

## JAMINIA (JAMINIA) MALATESTAE ESU, 1988 (MOLLUSCA, GASTROPODA, ENIDAE) FROM THE MIDDLE AND LATE PLEISTOCENE OF CENTRAL-SOUTHERN ITALY. PALAEOECOLOGICAL IMPLICATIONS

Carmine D'Amico<sup>1</sup> & Daniela Esu<sup>2</sup>

<sup>1</sup>Dipartimento STAT, Università degli Studi del Molise, Pesche (Isernia)

<sup>2</sup>Dipartimento di Scienze della Terra, Sapienza Università di Roma Sapienza, IGAG - CNR, Roma

Corresponding author: D. Esu <daniela.esu@uniroma1.it>

ABSTRACT: D'Amico C. & Esu D., *Jaminia (Jaminia) malatestae* Esu, 1988 (Mollusca, Gastropoda, Enidae) from the Middle and Late Pleistocene of Central-Southern Italy. Palaeoecological implications.

*Jaminia (Jaminia) malatestae* is a fossil land gastropod of the family Enidae. The species described by Esu (1988) was dedicated to the Quaternarist geologist and palaeontologist Alberto Malatesta who recognized, at the base of the Ponte Galeria formation (Rome), the "Blue-grey *Helicella* bearing clays", *stratum typicum* of the species, dated to the early Middle Pleistocene. *J. (J.) malatestae* is an endemic species of central-southern Italy ranging from the early Middle Pleistocene to the Late Pleistocene. It was recovered from deposits with oligotypic assemblages of terrestrial gastropods and small mammals of cold-arid climate. During the Middle Pleistocene the species occurred in Lazio, at Fontignano and San Cosimato (Ponte Galeria and Aurelia formations, Rome) in an oligotypic molluscan assemblage of cold climate and reworked in a polytypic assemblage of temperate-warm climate respectively, and in Abruzzo, at Case Picconetto (Pescara) in a palaeosol of an alluvial deposit, associated with non-marine mollusc species typical of open environments and cold climate. In the Middle and/or Late Pleistocene the species occurred in Marche, at Gola della Rossa (Ancona) in a cave-fill deposit with oligotypic molluscs of mountain grassland, and at Polesio (Ascoli Piceno) in a sandy layer interbedded to gravels of the last glacial period, associated with gastropods of open environment and cold climate. In the Late Pleistocene (last glacial period) the species occurred in Campania with oligotypic molluscan assemblage of cold climate from a loess deposit at Telese (Calore River valley) and from a sandy layer interbedded to gravels at Tufino (Naples). Both the structure of the molluscan assemblages and the autoecology of the accompanying species suggest that *J. (J.) malatestae* populated open-dry palaeoenvironments in the central-southern Italian peninsula during cold climatic periods of the Middle and Late Pleistocene. Its record in non-marine Quaternary deposits of Italy is an useful tool to infer reliable palaeoenvironmental and palaeoclimatic information.

RIASSUNTO: D'Amico C. & Esu D., *Jaminia (Jaminia) malatestae* Esu, 1988 (Mollusca, Gastropoda, Enidae) del Pleistocene medio e superiore dell'Italia centro-meridionale. Implicazioni paleoecologiche.

*Jaminia (Jaminia) malatestae* è una specie di gasteropode terrestre della Famiglia Enidae conosciuta solo allo stato fossile. La specie, descritta da Esu nel 1988 su materiale fossile proveniente dalle "argille ad *Helicella*" del Pleistocene medio-inferiore affioranti a Ponte Galeria (Roma), è stata dedicata dall'autrice ad Alberto Malatesta, paleontologo e geologo del Quaternario, che per primo individuò le "argille ad *Helicella*", *stratum typicum* della specie, alla base della formazione di Ponte Galeria.

La distribuzione cronostratigrafica di *J. (J.) malatestae*, che risulta essere una specie endemica dell'Italia centro-meridionale, va dal Pleistocene medio inferiore al Pleistocene superiore. Generalmente si rinviene in associazioni malacofaunistiche e a micromammiferi indicatrici di ambienti aperti e condizioni climatiche fredde ed aride. Nel Pleistocene medio è nota nel Lazio, a Ponte Galeria e, frammentaria, nella formazione Aurelia (Roma) come elemento non autoctono di un'associazione a molluschi terrestri e dulcicoli di clima temperato-caldo, in Abruzzo (Case Picconetto, Pescara) in un paleosuolo di un deposito alluvionale (età ca 0.48 Ma) associata a molluschi terrestri di ambiente aperto e clima freddo. Nelle Marche è nota a Gola della Rossa (Fabriano, Ancona) in un'associazione oligotipica a molluschi terrestri di prateria montana in depositi di riempimento di una grotta riferiti al "Riss" finale o "Würm" iniziale, e a Polesio (Ascoli Piceno), in un deposito sabbioso intercalato a conglomerati riferiti all'ultimo glaciale, associata a specie terrestri di ambiente aperto e clima freddo. In Campania è stata rinvenuta in associazioni oligotipiche indicatrici di clima freddo-arido in un deposito di loess appartenente al "terrazzo inferiore" del fiume Calore (Benevento), attribuito al Pleistocene superiore ("Würm"), e in sabbie intercalate a ghiaie riferite allo stadio isotopico 2 nei pressi di Tufino (Napoli) (valle del torrente Clanio-Acqualonga).

Il carattere generalmente oligotipico delle associazioni in cui *J. (J.) malatestae* è presente e l'autoecologia delle singole specie che l'accompagnano suggeriscono che questa specie popolava i paleoambienti privi di vegetazione arborea e relativamente aridi nell'Italia centro-meridionale durante le fasi climatiche fredde del Pleistocene medio e superiore, e ne fanno un elemento utile per significative indicazioni paleoambientali e paleoclimatiche.

Key words: *Jaminia (Jaminia) malatestae*, Enidae, Palaeoecology, Palaeoclimate, Pleistocene, Italy.

Parole-chiave: *Jaminia (Jaminia) malatestae*, Enidae, Paleoecologia, Paleoclima, Pleistocene, Italia.

### 1. INTRODUCTION

The distribution and abundance of terrestrial molluscan species are controlled by a number of interacting factors (BARKER, 2001; PFENNINGER & POSADA, 2002;

DAVIES, 2008). Among these both temperature and relative humidity constraining the physiology and life cycle of terrestrial molluscs influence the differing geographical distribution of the species. Each species has a thermal interval controlling its own physiological functions

and outside the ranges the species cannot survive (MOINE *et al.*, 2002 and references therein). These authors demonstrated that the mean temperature of the coldest month and annual thermal magnitude are the most important forcing parameters for the distribution of modern as well as Quaternary land mollusc species. Modern terrestrial molluscs are indices both of vegetation type and climate, permitting them to be grouped in ecological classes (BOYCOTT, 1934). Quaternary terrestrial molluscan assemblages are mainly constituted by extant species which do not show significant changes in their ecological requirements at least from the Middle Pleistocene (GLIOZZI *et al.*, 1997; ROUSSEAU *et al.*, 2007). They can be gathered in ecological groups, as well as the living species, and used to infer general variations of environmental conditions related to the climatic cyclicity of Quaternary glacial and interglacial periods. Among land molluscan assemblages, woodland and steppe/grassland communities provide the major useful data on climatic fluctuations, indicating respectively warm intervals characterized by woodland expansion, and cold phases with decreased arboreal covering (SPARKS, 1961; ID, 1964; LOŽEK, 1964; ID, 2000).

A large number of studies that utilized the ecological patterns of terrestrial molluscs to infer Quaternary palaeoclimatic signatures was published in past decades (for example, LOŽEK, 1964; ROUSSEAU & WU, 1999; ROUSSEAU *et al.*, 2000; WU *et al.*, 2000). Land molluscan assemblages were intensively studied in Quaternary loess deposits of Central and Eastern Europe, as well as in North America and in China, where their palaeoecological framework and related palaeoclimatic attributes have been used as useful biostratigraphical tools (ROUSSEAU, 2001).

In the Italian peninsula, at the beginning of the Middle Pleistocene, consequently to a general renewal probably related to the onset of the 100 ka orbital cyclicity, the non-marine molluscan assemblages became quite modern (ESU & GIROTTI, 1991; GLIOZZI *et al.*, 1997) and strongly influenced by climatic change: the polytypic assemblages are related to temperate and temperate-warm climatic phase (interglacial), while the oligotypic ones occurred during cold oscillations (glacial) (ESU *et al.*, 1989).

In this work we give an overview of the geographical (Fig. 1) and stratigraphical distribution of the terrestrial fossil species *Jaminia (Jaminia) malatestae* ESU based on literature data published over the last 30 years, and highlight its palaeoecological meaning. The palaeoecology of each molluscan assemblage in which the species was recorded is analyzed. Furthermore we report the unpublished occurrence of *J. (J.) malatestae* in an Upper Pleistocene deposit of the Marche region.

## 2. SYSTEMATIC REMARKS

Phylum Mollusca CUVIER, 1797  
 Class Gastropoda CUVIER, 1797  
 Order Stylommatophora SCHMITT, 1855  
 Family Enidae WOODWARD, 1903  
 Genus *Jaminia* RISSO, 1826  
 Subgenus *Jaminia* RISSO, 1826

***Jaminia (Jaminia) malatestae* ESU, 1988**

Fig. 2

1980 *Chondrula (Jaminia) reversalis* - CONATO *et al.*, p. 143 (non BIELZ).

1988 *Jaminia (Jaminia) malatestae* ESU, p. 228, Fig. 1.  
 1989 *Chondrula reversalis* - ESU *et al.*, p. 288 (non BIELZ).  
 1991 *Jaminia (Jaminia) malatestae* - ESU & GIROTTI, p. 144.  
 1992 *Jaminia (Jaminia) malatestae* - KOTSAKIS *et al.*, p. 336.  
 1997 *Jaminia malatestai* - GLIOZZI *et al.*, p. 378.  
 1998 *Jaminia malatestae* - DI VITO *et al.*, p. 281, Fig. 9c.  
 2003 *Jaminia malatestai* - MARCOLINI *et al.*, p. 548, Fig. 3a.

**Description** (ESU, 1988). Shell cylindro-conical, sinistral, of moderate size (height 10÷11.5 mm, diameter 4÷4.5 mm, occasionally 5 mm), with 7-7½ rather flat-sided whorls. Apex large. Sutures weak, faintly slanting. Shell surface with weak, irregular, growth-lines well visible at SEM. Shell rather thick continuing with the same thickness into the mouth-edge. Peristome neither expanded nor reflected, with a characteristic sinuous outer profile. Mouth oval, always furnished with only one blunt parietal tooth more or less developed; sometimes a weak lengthened swelling is present along the columellar side. Mouth-edge continuous bearing a little callus across the outer parietal area, always present in the specimens with preserved parietal peristome.

The type material of *J. (J.) malatestae* was collected from the "Blue-grey *Helicella* bearing clays" (early Middle Pleistocene) at Fontignano (Rome) (Figs. 1 and 3). At first it was ascribed to the species "*Chondrula (Jaminia) reversalis* (BIELZ, 1853)" by CONATO *et al.* (1980), then ESU (1988), after direct comparison with specimens of the BIELZ's species from Eastern European Quaternary non-marine deposits, stored in the Geological Institute of Hungary (Magyar Allami Földtani Intézet) at Budapest, formally classified the Fontignano fossil record as *J. (J.) malatestae* dedicating it to the

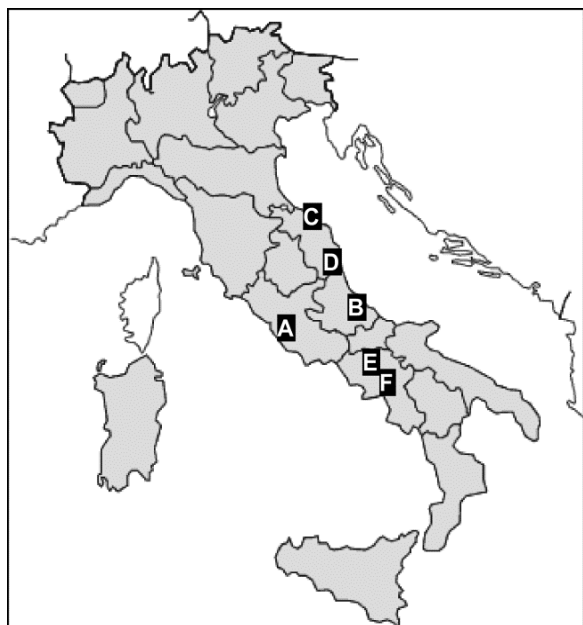


Fig. 1 - Geographical distribution of *J. (J.) malatestae*. A) Fontignano and San Cosimato (Rome); B) Case Picconetto (Pescara); C) Gola della Rossa (Ancona); D) Polesio (Ascoli Piceno); E) Telese (Calore River valley, Benevento); F) Tufino (Naples).

*Distribuzione geografica di J. (J.) malatestae*. A) Fontignano e San Cosimato (Roma); B) Case Picconetto (Pescara); C) Gola della Rossa (Ancona); D) Polesio (Ascoli Piceno); E) Telese (valle del fiume Calore, Benevento); F) Tufino (Napoli).

Quaternarist geologist and palaeontologist Alberto Malatesta, who first described the “Blue-grey *Helicella* bearing clays” in CONATO *et al.* (1980). GLIOZZI *et al.* (1997) reported the species as *J. malatestai*. Nevertheless, according to the Art. 31.1.1 of the International Code of Zoological Nomenclature (ICZN) (INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE, 1999), the correct specific name is *J. (J.) malatestae* as firstly reported by ESU (1988).

### 3. STRATIGRAPHICAL DISTRIBUTION AND ECOLOGICAL FRAMEWORK

*J. (J.) malatestae* ranges from the base of the early Middle Pleistocene<sup>1</sup> to the Late Pleistocene. It is endemic of the Italian peninsula and is recorded from few localities of central and southern Italy (Fig. 1).

As the fossil status of the species, its ecological requirements were inferred from the autoecology of similar extant species, such as the congeneric *Jaminia (J.) quadridens* (MÜLLER) to which it is often associate, and from the characteristics of the accompanying species. Generally *J. (J.) malatestae* occurs in Quaternary molluscan assemblages indicating grassland dried environments and cold climatic conditions.

Below we give an overview of the *J. (J.) malatestae* occurrences, focusing on the composition and the ecological framework of each related molluscan assemblage, according to LOŽEK’s (1964) ecological classification of the Central and Eastern European Quaternary non-marine molluscs (Tab. 1).

#### 3.1 Lazio

##### 3.1.1 Fontignano (Rome)

The oldest occurrence of *J. (J.) malatestae* is registered in the lowermost Middle Pleistocene at Fontignano (Rome), in the “Blue-grey *Helicella* bearing clays” (Fig. 3), a lower member of the Ponte Galeria formation in which CONATO *et al.* (1980) distinguished eight members, from the bottom: 1) river pebble and cobble conglomerates, 2) blue-grey *Helicella* bearing clays, 3) beach conglomerates and bright yellow *A. islandica* sands, 4) pebble gravels and sands with frequent cross-laminations, 5) *Venerupis senescens* clays, 6) aeolian salmon sands, 7) lacustrine and marshy deposits, 8) “tufi grigi inferiori” (earthy and pisolitic tuffs). This stratigraphical succession registers the transitions from non-marine to fully marine and non-marine conditions. More recently MILLI (1997) utilized a sequence-stratigraphy approach in refining the stratigraphy of the Pleisto-

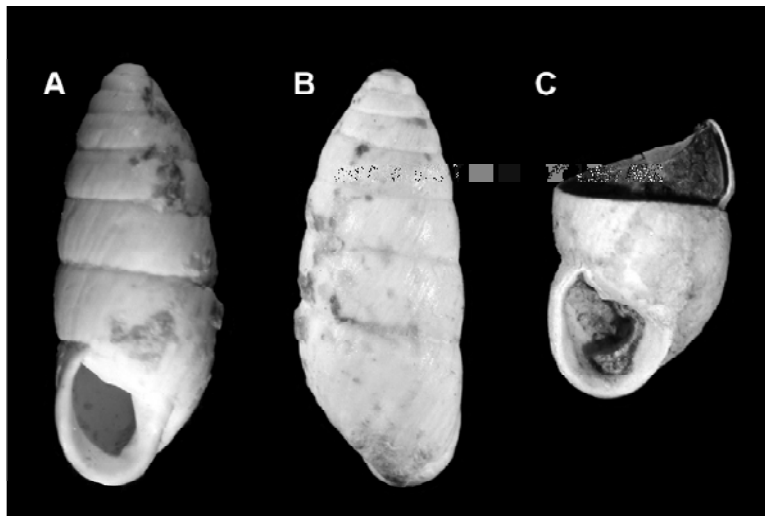


Fig. 2 - *Jaminia (J.) malatestae*. A-B) Fontignano (Rome), paratype; h: 9,5 mm. C) specimen collected by Alberto Malatesta in the Calore River valley; h: 6 mm.

*Jaminia (J.) malatestae*. A-B) Fontignano (Roma), paratipo; h: 9,5 mm. C) esemplare raccolto da Alberto Malatesta nella valle del fiume Calore; h: 6 mm.

cene/Holocene deposits of the Roman area, distinguishing two composite third-order sequences, the Monte Mario Sequence (MMS) (Early Pleistocene) and the Ponte Galeria Sequence (PGS) (Middle-Late Pleistocene/Holocene). The “Blue-grey *Helicella* bearing clays”, falling in the Matuyama reversed palaeomagnetic epoch (MARRA *et al.*, 1998), correspond to a lowstand system tract of the lower fourth-order sequence (PG1) of the PGS; it formed the inner portion of a coastal-barrier depositional system, laterally associated to a braid delta of a fluvial system evolving in a coastal plain with low-sinuosity braided channels (MILLI & PALOMBO, 2005).

This environmental interpretation is consistent with the terrestrial oligotypical molluscan assemblage rec-

1W	Strictly forest species
2W(S)	Species living in woods and scrubs, sometimes in open places (often in hedges and gardens)
4S	Species living in dry and sunny places without arboreal vegetation
4Sf	Xeric and thermophilous species, living on rock steppe environments
5O	Species living in open places without arboreal vegetation
7M	Mesophilous species which sometimes can live in damp or dry places
8H	Hygrophilous species

Tab. 1 - Ecological classes (LOŽEK, 1964) of the mollusc species associated with *Jaminia (J.) malatestae*.

Gruppi ecologici (LOŽEK, 1964) cui appartengono le specie di molluschi associate a *Jaminia (J.) malatestae*.

<sup>1</sup> HEAD *et al.* (2008; see also OGG *et al.*, 2008) proposed to correlate the Early-Middle Pleistocene boundary with the Matuyama-Brunhes palaeomagnetic Chron boundary (about 773 ka) (MIS 19). At present this proposal is informally accepted by the Subcommission on Quaternary Stratigraphy (SQS) of the International Commission on Stratigraphy (ICS), as reported in the “Global chronostratigraphical correlation table for the last 2.7 Ma v. 2009” (<http://www.quaternary.stratigraphy.org.uk/charts/>; GIBBARD & COHEN, 2008). Nevertheless, in the present work, according to MILLI & PALOMBO (2005), we utilize the ancient boundary of Early-Middle Pleistocene, at transition MIS 25 to MIS 24.

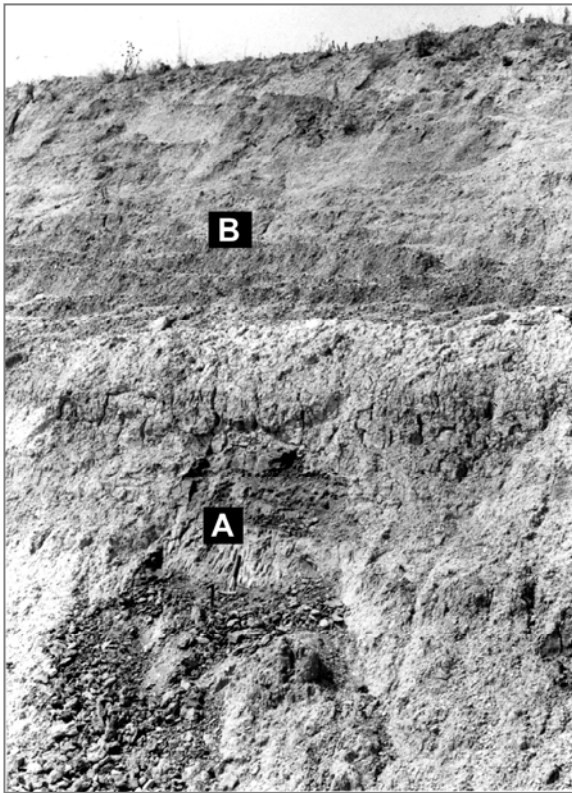


Fig. 3 - A) The “blue-grey *Helicella* bearing clays” at Fontignano (*stratum typicum* of *J. (J.) malatestae*); B) beach conglomerates and bright yellow *A. islandica* sands (photo: DANIELA ESU).

A) “argille grigio-azzurre ad *Helicella*” a Fontignano (*stratum typicum* di *J. (J.) malatestae*); B) conglomerati di spiaggia e sabbie giallo vivo ad *A. islandica* (foto: DANIELA ESU).

ordered in the “*Helicella* clays” (Tab. 2). *Granaria frumentum* (DRAPARNAUD), *Helicella Itala* (LINNÉ), and very probably *J. (J.) malatestae*, belong to the ecologic group 4S, including species that live in dry grassland (Tabs 1 and 2). *Pupilla muscorum* (LINNÉ) (5O) lives in dry exposed places or grassland, *Vallonia pulchella* (MÜLLER) (5O) prefers slightly humid open grounds, *Trochulus hispidus* (LINNÉ) (7M) is a widespread mesic species. *G. frumentum*, *P. muscorum* and *T. hispidus* are species more or less frequent in the loess molluscan assemblages of Central Europe (LOŽEK, 1964). The oligotypy and the dominance of the species referred to the group 4S (Fig. 4) are indicative of a steppe environment and cold-dry climatic conditions (ESU, 1988; KOTSAKIS *et al.*, 1992). This is also confirmed by the record in the same deposit of two species of boreal arvicolid (rodents) of Eastern Europe, *Prolagurus pannonicus* (KORMOS) and *Predicrostonyx* sp., belonging to the steppe lemming and collared lemming respectively (KOTSAKIS *et al.*, 1992).

Both the characteristics of the faunal assemblage and the fact that the “Blue-grey *Helicella* bearing clays” fall in reversed palaeomagnetic epoch led KOTSAKIS *et al.* (1992) to attribute the inset of the sedimentary cycle of the Ponte Galeria formation immediately after the coldest peak of marine isotope stage (MIS) 22. Nevertheless, MARRA *et al.* (1998) referred the base of the Ponte Galeria formation to MIS 20-19.

### 3.1.2 San Cosimato (Rome)

Only one fragmentary specimen (the last whorl with mouth), very probably reworked, was collected from the diatomitic muds of the Aurelia formation (CONATO *et al.*, 1980; PG6 of MILLI, 1997), in a rich politypic molluscan assemblage of about forty land and freshwater species characteristic of temperate-warm climate (ESU, 1988; ESU & GIROTTI, 1991).

Based on stratigraphic evidences, radiometric dating, and vertebrate fossil record the Aurelia formation was dated to Middle Pleistocene (MIS 8-10) and the mollusc-bearing diatomitic layers can be referred to MIS 9 likelihood (CONATO *et al.*, 1980; GLIOZZI *et al.*, 1997; MILLI, 1997; MILLI & PALOMBO, 2005).

## 3.2 Abruzzo

### 3.2.1 Case Picconetto (Pescara)

MARCOLINI *et al.* (2003) reported *J. (J.) malatestae* in a silty-clayey palaeosol of a sedimentary succession,

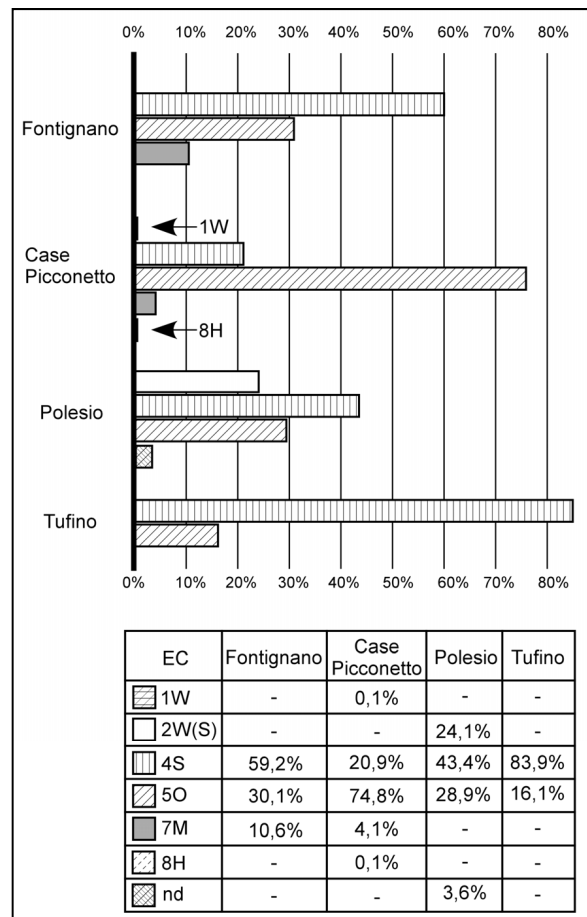


Fig. 4 - Palaeoecological features of the analyzed molluscan assemblages. The ecological classes (EC, see Tab. 1) and their relative frequency are reported for each assemblage (Tab. 2). The percentages of the ecological classes for Gola della Rossa and Telesse assemblages are not available.

*Carattere paleoecologico delle associazioni malacologiche analizzate. Sono riportate le classi ecologiche (EC, vedi Tab. 1) e le relative frequenze per ciascuna associazione (Tab. 2). Le percentuali delle classi ecologiche per le associazioni di Gola della Rossa e Telesse non sono disponibili.*

MOLLUSC SPECIES	EC (Tab. 1)	LOCALITIES					
		Fontignano (Roma) <sup>a</sup>	Case Picconetto (Pescara) <sup>b</sup>	Gola della Rossa (Ancona) <sup>c</sup>	Polesio (Ascoli Piceno) <sup>d</sup>	Telese (Benevento) <sup>e</sup>	Tufino (Naples) <sup>f</sup>
<i>Sphyradium</i> cf. <i>S. doliolum</i>	1W		0,1				
<i>Candidula spadae</i>	2W(S)			x	24,1		
<i>Clausilia</i> ( <i>C.</i> ) <i>rugosa pinii</i>	2W(S)			x			
<i>Cermeuella neglecta</i>	4S						73
<i>Granaria frumentum</i>	4S	16,8	12,7				
<i>Helicella itala</i>	4S	37,7					
<i>Jaminia</i> ( <i>J.</i> ) <i>malatestae</i>	4S	4,8	7,6	x	4,8	x	5
<i>Jaminia</i> ( <i>J.</i> ) <i>quadridens</i>	4S		0,6	x	6		5,9
<i>Pupilla triplicata</i>	4S				25,3		
<i>Truncatellina callicratis</i>	4S				7,2		
<i>Chondrina avenacea</i>	4Sf			x			
<i>Pupilla muscorum</i>	5O	25,7	15,2	x	16,9	x	9,1
<i>Truncatellina cylindrica</i>	5O		14,3				
<i>Vallonia pulchella</i>	5O	4,4	44,8		12	x	7
<i>Vertigo pygmaea</i>	5O		0,4				
<i>Trochulus hispidus</i>	7M	10,6					
<i>Vitrea contracta</i>	7M		4,1				
<i>Vertigo angustior</i>	8H		0,1				
<i>Candidula</i> sp.	nd				1,2		
<i>Cermeuella</i> sp.	nd			x			
<i>Helicella</i> sp.	nd					x	
<i>Monacha</i> sp.	nd				1,2		
<i>Vertigo</i> sp.	nd				1,2		

Tab. 2 - Percentage of the specimens of the recorded mollusc species in the different localities. EC: ecological classes (see Tab. 1); nd: not defined; X: not known.

<sup>a</sup>KOTSAKIS *et al.* (1992); <sup>b</sup>MARCOLINI *et al.* (2003); <sup>c</sup>ESU *et al.* (1990); <sup>d</sup>this work; <sup>e</sup>ESU & GIROTTI (1991); <sup>f</sup>DI VITO *et al.* (1998).

*Percentuali degli esemplari delle specie di molluschi rinvenuti nelle diverse località. EC: classi ecologiche (vedi Tab. 1); nd: non definita; X: valore percentuale non noto. <sup>a</sup>KOTSAKIS *et al.* (1992); <sup>b</sup>MARCOLINI *et al.* (2003); <sup>c</sup>ESU *et al.* (1990); <sup>d</sup>this work; <sup>e</sup>ESU & GIROTTI (1991); <sup>f</sup>DI VITO *et al.* (1998).*

cropping out at Case Picconetto (Pescara), interpreted as a distal part of an old alluvial fan deposit. The two palaeosols recorded in the succession, one of which, the uppermost, holding *J. (J.) malatestae*, are related to a local stasis in the alluvial fan accretion. A tephra layer dated  $0.48 \pm 0.04$  Ma (apatite fission track dating) lies above the palaeosol containing *J. (J.) malatestae*.

The molluscan assemblage consists mainly of terrestrial taxa (Tab. 2). Only two freshwater species, *Gyraulus* (*Armiger*) *crista* (LINNÉ) and *G. (G.) albus* (MÜLLER), occur reaching less than 0.3% of the assemblage. The land species typical of open ground (5O) are dominant, followed by open dry grassland taxa (4S) (Fig. 4). The mesic species (7M) are represented by a discrete number of specimens of *Vitrea contracta* (WESTERLUND). The strictly forest (1W) and hygrophilous taxa (8H) are very scarce, represented by *Sphyradium* cf. *S. doliolum* (BRUGUIÈRE) and *Vertigo angustior* JEFFREYS respectively, which, according to LOŽEK (1964), are warm-climate species.

The molluscs are associated to an oligotypical micromammal assemblage with dominant arvicolids, such as *Microtus* cf. *M. arvalis* (PALLAS), *M. (Terricola)* gr. *savii* (DE SELYS LONGSCHAMPS), followed by murids, such as *Apodemus* gr. *sylvaticus-flavicollis*, and insectivores (*Crociodura* sp.), indicative of open environment and Mediterranean-type climate (MARCOLINI *et al.*, 2003). Together, molluscs and small mammals indicate open ground environment and cold, but not severe, climatic conditions.

The radiometric dating, the results of chemical analysis carried out on the tephra layer, and the pa-

laeoenvironmental indications suggested by molluscs and small mammals, led MARCOLINI *et al.* (2003) to correlate the Case Picconetto succession with MIS 14.

### 3.3 Marche

#### 3.3.1 Gola della Rossa (Ancona)

ESU *et al.* (1990) recorded *J. (J.) malatestae* from a cave-fill deposit (Grotta del Vento, Gola della Rossa, Ancona) in an oligotypical molluscan assemblage (Tab. 2). *Candidula spadae* (CALCARA) and *Clausilia* (*Clausilia*) *rugosa pinii* WESTERLUND, prefer open woodland, but locally can live in open or semi-open habitats [2W(S)]. At present, they have Apennine distribution being common in the high mountain zone (MANGANELLI *et al.*, 1995; CIANFANELLI, 2009). *J. (J.) quadridens* (4S), *Chondrina avenacea* (BRUGUIÈRE) (4Sf) and *P. muscorum* (5O) populate dry grassland or open grounds. Small mammals and one reptile are associated with the land molluscs: *Sorex antinorii* BONAPARTE, *S. minutus* LINNÉ, *Rhinolophus ferrumequinum* (SCHREBER), *Myotis dasycneme* (BOIE), *Pliomys lenki* cfr. *relictus* CHALINE, *M. arvalis*, *Chionomys nivalis* (MARTINS), *Apodemus* cfr. *sylvaticus* (LINNÉ), and *Hierophis viridiflavus* (LACÉPÈDE) (revised by T. Kotsakis).

Both molluscs and mammals indicate open and rather dry mountain palaeoenvironment, and cold climatic conditions. Based on small mammals the cave-fill deposit of Gola della Rossa can be attributed to the late Middle Pleistocene (MIS 6) or early Late Pleistocene (MIS 4) (ESU *et al.*, 1990).

#### 3.3.2 Polesio (Ascoli Piceno)

We report the unpublished occurrence of *J. (J.) malatestae* in Upper Pleistocene non-marine deposits at Polesio (Ascoli Piceno).

In a recent work BUCCOLINI *et al.* (2010) (see also GENTILI *et al.*, 1998), analyzing the geomorphological evolution of the last 20 ka in the high hill sector (600-1100 m a.s.l.) of Mt. Ascensione area (southern Marche), described Upper Pleistocene stratified slope deposits made up of alternating sandy and gravel layers. The type stratigraphic sequence, about 30 m thick, crops out at Porchiano and Polesio (Fig. 5). In the sequence, several palaeosols 20-50 cm thick, located at different heights with respect to the bottom of the deposits, occur. BUCCOLINI *et al.* (2010) constrain chronologically these deposits with four <sup>14</sup>C AMS dating of charcoal fragments present in 4 palaeosols, two located 30 cm and 1 m above the bottom of the Porchiano sequence, and two 3 m below the top of the Polesio sequence. At Porchiano the palaeosols are dated > 51000 yr BP and  $41640 \pm 1260$  yr BP, respectively, at Polesio  $23230 \pm 170$  yr BP and  $22680 \pm 170$  yr BP.

In a sandy layer of the Polesio sequence, close to the dated palaeosols, an oligotypical assemblage of land molluscs rich in specimens was recovered. It is constituted by dominating (about 43%) taxa of steppe

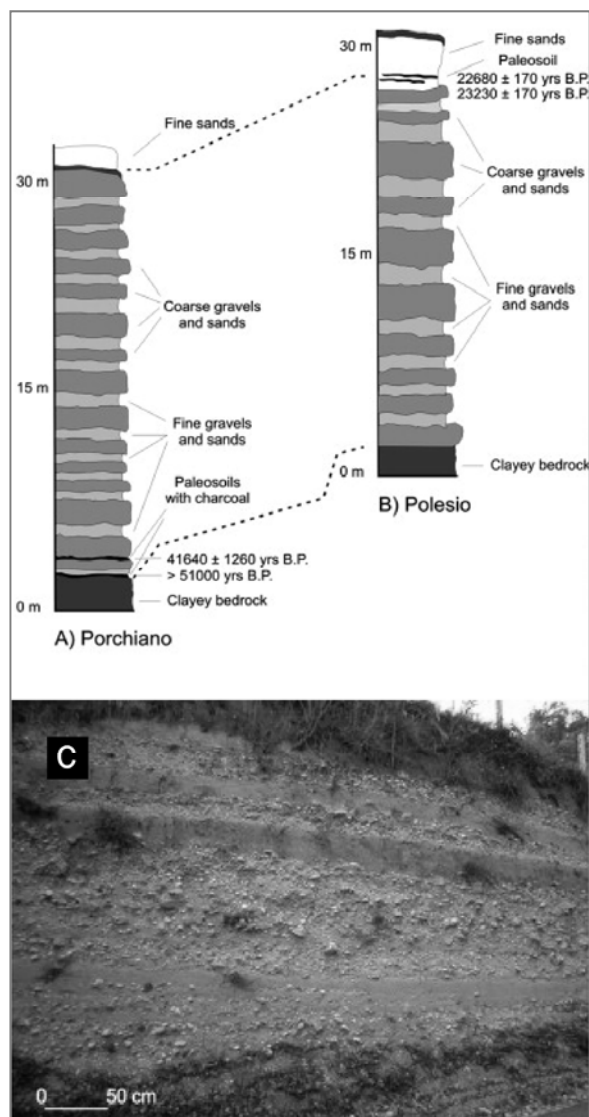


Fig. 5 - Upper Pleistocene stratified slope deposits of the Mt. Ascensione area (southern Marche). Schematic type stratigraphic sequences: Porchiano (A) and Polesio (B); C) stratigraphic section at Polesio (from BUCCOLINI *et al.*, 2010).

*Depositi stratificati di versante del Pleistocene superiore nell'area del Monte dell'Ascensione (Marche meridionali). Sequenze stratigrafiche tipo: Porchiano (A) e Polesio (B); C) sezione stratigrafica presso Polesio (da BUCCOLINI *et al.*, 2010).*

environment (4S) (Fig. 4) represented by *Pupilla triplicata* (STUDER), *Truncatellina callicratis* (SCACCHI), *J. (J.) quadridens* and *J. (J.) malatestae* (Tab. 2), followed (about 29%) by open land species (group 5O). *C. spadeae*, fairly abundant (about 24%), prefers open woodland, but locally can live in semi-open to open habitats.

The ecological framework of the molluscan assemblage leads us to infer open palaeoenvironment and cold climatic conditions.

### 3.4 Campania

#### 3.4.1 Calore River valley (Benevento)

MALATESTA (1959) reported the presence of a land molluscan assemblage in a loess layer interbed-

ded to tuffitic and detrital fluvial deposits of a sedimentary succession located near the mineral source named 'A Uolla on the left side of the Calore River (Telese, Benevento). At present, these deposits, related by the author to the "Würm", are no more cropping out. The molluscan assemblage is constituted only by four species, *J. (J.) malatestae* (4S), *V. pulchella* (5O), *P. muscorum* (5O) and *Helicella* sp. (Tab. 2), indicating open dry environment and cold climate (ESU, 1988; ESU & GIROTTI, 1991).

#### 3.4.2 Tufino (Naples)

DI VITO *et al.* (1998) reported *J. (J.) malatestae* in the Clanio-Acqualonga valley (Naples). Non-marine deposits mainly constituted by carbonate gravels crop out in a quarry near Tufino town. A sandy palaeosol, 80 cm thick, interbedded with gravels yielded a rich, but oligotypical land molluscan assemblage (Tab. 2). The species of dry grassland environment (4S) dominate (Fig. 4). *Cernuella neglecta* (DRAPARNAUD) represented by more than 500 specimens, *P. muscorum* of dry exposed places and *V. pulchella* of more or less damp open habitats (5O) are well represented. The ecological requirements of the molluscan fauna indicate steppe environment and cold climatic conditions. The deposit containing the molluscs was referred to the last glacial period (MIS 2).

## 4. CONCLUSION

So far *J. (J.) malatestae* was found only in the seven Quaternary non-marine deposits of central and southern Italy listed above, ranging from the early Middle Pleistocene to Late Pleistocene. In all the deposits *J. (J.) malatestae* is accompanied by the dominance of steppe species (4S) and open land species (5O) (Tab. 2 and Fig. 4), except at San Cosimato where it was reworked. The strictly forest species (1W) and the hygrophilous ones (8H), represented only at Case Picconetto by *Sphyradium* cf. *S. doliolum* and *V. angustior* respectively, are very scarce (Tab. 2 and Fig. 4). At Fontignano, Case Picconetto and Gola della Rossa, small mammals were recovered with the land molluscs. The ecological and climatic requirements of the mammal species confirm the palaeoenvironmental interpretation of open-dry habitats and cold climate inferred by the molluscs.

The palaeoecological interpretation of the molluscan assemblages containing *J. (J.) malatestae* is in agreement with the chronological attribution of the related deposits, correlated with the Middle and Late Pleistocene marine isotope stages MIS 22, 14, 6 (or 4) and 2, which, except MIS 14, correspond to major or minor glacial events occurred at global scale from the establishing of the 100 ka cyclicity, at about 900 ka BP (EHLERS & GIBBARD, 2007) (Fig. 6).

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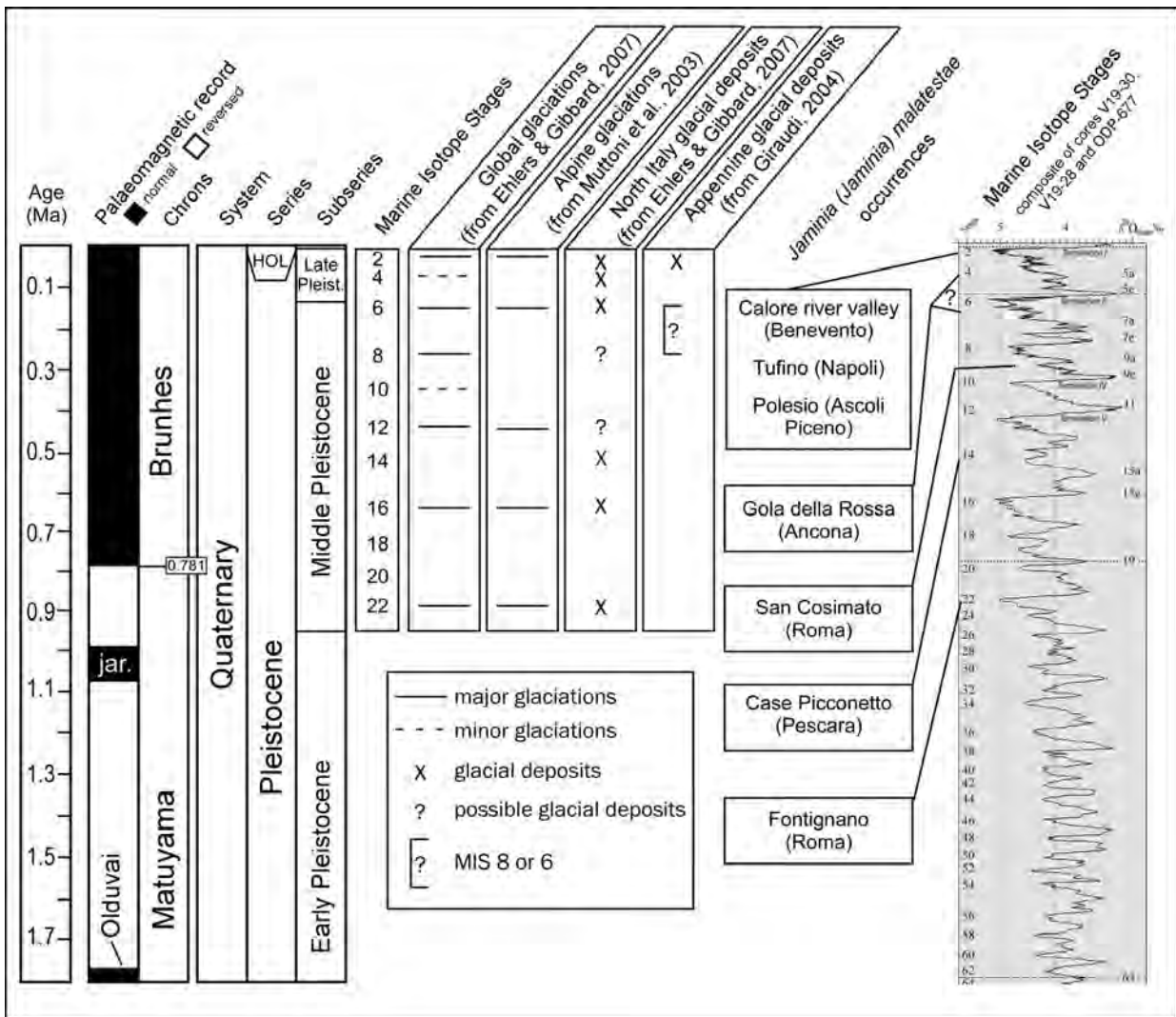


Fig. 6 - Relations among Middle-Late Pleistocene glacial events, Marine Isotope Stages and the occurrences of *Jaminia (J.) malatestae* in Middle-Upper Pleistocene non-marine deposits of central and southern Italy.

Relazione tra eventi glaciali del Pleistocene medio e superiore, stadi isotopici marini dell'ossigeno e presenza di *Jaminia (J.) malatestae* nei depositi continentali medio e tardo pleistocenici dell'Italia centro-meridionale.

**REFERENCES**

BARKER G.M. (Ed.) (2001) - *The biology of terrestrial molluscs* - CABI Publishing, New York, xiv + 558 pp.  
 BOYCOTT A.E. (1934) - *The Habitat of Land Mollusca in Britain* - Journ. Ecol., **22**, pp. 1-38.  
 BUCCOLINI M., GENTILI B., MATERAZZI M. & PIACENTINI T. (2010) - *Late Quaternary geomorphological evolution and erosion rates in the clayey peri-Adriatic belt (Central Italy)* - Geomorphology, **116**, pp. 145-161.  
 CIANFANELLI S. (2009) - *I Molluschi della Provincia di Pistoia: le specie da tutelare e quelle da combattere* - Quaderni del Padule di Fucecchio, Centro di Ricerca, Documentazione e Promozione del Padule di Fucecchio, **6**, pp. 1-111.  
 CONATO V., ESU D., MALATESTA A. & ZARLENGA F. (1980) - *New data on the Pleistocene of Rome* - Quaternaria, **22**, pp. 131-176.  
 DAVIES P. (2008) - *Snails: Archaeology and landscape*

*change* - Oxbow Books, Oxford, xvii + 199 pp.  
 DI VITO M., Sulpizio R. & ZANCHETTA G. (1998) - *I depositi ghiaiosi della valle dei torrenti Clanio e Acqualonga (Campania centro-orientale): significato stratigrafico e ricostruzione paleoambientale* - Il Quaternario, **11**, pp. 273-286.  
 EHLERS J. & GIBBARD P.L. (2007) - *GLACIATIONS/ Overview* - Encyclopedia of Quaternary Science, Elsevier, pp. 1023-1031.  
 ESU D. (1988) - *Jaminia (Jaminia) malatestae n.sp. from the Italian Pleistocene (Pulmonata: Enidae)* - Arch. Moll., **119**, pp. 227-233.  
 ESU D. & GIROTTI O. (1991) - *Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey* - Il Quaternario, **4**, pp.137-150.  
 ESU D., GIROTTI O. & KOTSAKIS T. (1989) - *Oligotipia nei vertebrati e nei molluschi continentali fossili* - Atti III Simposio di Ecologia e Paleoecologia delle Comunità Bentoniche, Catania, 1985, pp. 285-298.

- ESU D., GALDENZI S. & KOTSAKIS T. (1990) - *Molluschi e microvertebrati del deposito pleistocenico della Grotta del Vento (Gola della Rossa - Ancona). Nota Preliminare* - In: GALDENZI S. & MENICETTI M. (eds) - *Il carsismo della Gola di Frasassi* - Mem. Ist. It. Spel., **4**, s. II, pp. 193-198.
- GENTILI B., MATERAZZI M., PAMBIANCHI G. & SCALELLA G. (1998) - *I depositi di versante del Monte dell'Ascensione (Marche meridionali, Italia)* - Geogr. Fis. Dinam. Quat., **21**, pp. 205-214.
- GIBBARD P. & COHEN K.M. (2008) - *Global chronostratigraphical correlation table for the last 2.7 million years* - Episodes, **31**, pp. 243-247.
- GIRAUDI C. (2004) - *The Apennine glaciations in Italy* - In: EHLERS J. & GIBBARD P.L. (eds) - *Quaternary Glaciations - Extent and Chronology. Part I: Europe* - Develop. Quatern. Sci., **2**, pp. 215-223.
- GLIOZZI E., ABBAZZI L., ARGENTI P., AZZAROLI A., CALOI L., CAPASSO BARBATO L., DI STEFANO G., ESU D., FICCARELLI G., GIROTTI O., KOTSAKIS T., MASINI F., MAZZA P., MEZZABOTTA C., PALOMBO M.R., PETRONIO C., ROOK L., SALA B., SARDELLA R., ZANALDA E. & TORRE D. (1997) - *Biochronology of selected mammals, molluscs and ostracods from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art* - Riv. Ital. Paleont. Strat., **103**, pp. 369-388.
- HEAD M.J., PILLANS B. & FARQUHAR S.A. (2008) - *The Early-Middle Pleistocene transition: characterization and a proposed guide for the defining boundary* - Episodes, **31**, pp. 234-238.
- INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE (1999) - *International Code of Zoological Nomenclature. Fourth edition* - International Trust for Zoological Nomenclature, London, 306 pp.
- KOTSAKIS T., ESU D. & GIROTTI O. (1992) - *A post-Villafranchian cold event in Central Italy testified by continental molluscs and rodents* - Boll. Soc. Geol. It., **111**, pp. 335-340.
- LOŽEK V. (1964) - *Quartärmollusken der Tschechoslowakei* - Rozpr. Ústř. Úst. Geol., **31**, pp. 1-374.
- LOŽEK V. (2000) - *Palaeoecology of Quaternary Mollusca* - Antropozoikum, **24**, pp. 35-59.
- MALATESTA A. (1959) - *Note di geologia e morfologia sulla Valle Caudina e sulla Valle del F. Calore* - Boll. Serv. Geol. It., **80**, pp. 255-260.
- MANGANELLI G., BODON M., FAVILLI L. & GIUSTI F. (1995) - *Gastropoda Pulmonata*. In: MINELLI, A., RUFFO, S., LA POSTA, S. (eds.) - Checklist delle specie della fauna italiana. Calderini, Bologna, **16**, 60 pp.
- MARCOLINI F., BIGAZZI G., BONADONNA F.P., CENTAMORE E., CIONI R. & ZANCHETTA G. (2003) - *Tephrochronology and tephrostratigraphy of two Pleistocene continental fossiliferous successions from central Italy*. J. Quaternary Sci., **18**, pp. 545-556.
- MARRA F., FLORINDO F. & KARNER D.B. (1998) - *Paleomagnetism and geochronology of early Middle Pleistocene depositional sequence near Rome: comparison with the deep-sea  $\delta^{18}\text{O}$  record*. Earth Planet. Sci. Lett., **159**, pp. 147-164.
- MILLI S. (1997) - *Depositional setting and high-frequency sequence of the Middle-Upper Pleistocene to Holocene deposits of the Roman Basin* - Geol. Romana, **33**, pp. 99-136.
- MILLI S. & PALOMBO M.R. (2005) - *The high-resolution sequence stratigraphy and the mammal fossil record: a test in the Middle-Upper Pleistocene deposits of the Roman Basin (Latium, Italy)* - Quaternary Int., **126-128**, pp. 251-270.
- MOINE O., ROUSSEAU D.-D., JOLLY D. & VIANEY-LIAUD M. (2002) - *Paleoclimatic Reconstruction Using Mutual Climatic Range on Terrestrial Mollusks* - Quaternary Res., **57**, pp. 162-172.
- MUTTONI G., CARCANO C., GARZANTI E., GHIELMI M., PICCIN A., PINI R., ROGLEDI S. & SCIUNNACH D. (2003) - *Onset of major Pleistocene glaciations in the Alps* - Geology, **31**, pp. 989-992.
- OGG J.G., OGG G. & GRADSTEIN F.M. (2008) - *The concise geologic time scale* - Cambridge University Press, vii + 177 pp.
- PFENNINGER M. & POSADA D. (2002) - *Phylogeographic history of the land snail *Candidula unifasciata* (Helicellinae, Stylommatophora): fragmentation, corridor migration, and secondary contact* - Evolution, **56**, pp. 1776-1788.
- ROUSSEAU D.D. (2001) - *Loess biostratigraphy: new advances and approaches in mollusk studies* - Earth Sci. Rev., **54**, pp. 157-171.
- ROUSSEAU D.D. & WU N. (1999) - *Mollusk record of monsoon variability during the L2-S2 cycle in the Luochuan Loess Sequence, China* - Quaternary Res., **52**, pp. 286-292.
- ROUSSEAU D.D., WU N. & GUO Z. (2000) - *The terrestrial mollusks as new indices of the Asian paleomonsoons in the Chinese Loess plateau* - Global Planet. Change, **26**, pp. 199-206.
- ROUSSEAU D. D., DERBYSHIRE E., ANTOINE P. & HATTÉ C. (2007) - *LOESS RECORDS/Europe* - Encyclopedia of Quaternary Science, Elsevier, pp. 1440-1456.
- SPARKS O. (1961) - *The ecological interpretation of Quaternary non-marine Mollusca* - Proc. Linn. Soc. Lond., **172** (1959-1960), pp. 71-80.
- SPARKS O. (1964) - *Non-marine Mollusca and Quaternary ecology* - J. Anim. Ecol., **33**, pp. 87-98.
- WU N., ROUSSEAU D.D., & LIU X. (2000) - *Response of mollusk assemblages from Luochuan loess section to orbital forcing since the last 250 ka* - Chinese Sci. Bull., **45**(17), pp. 1617-1622.

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