

THE VILLAFRANCHIAN MOLLUSCAN FAUNA FROM THE STEGGIO BASIN (TREVISO, NORTHEAST ITALY): PALEOECOLOGY AND BIOCHRONOLOGY

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RIASSUNTO - *La malacofauna villafranchiana del bacino di Steggio (Treviso, Italia nord-orientale): paleoecologia e biocronologia* - Una ricca fauna a molluschi continentali è stata rinvenuta nei depositi plio-pleistocenici fluvio-lacustri del bacino di Steggio (Treviso) insieme a resti di vertebrati villafranchiani e macroflore. Le associazioni sono costituite da numerose specie di gasteropodi terrestri e da piccoli bivalvi di acqua dolce. L'analisi paleoecologica qualitativa e quantitativa della malacofauna indica un'evoluzione ambientale caratterizzata da una crescente umidità fino all'instaurarsi di ambienti paludosi, testimoniati, al tetto della successione, dalla predominanza di taxa fortemente igrofilii. Parallelamente si registra una progressiva riduzione della copertura boscosa. Le associazioni malacologiche indicano condizioni climatiche di tipo temperato-caldo. Il carattere piuttosto moderno delle associazioni a molluschi e la presenza di due specie estinte caratterizzanti le faune villafranchiane dell'Italia e dell'Europa centro-occidentale, *Carychium (Saraphia) pseudotetrodon* Strauch e *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch, permette di inquadrare le associazioni rinvenute nella parte terminale del Pliocene o nel Pleistocene inferiore basale.

ABSTRACT - *The Villafranchian molluscan fauna from the Steggio basin (Treviso, Northeast Italy): paleoecology and biochronology* - A rich non-marine molluscan fauna has been recorded from Plio-Pleistocene fluvio-lacustrine deposits of the Steggio basin (Treviso, Northeast Italy) together with Villafranchian vertebrate and macroflora remains. The molluscan assemblages are composed of numerous land gastropods and little freshwater bivalves. The qualitative and quantitative analysis of the molluscs has permitted us to obtain a paleoecological reconstruction of the deposition environment of the Steggio clay unit. The environment seems to be affected by an increase in humidity up to the settlement of a palustrine biotope, characterised by a water saturated ground and testified by the dominance of strongly hygrophilous taxa in the upper part of the succession. A progressive decrease in the arboreal cover and a warm-temperate climate have been detected. The rather modern character of the molluscan assemblages and the presence of two extinct species characterising the Central-Western European and Italian Villafranchian faunas, *Carychium (Saraphia) pseudotetrodon* Strauch and *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch, makes it possible to attribute the studied molluscan assemblages to the latest Pliocene or to the lowermost Pleistocene.

Key words: Non-marine molluscs, paleoecology, biochronology, Villafranchian, Northeast Italy.

Parole chiave: Molluschi continentali, paleoecologia, biocronologia, Villafranchiano, Italia nord-orientale.

1. INTRODUCTION

The Steggio basin (Treviso, Northeast Italy) is located east of Bassano del Grappa, along a piedmont area at the foot of Cima della Mandria - M. Pallon - M. Tomba ridge (Venetian Prealps, south of M. Grappa), south of which a continuous sheet of Quaternary deposits extends along the directrix Bassano-Crespano (Fig. 1). In this area, in the Valcavasia intravalline basin located between Brenta and Piave rivers, a continental succession, prevalingly composed of frankly lacustrine clay and organic layers and secondly of fluvatile-lacustrine gravel, crops out. It has been described by Paronuzzi & Tonon (1992). The Authors have distinguished the following four lithostratigraphic units, from the bottom to the top, lying over an Upper Eocene substratum represented by the Marna di Posagno Formation:

- a) clay beds of Steggio unit;
- b) conglomerate of Fusere unit;
- c) clayey and sandy silt of Casa Esercizi-Sorbas unit;
- d) conglomerate of Cioppe unit.

The geological and stratigraphical studies of Paronuzzi & Tonon (1992) demonstrated that the clay beds of Steggio unit was deposited in a lacustrine basin oriented WSW-ENE, in which afflux of material was variable, as indicated by frequent gravel episodes due to underwater canals connected to the delta system of a west tributary of the lake. The Steggio unit, that shows a total thickness of about 25 m, characterises the whole terrace of Steggio; its stratigraphy has been studied by Paronuzzi & Tonon (1992) through five trenches (TR1÷5) opened on the terrace in 1990-91 (Fig. 2). It is composed of grey and grey-green clay interbedded by highly organic-peaty black clay and, less frequently, by layers of gravel.

The preliminary findings of mammal remains, as *Eucladoceros cf. senezensis* Dépéret, *Stephanorhinus etruscus* (Falconer), *Pseudodama* sp., *Miomys* sp., *Pliomys episcopalis* Mehely and *Glis minor* Kowalsky, in the clay beds of Steggio unit, made it possible to attribute the vertebrate assemblage to the Middle-Upper or Upper Villafranchian Mammal Age¹ and the fluvio-lacustrine succession within the time-span Late Pliocene-

¹ The term Villafranchian referred to the molluscan faunas is used in a biochronological meaning and is related to the Mammal Ages as recently stated for Pliocene and Pleistocene Italian molluscs by D. Esu and O. Girotti in Gliozzi *et al.* (1997) and Esu (1999).

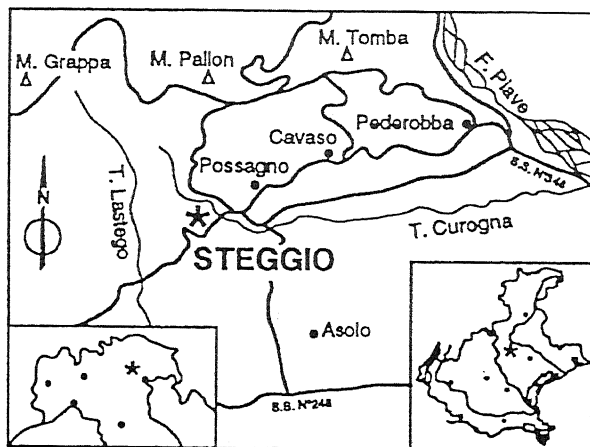


Fig. 1 – Location of the Steggio area.
Ubicazione del bacino di Steggio.

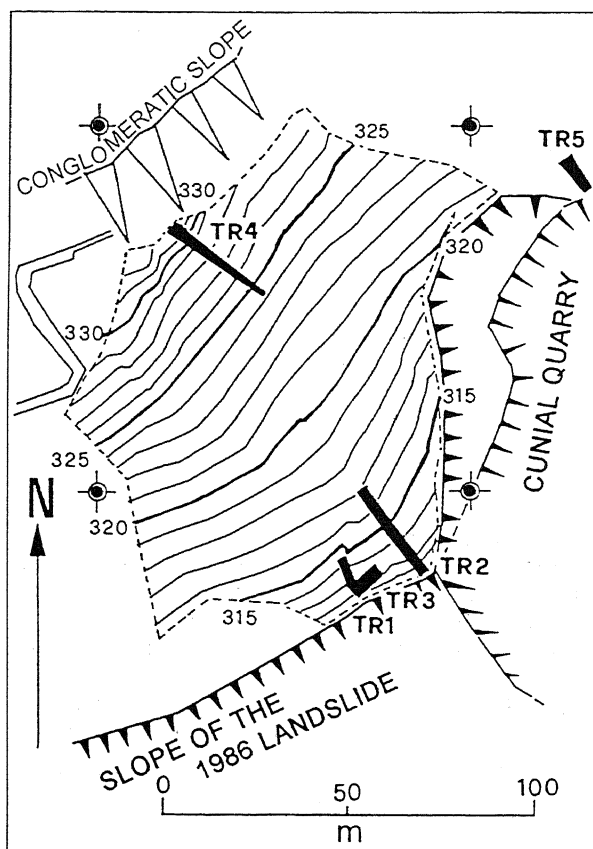


Fig. 2 – Location of the five Trenches opened on the terrace of Steggio in 1990 (TR1-4) and in 1991 (TR5) in the Cunial quarry (from Paronuzzi & Tonon, 1992, modified).

Ubicazione delle cinque trincee aperte sul pianoro di Steggio nel 1990 (TR1-4) e nel 1991 (TR5) nella Cava Cunial (da Paronuzzi & Tonon, 1992, modificato).

Early Pleistocene (Sala & Tonon, 1992; Paronuzzi & Tonon, 1992; Paronuzzi, 1993). Moreover, in June 1993, during the sampling for mollusc analysis, a tooth belonging to *Mammuthus (Archidiskodon) meridionalis* (Nesti), studied by Reggiani (1999), was recovered in

the clay beds of Steggio unit (TR5, u.s. 209), which confirms the given chronostratigraphical attribution (Gliozzi *et al.*, 1997).

The Steggio unit is also characterised by a richness in macroflora remains which were studied by Ghiotto (1993, 1995).

2. PALEOECOLOGICAL ANALYSIS

The non-marine molluscan faunas object of this research have been recovered in the clay beds of Steggio unit. Numbering of samples for mollusc analysis corresponds to the stratigraphical units (s.u.) distinguished by Paronuzzi & Tonon (1992). Only trenches TR2, TR4 and TR5 yielded mollusc remains.

The most complete lithostratigraphical succession is exposed in Trench 5, opened on the front of Cunial quarry, where most of the samples analysed have been kept; the lowermost levels of the Steggio clay unit are visible in it (Fig. 3). The sedimentation is characterised by a decreasing energy trend of a thinning upward type (Paronuzzi & Tonon, 1992).

Trench 2 is opened in the southern margin of the Steggio terrace; the only fossiliferous sample was taken from a highly organic-peaty black clay (s.u. 48). It corresponds to the lower portion of the stratigraphic succession exposed in trench 5.

Trench 4 is cut in the most recent beds of the Steggio clay unit; it shows thin organic black clay and grey clay layers interbedded with pale grey to white fine sand towards the top. Fossil molluscs are recorded in s.u. 122.

Paleoecological analyses of the assemblages have been carried out assuming the method introduced by Ložek in 1964 and still used by several authors. According to this, species or genus of non-marine molluscs identified have been attributed to an ecological class (see Tab. 1) in conformity with their ecological character. Then the number of specimens of the occurring taxa and the percentage of specimens of the ecological classes represented in each sample have been calculated; the data obtained are graphically reported in Figs. 4-5.

The molluscan assemblages are characterised by numerous terrestrial species and by some bivalves in a fair state of preservation. The following 32 species of gastropods and bivalves have been recovered in these deposits:

Prosobranch gastropods: ?*Renea* sp.; *Pomatias elegans* (Müller).

Pulmonate gastropods: *Carychium (Saraphia) pseudotetrodon* Strauch, *Carychium* sp., *Lymnaea truncatula* (Müller), *Lymnaea* sp., *Cochlicopa* sp., *Vertigo (Vertigo) antivertigo* (Draparnaud), *V. (V.) pygmaea* (Draparnaud), *V. (Vertilla) angustior* Jeffreys, *Vertigo* sp., *Truncatellina* sp., *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch, ?*Gastrocopta* sp., *Pupilla muscorum* (Linné), *Vallonia costata* (Müller), *V. pulchella* (Müller), *Punctum pygmaeum* (Draparnaud), *Discus* sp., *Vitrinobranchium breve* (Férussac), *Vitrea* sp., *Oxychilus* sp., *Limax* sp., *Carpathica* cf. *C. stussineri* Wagner, *Clausilia* sp., *Macrogastra densestriata* (Rossmässler), *Cochlodina* sp., *Helicodonta* sp., *Helix* cf. *H. pomatia* (Linné).

Heterodont bivalves: *Pisidium milium* Held, *P. personatum* Malm, *Pisidium* sp.

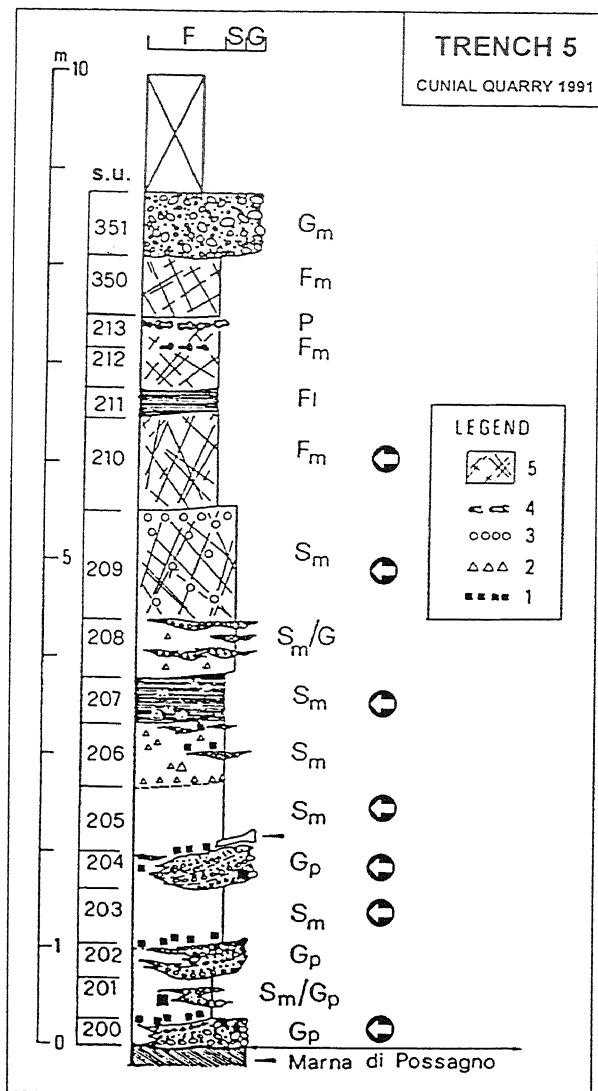


Fig. 3 – Lithostratigraphical succession of the Trench 5 sampled for mollusc analysis. Gm = massive gravel; Gp = gravel with planar crossbeds; Sm = massive sand; Fm = massive clay and silty clay; Fl = micro-laminated clay and silty clay; P = calcareous-sandstone nodule. 1) coal fragment and fossil wood; 2) small calcareous nodule (0.5-2 mm); 3) vivianite nodule (0.5-3 cm); 4) large calcareous-sandstone nodule (4-15 cm); 5) fissured massive sand and silty clay (from Paronuzzi & Tonon, 1992). Arrows indicate mollusc sampling.

Successione litostratigrafica della trincea 5 campionata per le analisi malacologiche. Gm = ghiaie massive; Gp = ghiaie a stratificazione inclinata planare; Sm = sabbie massive; Fm = peliti massive; Fl = peliti micro-laminate; P = noduli calcareo-arenacei. 1) frustoli carboniosi e legni fossili; 2) piccoli noduli calcarei (0.5-2 mm); 3) noduli di vivianite (0.5-3 cm); 4) grandi noduli calcareo-arenacei (4-15 cm); 5) sabbie e peliti massive fessurate (da Paronuzzi & Tonon, 1992). Le frecce indicano le campionature per le analisi malacologiche.

By the composition of the molluscan assemblages from each s.u. it has been possible to reconstruct the environmental evolution in the time-span in which such sediments were deposited (Figs. 4-6).

Trench 5 - More than 1/3 of the molluscan fauna from s.u. 200 (the basal level) is represented by specimens of terrestrial species living in more or less open and mesophilous woods (1W, 2W(M)) (*Pomatias ele-*

gans, *Gastrocopta* (*Vertigopsis*) *dehmi*, *Discus* sp., *Helicodonta* sp.). Almost the same percentage of specimens (35.38%) belongs to hygrophilous and strongly hygrophilous species (8H, 9P) (*Vertigo* (*Vertigo*) *angustior* and *Carychium* (*Saraphia*) *pseudotetrodon*, respectively). One specimen of *Truncatellina* sp. has been found too: species of this genus are generally well adapted to places characterised by grassy vegetation and calcareous soil (50) (Ložek, 1964; Kerney & Cameron, 1979). The aquatic taxa are only represented by two specimens of the bivalve *Pisidium* sp.

| ECOLOGICAL CLASSES (after Ložek, 1964) | |
|---|--|
| 1W | strictly forest species |
| 1W(f) | Forest species living among rocks and ground litter |
| 2W(M) | Species living mainly in woods, but also in mesophilous places and both damp and dry biotopes |
| 2W(s) | Species living in woods and scrubs, sometimes in open places (often in hedges and gardens) |
| 50 | Species living in open places without arboreous vegetation |
| 50(W) | Species living in open places or, less frequently, in dry open woods |
| 7M | Mesophilous species which sometimes can live in damp or dry places |
| 8H | Hygrophilous species |
| 9P | Strongly hygrophilous species living in marshes or in similar very damp to wet places, generally very close to the water |
| T | Terrestrial molluscs whose genus and species can't be determined, so that there are not enough information about their habitat |
| 10 | aquatic species which can live in different biotopes or whose habitat can't be determined |
| 10P | aquatic species living in marshes and in shallow waters rich in vegetation |
| 10S | aquatic species living in still waters |
| 10SPPP | aquatic species living either in still waters or in marshes and periodic marshes |
| ! | species indicative of warm-damp climate conditions |
| !! | species exclusive of warm-damp climate conditions |
| + | loess species |
| (+) | species locally present in loess |

Tab. 1 – List of the ecological classes mentioned in the text and explanation of symbols according to Ložek (1964).

Lista delle classi ecologiche menzionate nel testo e spiegazione dei simboli secondo Ložek (1964).

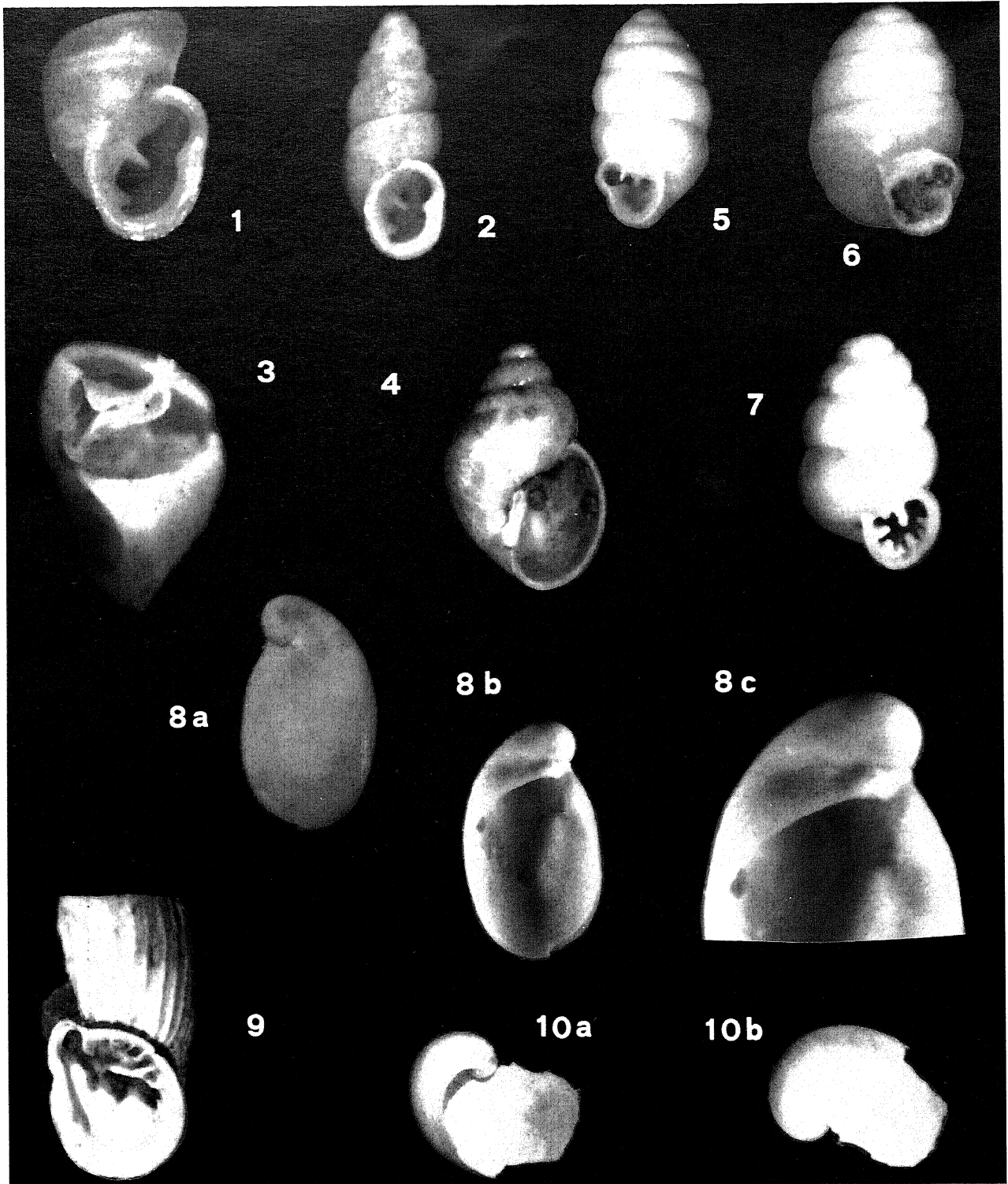


Plate 1: 1+3 - *Carychium (Saraphia) pseudotetrodon* Strauch, s.u. 209; 1 (x 33) (M.P.U.R.-7-1431), 2 (x 19) (M.P.U.R.-7-1432), 3 (x 37) (M.P.U.R.-7-1433), particular of the collumellar fold which displays the peculiar tooth of this species. 4 - *Lymnaea truncatula* (Müller), s.u. 208, (x 13) (M.P.U.R.-7-1434). 5 - *Vertigo (Vertilla) angustior* Jeffreys, s.u. 210, (x 20.5) (M.P.U.R.-7-1435). 6 - *Vertigo (Vertigo) antivertigo* (Draparnaud), s.u. 208, (x 20) (M.P.U.R.-7-1436). 7 - *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch, s.u. 208, (x 20) (M.P.U.R.-7-1437). 8 a, b, c - *Carpathica cf. stussineri* Wagner; s.u. 209, (x 13) (M.P.U.R.-7-1438). 9 - *Macrogastra densestriata* (Rossmässler), s.u. 210, (x 10) (M.P.U.R.-7-1439). 10 a, b - *Vitrinobrachium breve* (Férussac), s.u. 209, (x 7) (M.P.U.R.-7-1440).

Tavola 1: 1+3 - *Carychium (Saraphia) pseudotetrodon* Strauch, s.u. 209; 1 (x 33) (M.P.U.R.-7-1431), 2 (x 19) (M.P.U.R.-7-1432), 3 (x 37) (M.P.U.R.-7-1433), particolare dell'apparato columellare in cui è evidente il dente caratteristico di questa specie. 4 - *Lymnaea truncatula* (Müller), s.u. 208, (x 13) (M.P.U.R.-7-1434). 5 - *Vertigo (Vertilla) angustior* Jeffreys, s.u. 210, (x 20.5) (M.P.U.R.-7-1435). 6 - *Vertigo (Vertigo) antivertigo* (Draparnaud), s.u. 208, (x 20) (M.P.U.R.-7-1436). 7 - *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch, s.u. 208, (x 20) (M.P.U.R.-7-1437). 8 a, b, c - *Carpathica cf. stussineri* Wagner; s.u. 209, (x 13) (M.P.U.R.-7-1438). 9 - *Macrogastra densestriata* (Rossmässler), s.u. 210; (x 10) (M.P.U.R.-7-1439). 10 a, b - *Vitrinobrachium breve* (Férussac), s.u. 209, (x 7) (M.P.U.R.-7-1440).

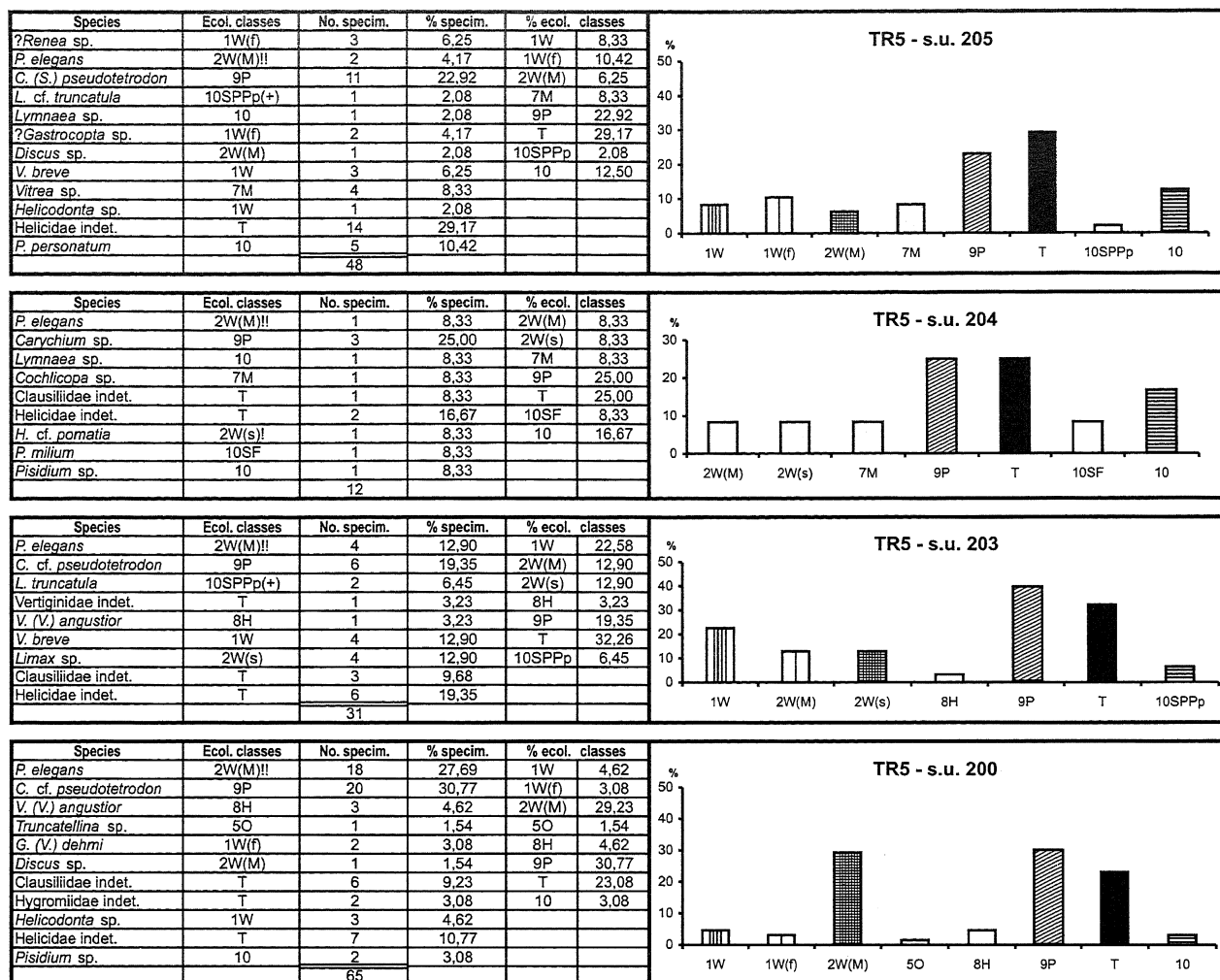


Fig. 4 – Paleoecological features of the non-marine molluscan assemblages recorded from TR5 of Steggio clay unit (s.u. 200 ÷ 205). Species, number and percentage of specimens, ecological classes and their relative frequency are reported.

Spettri paleoecologici delle associazioni a molluschi continentali presenti nella unità delle argille di Steggio campionate nella Trincea 5 (s.u. 200 ÷ 205). Sono riportate le specie, il numero e la percentuale degli individui, le classi ecologiche e le relative frequenze.

The remaining percentage of specimens in this assemblage is represented by land molluscs, marked with "T", not well identified for their bad state of preservation, whose paleoecological character cannot be determined.

The next sample (s.u. 203) has yielded not much abundant molluscan fauna, in which specimens of forestal species prevail (48.39%); in particular, in comparison with the assemblage from the previous level, an increase in the group of species exclusively living in woods, represented in this case by *Vitrinobrachium breve*, has been checked. Specimens belonging to hygrophilous taxa (8H, 9P; the same species found in s.u. 200) have instead reduced to about 30%. Strictly aquatic species are still present (6.45%) with two specimens of *Lymnaea truncatula*, a pulmonate living in ponds, slow flowing streams and not very deep ditches, able to survive temporarily out of water and to take refuge in mud in case of draught.

The assemblage from s.u. 204 is very poor. It is composed of just twelve specimens, mostly land molluscs; their poor number and the bad preservation is insufficient to obtain precise paleoecological information.

In the molluscan fauna yielded by s.u. 205, a considerable reduction in forestal groups (25%) - here represented by specimens of ?*Renea* sp., *P. elegans*, ?*Gastrocopta* sp., *Discus* sp., *V. breve* and *Helicodonta* sp. - and a great increase in aquatic molluscs, such as *L. cf. L. truncatula*, *Lymnaea* sp., *Pisidium personatum*, which reach 14.58%, can be observed. Mesophilous land pulmonates, such as *Vitrea* sp., make their appearance, while about 23% of the assemblage is represented by *C. (S.) pseudotetrodon*, a very hygrophilous species, which probably lived in swampy places, like its congeners.

Sample s.u. 207 has yielded three specimens only, belonging to the forestal species *P. elegans*, *V. breve* and *Limax* sp., clearly transported as their bad preservation shows.

The molluscan faunas from the last two samples of the Trench 5 succession (s.u. 209 and 210) are the richest in specimens and number of species in the whole sampling (Fig. 5).

Almost half of the material collected in s.u. 209 is composed of land hygrophilous pulmonates typical of a

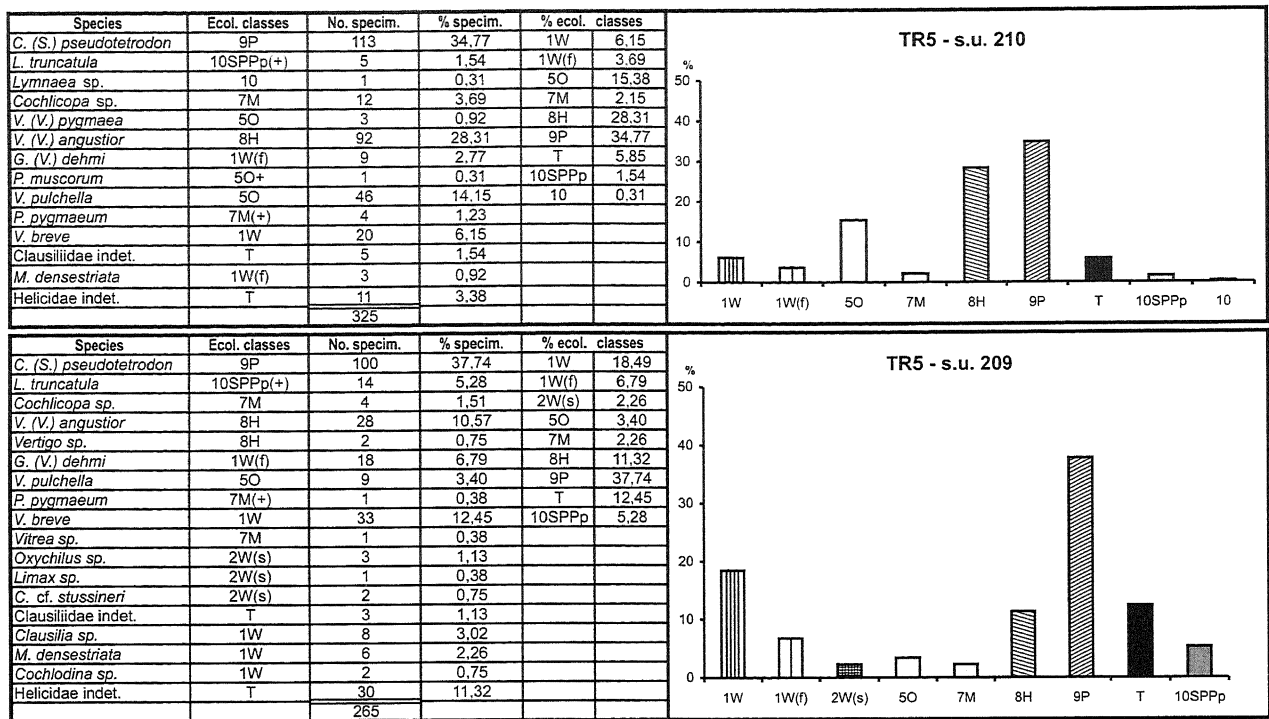


Fig. 5 – Paleoecological features of the non-marine molluscan assemblages recorded from TR5 of Steggio clay unit (s. u. 209 ÷ 210).

Spettri paleoecologici delle associazioni a molluschi continentali presenti nella unità delle argille di Steggio campionate nella Trincea 5 (s. u. 209 ÷ 210).

damp and swampy environment, respectively two representatives of the genus *Vertigo* (*V. angustior* and *Vertigo* sp.) and one species of *Carychium*, *C. (S.) pseudotetrodon*. Strictly aquatic elements are also present (5.28%), they all belong to *L. truncatula*. Forest groups are present with a high diversity of species, some of which live only in woods (*G. (V.) dehmi*, *V. breve*, *Macrogastra densestriata*, *Cochlodina* sp.), the others also on quite open surfaces such as wood steppes and shrubby places (*Oxychilus* sp., *Limax* sp. and *Carpathica cf. stussineri*). The ecology of *C. stussineri*, an eastern prealpine and dinarish species living in beechwood, found for the first time fossil in Italy, is taken from Kerney *et al.*, 1983 and Giusti *et al.*, 1985. Specimens of *Vallonia pulchella* (3.40%) - a species absent in woods, living in open and calcareous places - and mesophilous elements, like *Cochlicopa* sp. and *Punctum pygmaeum* (2.2%), are also present.

In the assemblage recorded in s.u. 210, the forest group decreases very much in specimens (9.85%) and is represented by few species, *G. (V.) dehmi*, *V. breve* and *M. densestriata*, characterising the wood molluscan fauna. Specimens of hygrophilous and highly hygrophilous species, such as *V. angustior* and *C. (S.) pseudotetrodon*, reach the values 28.31% and 34.77% respectively and, if considered together, the 63% of the whole assemblage. Also gastropods living in open habitats (5O) have increased considerably both in diversity of species (*Vertigo (Vertigo) pygmaea*, *Pupilla muscorum*, *V. pulchella*) and in number of specimens, reaching a percentage of 15.38%. Mesophilous species are represented by specimens of *Cochlicopa* sp. and *Punctum pygmaeum* and remain around 2%. Finally, strictly

aquatic mollusc percentage is very low: their specimens belong to the genus *Lymnaea* (*L. truncatula*, *Lymnaea* sp.) and neither reach the 2% of the assemblage.

Trench 2 - The molluscan assemblage collected from s.u. 48 (Fig. 6) can be considered a level rich in one species of the bivalve *Pisidium*, since most of the assemblage is composed of very fragmented valves of this genus, whose species cannot be determined; the occurrence of about 20 specimens - that means more than 50% of the assemblage - has been calculated by a careful analysis of the fragments. Other aquatic species have been found next to them - the pulmonates *Gyraulus crista* and *Lymnaea* sp. and the prosobranch *Valvata cristata* - generally living in still or swampy water. The total number of specimens of aquatic species makes up over 97% of the assemblage, suggesting that the area in which deposition took place was probably represented by a pond or little lake. The remaining fossil material is a fragment of shell of a land gastropod (?Helicidae) which should live near to it.

Trench 4 - Four samples from the lacustrine fine sediments of this trench have been analysed (s.u. 122, 127, 131, 132; see Fig. 10 in Paronuzzi & Tonon, 1992). Only one, s.u. 122, yielded mollusc remains: a rich assemblage of terrestrial and palustral species has been recorded (Fig. 6). Almost 1/3 of the molluscan fauna is composed of specimens belonging to two *Vallonia* species (*V. costata* and *V. pulchella*), generally living in not very damp open places with calcareous soil; *V. pulchella*, here most represented, usually prefers wetter habitats than its congeners (Killeen, 1992; Kerney, 1999). A similar percentage regards the whole of hygrophilous and highly hygrophilous species (*V. angus-*

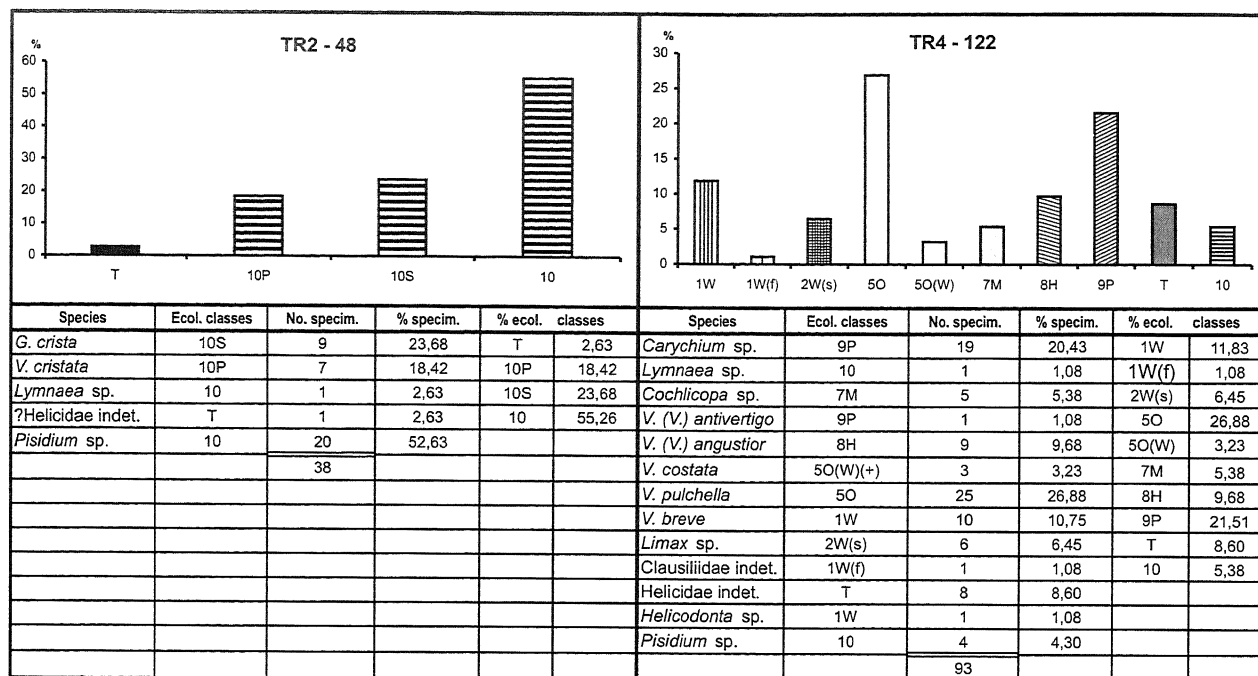


Fig. 6 – Paleocological features of the non-marine molluscan assemblages recorded from TR2 (s. u. 48) and TR4 (s. u. 122) of Steggio clay unit.

Spettri paleoecologici delle associazioni a molluschi continentali presenti nella unità delle argille di Steggio in TR2(s u. 48) e TR4 (s. u. 122).

tior. 9.68%; *Carychium* sp. and *Vertigo antivertigo*: 21.51%). Also forestal species, such as *V. breve*, *Limax* sp. and *Helicodonta* sp., are represented by a significant percentage of specimens (18.28%). The mesophilous *Cochlicopa* sp. (5.38%) and, in the same percentage, aquatic molluscs, such as the pulmonate *Lymnaea* sp. and the bivalve *Pisidium* sp., occur too.

Also in this case we have indications of a very damp and probably palustrine environment, characterised by not very large and not very deep ponds and by a prevailing grassy vegetation.

3. PALEOECOLOGICAL AND PALEOCLIMATICAL REMARKS

The paleoecological character of the analysed molluscan assemblages indicates, in correspondence to the lower levels of the succession (TR4, s.u. 48 and TR5, s.u. 200÷205) in which, respectively, aquatic and forest species are dominant, that the deposition area of the Steggio clay unit should be characterized by quite a thick arboreous vegetation around water bodies such as not very deep ponds. This datum agrees with the results obtained from the analyses of the Steggio macroflora by Ghiotto (1993, 1995): the slopes around the water body should be in fact covered with a mesophilous forest composed of deciduous plants and conifers. The moistness of the soil in this kind of environment should be high enough to make possible life of species belonging to hygrophilous terrestrial taxa such as *Carychium* and *Vertigo angustior*.

The molluscan assemblages from the following levels (TR5, s.u. 209-210) show a great increase in hy-

grophilous and highly hygrophilous pulmonates, that, at the top of the succession, in s.u. 210 reach their highest percentage (63%). Arboreous vegetation, still quite diffused during deposition of s.u. 209, later reduces to be replaced by a more open and prevailing grassy vegetation. The composition of the assemblage from TR4 122 is similar to that recorded in s.u. 210; it shows a more open environment covered by prevailing grassy vegetation with a high moistness of the soil. The presence of hygrophilous taxa is also consistent.

The environment in which the deposition of the succession took place seems then to be evolved towards a palustrine biotope, characterised by a water saturated ground, suitable for many molluscan species, which, in such conditions, could save from drying also without a fair plant cover. These data agree with the lithostratigraphic evolution of the Steggio clay unit.

From a paleoclimatological point of view some evidence can be detected. The occurrence of terrestrial thermophilous elements, such as the subgenus, *Gastrocopta (Vertigopsis)*, no more occurring in Europe, but still living in temperate and warm regions of North and Central America (Zilch, 1959-60; Schileyko, 1998; Esu, 1999) and two extinct species, *G. (V.) dehmi* and *C. (S.) pseudotetrodon*, recorded in Late Pliocene warm assemblages of Central Italy (Ciangherotti *et al.*, 1998), suggests that such sediments were deposited in temperate-warm climatic conditions. The same indication is given by the presence of two still living species, *P. elegans* and *H. cf. pomatia*, recorded in the warmest Quaternary phases of Europe (Ložek, 1964, Puisségur, 1984). This is confirmed by paleocarpologic analyses by Ghiotto (1993, 1995) who has described the Steggio flo-

ra as characterised by deciduous elements and conifers common in the mesic forests of the European Plio-Pleistocene, with Asian-American affinities (*Tsuga*, *Carya*).

4. BIOCHRONOLOGY

The molluscan faunas just examined are almost totally composed of still living species of non-marine molluscs, giving a modern character to the assemblages. Only two extinct species, belonging to terrestrial pulmonates (Ellobiidae and Gastrocoptidae) have been recorded in different layers of Trench 5: *Carychium* (*Saraphia*) *pseudotetrodon* (s.u. 200, 203, 205, 209, 210) and *Gastrocopta* (*Vertigopsis*) *dehmi* (s.u. 200, 205, 209, 210).

The stratigraphic range of *C. (S.) pseudotetrodon* is comprised in the whole Pliocene epoch: it occurs in Lower Pliocene (Celleneuve, Hérault) and Middle Pliocene French deposits (Cessey-sur-Tille, Rhone basin) (Strauch, 1977; Esu, 1999), in the Italian Middle and Late Pliocene (Villafranca d'Asti, Piedmont basin - Triversa Faunal Unit; Camorena, Dunarobba and Cava Toppetti, Ponte Naia Formation, Umbria, Central Italy) (Esu & Girotti, 1991; Esu *et al.*, 1993; Ambrosetti *et al.*, 1995; Gliozzi *et al.*, 1997; Ciangherotti, 1997; Ciangherotti *et al.*, 1998) (Tab. 2).

| Chronostratigraphy | PLIOCENE | | | PLEISTOCENE |
|-----------------------------|----------|--------|------|-----------------------|
| | EARLY | MIDDLE | LATE | EARLY (Tasso F.U.) |
| <i>C.(S.)pseudotetrodon</i> | • | • | • | |
| <i>G.(V.)dehmi</i> | | • | • | • |

Tab. 2 – Chronostratigraphic distribution known so far of the two extinct mollusc species from the Steggio clay unit.

Distribuzione cronostratigrafica nota fin'ora delle due specie estinte di molluschi provenienti dall'unità delle argille di Steggio.

G. (V.) dehmi ranges from Middle Pliocene (Triversa F.U.) to Early Pleistocene (Tasso F.U.) (Ciangherotti & Esu, 1997; 2000). It has been recorded in Middle Pliocene deposits of Germany (Frechen and Fortuna, Rhine basin, Schlickum & Strauch, 1979; Esu, 1999) and of Italy (Piedmont basin, Triversa F.U.) (Ciangherotti, 1997; Gliozzi *et al.*, 1997; Ciangherotti *et al.*, 1998); in Late Pliocene and in Early Pleistocene of Central Italy (Dunarobba, Umbria, Le Cerbaie and Anghiari, Tuscany; Ambrosetti *et al.*, 1995; Zanchetta, 1995; Gliozzi *et al.*, 1997; Ciangherotti & Esu, 2000) and in Early Pleistocene (probably since Late Pliocene) of France (Bresse; Puisségur, 1984); with doubt in Middle Pliocene of Sessenheim (Unterelsass) (Schlickum & Geissert, 1980). Its last occurrence in Italy is in lowermost Pleistocene deposits, in correspondence with the Tasso F.U. (Tab. 2). Recently a taxonomical revision of Gastrocoptidae has been carried out by Manganelli & Giusti (2000). The Authors consider *G. (V.) dehmi* Schlickum & Strauch (1979) as a junior synonymous of *Gastrocopta* (*Vertigopsis*) *moravica* (Petrbok, 1959). This extinct species is known in Early Pleis-

tocene of Hungary and in ex Czechoslovakia (Ložek, 1964; Krolopp, 1983). If the identity of the two species is confirmed the geographical distribution of *G. (V.) moravica* must be extended to Western and Southern Europe and its stratigraphical range to Middle Pliocene.

Taking into account the modern character of the fauna from Steggio and the occurrence of the two extinct and archaic species it is possible to attribute the mollusc fauna to the Olivola F.U. or Tasso F.U. and the study deposits to the latest Pliocene or to the Early Pleistocene, in accordance with the data obtained so far by the analysis of mammal remains (Sala & Tonon, 1992; Paronuzzi & Tonon, 1992; Paronuzzi, 1993; Reggiani, 1999; Sala, oral com., 1999). In the last case we must suppose a survival of the Pliocene species *C. (S.) pseudotetrodon* up to Early Pleistocene.

5. CONCLUSIONS

The paleoecological analysis carried out on the molluscan assemblages coming from the Steggio clay unit has allowed us to reconstruct the environmental development during the time-span of the deposition of the fluvio-lacustrine succession. The recorded assemblages are characterised by the prevalence of terrestrial taxa living in woodlands and hygrophilous habitats. The forestal species indicate that the landscape was at first covered by a thick mesophilous arboreal vegetation and the highly hygrophilous land and lacustrine species show a high moistness of the soil in the area where not very deep ponds were present. A progressive decrease in arboreal cover is detected; the settlement of an open environment is recorded at the top of the succession where an increase in hygrophilous taxa, living in damp and swampy environment, points to the settlement of wetlands with soil nearly always waterlogged. The strictly aquatic molluscs are very scarce all along the succession; they point to low water bodies, such as wet meadows, ponds, fens and slow flowing streams. The occurrence of thermophilous taxa and the relatively high species diversity, all along the succession, point to temperate-warm climatic conditions. The lithostratigraphic study and the analysis of the abundant macroflora remains recorded in the Steggio clay unit indicate the same environmental development.

Palaeomagnetic analyses, carried out in some clay beds of Steggio unit (TR2, TR4) have pointed out a normal polarity which Paronuzzi & Tonon (1992) probably refer to one of the two Reunion's Subchrons in Late Pliocene. The structure of the molluscan assemblages and the stratigraphic range of some extinct species found in the clay beds of Steggio unit allows us to frame the whole molluscan fauna in the biochronological picture of the Italian Plio-Pleistocene molluscan assemblages (Gliozzi *et al.*, 1997) and to correlate it to the Olivola F.U. (latest Pliocene) or to the Tasso F.U. (Early Pleistocene). Thus the detected normal polarity could be attributed preferably to the Subchron Olduvai. Mammal remains studied so far, referred by the Authors to Middle-Upper or Upper Villafranchian Mammal Age, cover the same time-span

(Late Pliocene-Early Pleistocene). A more detailed chronostratigraphic position of the deposits could be inferred from the studies in progress on the other many vertebrate remains (micro- and macromammals) recorded in the Steggio clay unit.

ACKNOWLEDGEMENTS

Thanks are due to Dr. P. Paronuzzi for the request of collaboration in studying the Steggio basin from a malacofaunistic point of view and to Prof. O. Girotti for his help in the field work.

This work is financially supported by grants from C.N.R. "Progetto coordinato – Rapporti tra eventi biologici e fisici nell'evoluzione di due bacini continentali: Villafranca d'Asti (Asti) e Steggio (Treviso)".

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Ms. ricevuto il 17 maggio 2000
Testo definitivo ricevuto il 21 luglio 2000

Ms. received: May 17, 2000
Final text received: July 21, 2000