more frequently in harder substrata.

According to Tebble (1966) the species ranges from the middle of intertidal zone to depths of a few fathoms. Irving (1998) quoted the species from the mid-shore to less than ten metres in Sussex. McAndrew (*vide* Forbes & Hanley, 1853) dredged specimens alive from about five metres of depth at Portland (southern England).

Lebour (1938) described some aspects of its larval growth. According to that author, the larval shell is very small and the planktonic veliger loses the velum at a very early stage. This would indicate a relatively short planktonic larval life.

Geographical distribution - The data available from sources listed in the synonymy allowed reconstruction of the present-day geographical distribution of *B. (A.) parva* (Fig. 4). The species is rather frequent in numerous localities of southern England. Its distribution extends northward along the Irish coasts up to the Bay of Belfast. In the North Sea, the species is quoted to the coast of Kincardineshire (Scotland) and, eastward, to Ostend (Belgium). The frequency of *B. (A.) parva* remains high in Brittany and along the coasts of the Bay of Biscay.

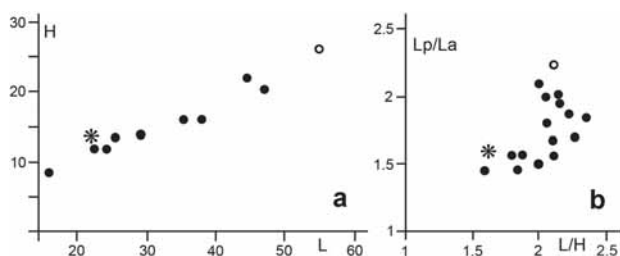


Fig. 3 - *Barnea (Anchomasa) parva*. a - Plot showing relation of length (L) with height (H), i.e. degree of elongation of valve. b - Position of umbo (Lp/La ratio) in relation to the degree of elongation of valve (L/H ratio). See text for abbreviations of the dimensions. Data from sources listed in synonymy reporting dimensions in text and obtained from the measurement of figured specimens. The asterisk (*) indicates specimen MACB311. The open circle represents the specimen described by Pallary (1900) from the Algerian coast.

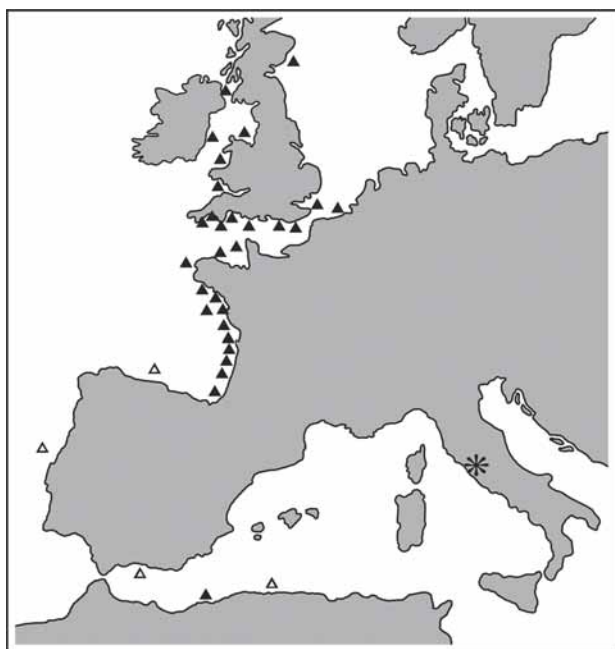


Fig. 4 - Present-day geographical distribution of *Barnea (Anchomasa) parva*. Data from sources listed in synonymy. Solid triangles represent sources reporting exact localities; open triangles represent generic quotations referred to wide areas. The asterisk (*) indicates the location of Tarquinia outcrop.

Conversely, its presence along the Atlantic coasts of Spain and Portugal is reported only by McAndrew (*vide* Weinkauff, 1867), who did not mention exact localities. According to Piani (1980) and Sabelli et al. (1990), the occurrence of the species in the Mediterranean Sea needs some confirmation. In fact, although Weinkauff (1867) cited its presence at Malaga and Algeri, the shell from Oran (Algeria) described by Pallary (1900) is the only documented evidence of the presence of the species in the Mediterranean region.

These data indicate that *B. (A.) parva* is most common along the Atlantic coasts of the British Isles and France. The scarce information on the occurrence of the species along the Atlantic coasts of Spain and Portugal suggest that the species vanishes towards progressively lower latitudes.

Its sporadic quotation in the westernmost part of the Mediterranean area could represent incidental occurrences beyond the southern boundary of the species distribution.

Considering the planktonic larval development of the species, although seemingly short, its capability of adaptation to a wide variety of substrata and the absence of strong geographical barriers, a certain sensitivity of *B. (A.) parva* to the seawater temperature is most probably the main factor limiting its southern dispersal.

PALAEOECOLOGICAL CONSIDERATIONS

The sediment yielding *B. (A.) parva* (Bed 3 in fig. 1B) and the associated macrobenthonic content were analysed

in order to frame the occurrence of the species in the scenario of the Pleistocene evolution of the shorelines of the Tarquinia area. Due to the disappearance of the outcrop, the available material consists only of the original samples accompanied by the field notes of M.A. Conti and the data reported by Bartolini & Bosi (1983). Thus, one should take into consideration that the interpretations below suffer from the impossibility to perform a detailed stratigraphical study and, in particular, a bed-by-bed palaeoenvironmental analysis.

On the whole, the bed is composed of a poorly cemented pebbly-sand. The sandy component is mainly siliciclastic. The pebbles rarely reach one centimetre and are relatively rounded. The bioclastic component is frequent but never forms particularly rich concentrations. Encrusted elements and traces of bioerosion are scarce.

The specimens of *B. (A.) parva* were found dispersed in the sediment and in good state of preservation (Fig. 2). Specimen MACB311 is almost complete whereas specimen MACB312 is broken but lacks traces of erosion. Both specimens exhibit the details of the ornamentation. These observations and the relative fragility of the shell exclude that the specimens were involved in high-energy transport or exhumation.

The pholadid-bearing sample consists of about 10 cm³ of sediment. It yielded numerous specimens belonging to thirty-three fully marine species (Tab. 1). In addition, two specimens of freshwater to brackish water *Theodoxus fluviatilis* (Linné, 1758) were identified. All the species listed in Tab. 1 live today in the Mediterranean Sea and eight of them are exclusive of that area. Most of the remaining species have a wide distribution, which extends from the Boreal to Mauritanian regions, and few of them occur also in Senegalese and Arctic regions. Some other species have a more restrict distribution comprising the Lusitanian-Mauritanian and the Lusitanian-Boreal areas. The biogeographical structure of the malacofauna emerging from these data recollects the normal composition of the mollusc associations living today in the Mediterranean Sea.

The bionomical study (*sensu* Pérès & Picard, 1964) revealed a significant faunal mixing. In terms of number of specimens, the SFBC (sables fins bien calibrés; Pérès & Picard, 1964) stock is the best represented. In fact, about one third of the specimens belongs to *Spisula subtruncata* (Da Costa, 1778). On the whole, the specimens show a good state of preservation and an almost complete range of size distribution, from early juvenile to fully adult individuals. Moreover, fragments of specimens of that species compose the great part of the bioclastic component of the sediment. *Bela nebula* (Montagu, 1803), which is also an exclusive species of SFBC stock, is represented in the sample by a single, well-preserved specimen.

The stocks of vegetated bottoms are also relevant. They are composed of a significant number of accompanying species, which indicate a slight predominance of *Posidonia* meadows (HP) stock with respect to that of photophilic algae (AP). Contrarily to the SFBC, these stocks consist of numerous species, each represented by few specimens. The great majority of them exhibits a relatively good state of preservation and the juvenile specimens are the most abundant. The

SPECIES	n	PRESENT-DAY DISTRIBUTION					ECOLOGY
		SE	MA	LU	BO	AR	
<i>Chiton (Rhyssoplax) olivaceus</i> Spengler, 1797	1 plate		x	x			
<i>Striarca lactea</i> (Linné, 1758)	3	x	x	x	x		pss - Ire
<i>Glycymeris glycymeris</i> (Linné, 1758)	2		x	x	x		SGCF excl
<i>Mytilus</i> sp.	1 fr						
<i>Pododesmus</i> sp.	1 juv						
<i>Parvicardium ovale</i> (Sowerby, 1840)	1		x	x	x	x	I - C sspr
<i>Spisula subtruncata</i> (Da Costa, 1778)	<20	x	x	x	x		SFBC excl
<i>Donax (D.) semistriatus</i> Poli, 1795	1						SFS excl
<i>Venus verrucosa</i> Linné, 1758	1	x	x	x	x		SGCF - HP excl
<i>Dosinia (Pectunculus) exoleta</i> (Linné, 1758)	1	x	x	x	x		SGCF excl
<i>Irus irus</i> (Linné, 1758)	1	x	x	x	x		
<i>Pholas dactylus</i> Linné, 1758	2 fr		x	x	x		
<i>Acmaea (Tectura) virginea</i> (Müller, 1776)	1	x	x	x	x		AP - DC - C
<i>Clanculus (C.) corallinus</i> (Gmelin, 1791)	1 juv						HP - C
<i>Jujubinus exasperatus</i> (Pennant, 1777)	3		x	x	x		AP - HP acc
<i>Homalopoma sanguineum</i> (Linné, 1758)	1		x	x			HP - C
<i>Tricolia pullus</i> (Linné, 1758)	4		x	x	x		HP acc - I
<i>Bittium reticulatum</i> (Da Costa, 1778)	1		x	x	x		AP - HP - Ire
<i>Rissoa variabilis</i> (von Muehlfeldt, 1824)	1						HP acc
<i>Rissoa</i> sp.	3 juv						
<i>Alvania (Alvania) discors</i> (Allan, 1818)	2						AP - HP acc
<i>Alvania (Alvania) cimex</i> (Linné, 1758)	3 juv						AP - HP acc
<i>Manzonina (M.) crassa</i> (Kanmacher, 1798)	2		x	x	x		AP - HP acc
<i>Alvania</i> sp.	7 fr						
<i>Pusillina philippi</i> (Aradas & Maggiore, 1844)	1			x			HP acc
<i>Pusillina</i> spp.	7 juv						
<i>Caecum cf. auriculatum</i> De Folin, 1868	1 juv						
<i>Nassarius (Hima) incrassatus</i> (Stroem, 1768)	1	x	x	x	x	x	I - C
<i>Nassarius (Hinia) reticulatus</i> (Linné, 1758)	1 fr			x	x		SVMC - LEE acc
<i>Nassarius (Plicarcularia) gibbosulus</i> (Linné, 1758)	1						
<i>Vexillum (Pusia) tricolor</i> (Gmelin, 1790)	1						AP - sspr
<i>Bela nebula</i> (Montagu, 1803)	1			x	x		SFBC excl
<i>Chrysallida brusinae</i> (Cossmann, 1921)	1						

Tab. 1 - Number of specimens (n), present day extra-Mediterranean distribution and ecology of the mollusc species associated with *Barnea (Anchomasa) parva*. Species names from Sabelli et al. (1990). juv = juvenile; fr = fragment; SE = Senegalese area; MA = Mauritanian area; LU = Lusitanian area; BO = Boreal area; AR = Arctic area. Data on ecology, associations and their abbreviations from Pérès & Picard (1964), Di Geronimo (1979), Di Geronimo et al. (1997), Basso & Corselli (2002), Basso & Brusoni (2004), and D'Alessandro et al. (2004): C = circalittoral; I = infralittoral; acc = accompanying; excl = exclusive; pss = small solid substrate; sspr = species without precise ecological significance; Ire = wide ecological range. Associations (original French names, from Pérès & Picard, 1964): AP = algues photophiles; SVMC = sables vaseux en mode calme; LEE = lagunes euryhalines et eurythermes; SFBC = sables fins bien calibrés; SFS = sables fins superficiels; HP = herbier de Posidonia; SGCF = sables grossiers et fins graviers sous l'influence des courants de fond; DC = détritique côtier.

species exclusive of SGCF (sables grossiers et fins graviers sous l'influence des courants de fond; Pérès & Picard, 1964) stock could belong to the same original biotope as that of the *Posidonia* meadows, being frequently the main component inhabiting its intermediate and adjacent areas (Masse, 1962; Pérès & Picard, 1964; Biagi & Corselli, 1978).

The other species indicate a relatively high contribution from shallow bottom communities. *Donax (Donax) semistriatus* Poli, 1795 is exclusive of the SFS (sables fins superficiels; Pérès & Picard, 1964) stock. Moreover, *Mytilus* sp., *Pholas dactylus* Linné, 1758, *Nassarius (Hinia) reticulatus* (Linné, 1758), *Nassarius (Plicarcularia) gibbosulus* (Linné, 1758), and *B. (A.) parva* itself, commonly live at shallow depths. Apart from *D. (D.) semistriatus* and *B. (A.) parva*, these species are represented by badly preserved, strongly eroded specimens suggestive of some transport.

The small size of the sample and the lack of direct observations on the outcrop impose caution in the interpretation of these data. However, the structure of the deposit and the sedimentological data seem to indicate processes of infilling of a depression on a substrate subjected to high-energy hydrodynamic regimes within the infralittoral zone. These depositional dynamics were most probably responsible for the strong faunal mixing evidenced by the bionomic analysis. That depression acted as a trap for the elements from the nearest biotopes, which were mainly inhabited by SFBC and vegetated

bottoms associations, the latter coalescent with SGCF association.

The relatively high frequency of species commonly living at shallow depths, the occurrence of well preserved specimens of *Theodoxus fluviatilis* (Linné, 1758), thought obviously alien to the associations, the strong impoverishment of the nannoplankton component (E. Fornaciari, pers. comm.), and the presence of foraminifers represented exclusively by *Ammonia* and *Elphidium* (A. Piva, pers. comm.) are further lines of evidence suggesting that the deposit formed within the upper part of the infralittoral zone. This is consistent with the ecological data known for *B. (A.) parva* and strongly suggests that the specimens probably underwent only a limited displacement, allowing the extraction of the valves from their borings, and short transport.

CONCLUSIONS

As shown above, the present-day distribution of *B. (A.) parva* is characterised by its highest frequency in the Boreal and northern Lusitanian regions decreasing towards progressively lower latitudes. The planktonic stage of the larval development, the adaptation to a wide variety of substrata and the absence of evident geographical barriers suggest that the dependence of *B. (A.) parva* on a relatively narrow range of seawater

temperature is one of the main factors limiting its southward dispersal.

The palaeoecological analysis indicates that the specimens most probably were only slightly displaced. Moreover, they were found in sediments deposited at shallow depths, within the upper infralittoral zone.

Consequently, the occurrence of the species in an area far from the boundary of its present-day distribution and at a latitude much lower than its geographical acme, could reflect an event of dispersal during a time of climatic conditions relatively cooler than today. However, the bed bearing the species was referred to the MIS 7 (Bartolini et al., 1984; Bosi & Palieri, 1990). This was a warm stage, though characterised by wide climatic oscillations, with maximum temperatures slightly higher than today in the western Mediterranean area (e.g. Martrat et al., 2004). The available data are currently insufficient to clear up this contradiction and may support only speculative interpretations. For example, one can presume that *B. (A.) parva* reached the Tarquinia area during the rise of temperature at the beginning of MIS 7 or during one of its stadial-interstadial transitions.

ACKNOWLEDGMENTS

I am grateful to M.A. Conti (Department of Earth Sciences, University "La Sapienza", Rome, Italy) who placed the material at my disposal and made a critical reading of the manuscript. A. Kaim (Institute of Paleobiology, Polish Academy of Sciences, Warszawa, Poland) and S. Raffi are gratefully acknowledged for having revised and improved the manuscript. I also thank V. Verrubbi (ENEA) for the pleasant discussions on wider topics concerning the Pleistocene of central Italy. I am indebted to E. Fornaciari (Department of Geosciences, University of Padua, Italy) and A. Piva (CNR-ISMAR, Bologna, Italy) for the analysis of nannoplankton and microplankton assemblages, respectively.

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Manuscript received 29 January 2008

Revised manuscript accepted 21 May 2008