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Taxonomy and distribution of the Late Miocene genus *Tavanicythere* Bossio, 1980 (Ostracoda, Leptocytheridae)

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ABSTRACT – The genus *Tavanicythere* was established in 1980 by Bossio on the basis of several valves recovered in the lower Messinian brackish deposits of the Radicondoli area (Volterra Basin, Tuscany, central Italy). Three species were included in this genus: *Tavanicythere lepida* Bossio (the type species), *Tavanicythere etrusca* Bossio and *Tavanicythere pulchra* Bossio. Since then, many other specimens referable to *Tavanicythere* have been collected from several Neogene Tuscany basins (Volterra, Valdelsa, Cinigiano-Baccinello), but no specific identifications were carried out and they were generally reported in literature as *Tavanicythere* sp. In this paper we have revised all the collected material. Up to 15 different new taxa have been recognised, even if only 11 are formally established herein as new species, due, in some cases, to the scarcity of valves: *Tavanicythere varieornata* nov. sp., *Tavanicythere persculpta* nov. sp., *Tavanicythere posteroalata* nov. sp., *Tavanicythere sulcata* nov. sp., *Tavanicythere magna* nov. sp., *Tavanicythere nodosa* nov. sp., *Tavanicythere armata* nov. sp., *Tavanicythere ioachinoi* nov. sp., *Tavanicythere julianii* nov. sp., *Tavanicythere parva* nov. sp. and *Tavanicythere irregularis* nov. sp. Only few species of *Tavanicythere* appear to be distributed in different basins, the majority being confined to one basin only. This could be due to particular brackish environmental conditions that triggered basin endemisms. The recovery of new *Tavanicythere* species lead to enlarge the stratigraphical distribution of this genus, prior limited to the early Messinian, to the time interval Late Tortonian-Messinian. *Tavanicythere* seems to be widespread only in the Mediterranean basin and, in particular, in Italy (Tuscany). At present, outside of Italy it has been collected only from the late Messinian brackish deposits of the Sorbas basin (SE Spain).

RIASSUNTO – [Tassonomia e distribuzione del genere *Tavanicythere* Bossio, 1980 (Ostracoda, Leptocytheridae) del Miocene superiore] – Il genere *Tavanicythere* fu istituito da Bossio nel 1980 sulla base di diverse valve raccolte in depositi del Messiniano inferiore dell'area di Radicondoli (Bacino di Volterra, Toscana, Italia centrale). Nel nuovo genere vennero incluse tre specie: *Tavanicythere lepida* Bossio (la specie tipo), *Tavanicythere etrusca* Bossio e *Tavanicythere pulchra* Bossio. Dal 1980, nuovi campionamenti nei depositi miocenici di diversi bacini toscani (Volterra, Valdelsa, Cinigiano-Baccinello) hanno portato alla luce numerose altre valve di *Tavanicythere*, non riferibili alle tre specie già note. In letteratura queste forme sono state riportate genericamente come *Tavanicythere* sp. In questo lavoro, questo materiale è stato revisionato e sono stati riconosciuti 15 taxa diversi anche se, a causa della scarsità delle valve raccolte, solo per 11 di essi è stata possibile l'istituzione formale di nuove specie: *Tavanicythere varieornata* nov. sp., *Tavanicythere persculpta* nov. sp., *Tavanicythere posteroalata* nov. sp., *Tavanicythere sulcata* nov. sp., *Tavanicythere magna* nov. sp., *Tavanicythere nodosa* nov. sp., *Tavanicythere armata* nov. sp., *Tavanicythere ioachinoi* nov. sp., *Tavanicythere julianii* nov. sp., *Tavanicythere parva* nov. sp. e *Tavanicythere irregularis* nov. sp. Solo poche specie di *Tavanicythere* risultano distribuite in più di un bacino; in genere, ciascuna di esse è limitata ad uno solo. Questo potrebbe essere dovuto a particolari condizioni ambientali che hanno innescato la speciazione endemica. Il riconoscimento di queste nuove specie di *Tavanicythere* ha permesso di ampliare il range stratigrafico di questo genere, prima limitato al Messiniano inferiore, all'intervallo Tortoniano superiore-Messiniano. *Tavanicythere* sembra distribuito solo nell'area mediterranea ed in particolare in Toscana (Italia). Al momento è nota un'unica segnalazione di *Tavanicythere* al di fuori dell'Italia, in depositi del Messiniano superiore del Bacino di Sorbas (Spagna).

INTRODUCTION

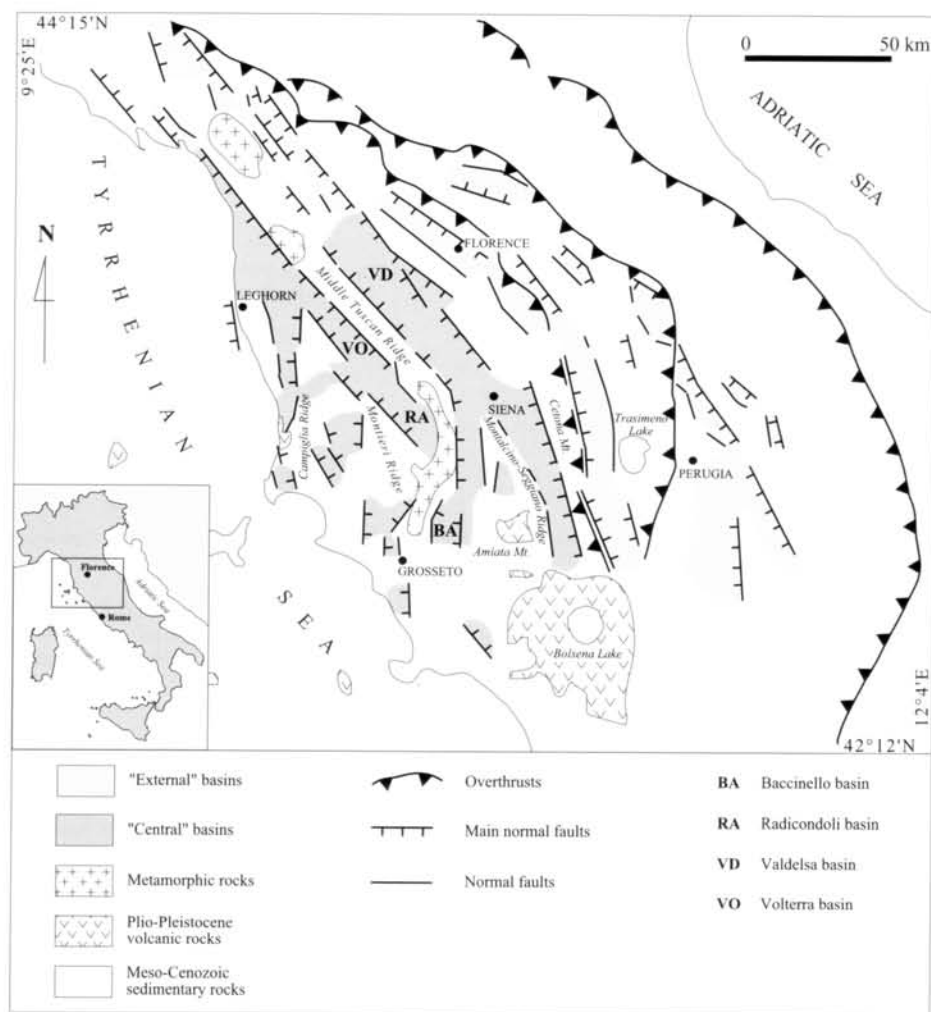
The genus *Tavanicythere* (Ostracoda, Leptocytheridae) was established by Bossio in 1980 on the basis of some peculiar characters like the crenulated median element of the hinge, the absence of vestibulum, the absence of postero-ventral angularity, the presence of snap-pit and snap-knob and the presence of a postero-ventral spine in the male carapaces.

Bossio (1980) established three new species pertaining to this genus: *Tavanicythere lepida*, the type species, *Tavanicythere etrusca* and *Tavanicythere pulchra*. All of them came from the lower Messinian deposits of the Radicondoli area (Volterra Basin, Tuscany).

During the following 20 years, studies on the Tus-

can Late Miocene continental brackish basins and marginal marine environments were carried out by several authors (Bossio *et al.*, 1978, 1981, 1993, 1994, 1996a, b; Sarti & Testa, 1994; Benvenuti *et al.*, 1995, 2001; Benvenuti & Degli Innocenti, 2001). Rich ostracod assemblages, including many *Tavanicythere* species, were recovered. Most of them were morphologically different from the three known *Tavanicythere* species. Their potential relevance as biochronological and palaeobiogeographical tools for the Late Miocene time-interval (as underlined also by Gliozzi *et al.*, in press) prompted the authors to propose a taxonomical revision of this genus, which is the object of the present paper.

The analysed samples come from different Tuscan



Text-fig. 1 - Location of the Tuscan basins from which were collected samples bearing *Tavanicythere*.

"central" basins (*sensu* Martini & Sagri, 1994). In particular, *Tavanicythere* valves were recovered from upper Tortonian-lower Messinian deposits of the Volterra Basin, Valdelsa Basin and Cinigiano-Baccinello Basin (Text-fig. 1).

GEOLOGICAL SETTING AND SAMPLE LOCATION

Volterra Basin – The Volterra Basin is located in northern Tuscany, to the west of the Mid Tuscan Ridge, and the Radicondoli area constitutes its southern sector. The Miocene succession of the Volterra Basin has been investigated by Bossio *et al.* (1978, 1981, 1994, 1996a). The ostracode species described herein are from the following two Miocene formations: the Argille del Torrente Fosci Fm. and the Spicchiola Fm.

The Argille del Torrente Fosci Fm. consists mostly of clays and marly clays. In its lower part, the depositional environment is referable to a lacustrine setting, whereas upwards, the presence of *Loxoconchidae* and brackish water foraminifers indicate a brackish lagoonal

environment. The Spicchiola Fm. is heteropic and/or overlaps the Argille del Torrente Fosci Fm. It essentially consists of clays and sandy clays with interbedded laminated calcareous sandstones, yielding a microfauna very similar to that present in the upper part of the Argille del Torrente Fosci Fm. The brackish portion of the Argille del Torrente Fosci Fm. and the Spicchiola Fm. are correlatable with the lower Messinian Rosignano Reef Complex, outcropping in the Livornesi Mts. (Bossio *et al.*, 1996b). The lower part of the Argille del Torrente Fosci Fm. rests unconformably on the Lower Tortonian Arenarie di Ponsano Fm. and is, therefore, referable to the Late Tortonian.

Samples RA 88(1), RA 88(2), RA 107, RA 118, RA 132, RA 132TG, RA 133, RA 134 and RA 152 came from the lower part of the Argille del Torrente Fosci Fm. cropping out in the Radicondoli area and are Late Tortonian in age; Pozzo Gello samples came from the lower part of the Argille del Torrente Fosci Fm. which were bored in the Volterra area and are Late Tortonian in age; GB samples pertain to the Spic-

chiaiola Fm. cropping out in the Volterra area and are early Messinian in age; all the remaining RA samples are from the upper part of the Argille del Torrente Fosci Fm. cropping out in the Radicondoli area and are early Messinian in age.

Valdelsa Basin – The Valdelsa Basin is located in central Tuscany, north of Siena, to the east of the Mid Tuscan Ridge. It has been investigated firstly by Bossio *et al.* (1993) and more recently, by Benvenuti & Degli Innocenti (2001). The sample ALC Fizzano, bearing *Tavanicythere* specimens, comes from a very small outcrop located in the south-eastern end of the basin (Borro Strolla area), and is referable to the Late Tortonian-early Messinian, thus correlatable with the Argille del Torrente Fosci (Abbazzi *et al.*, in press). Candoninae, *Cyprideis* spp. and Loxoconchidae have been found associated with *Tavanicythere*, recording a brackish environment.

Cinigiano-Baccinello Basin – The Cinigiano-Baccinello Basin is located in southern Tuscany, near Grosseto. It is classified as a “central” basin, located to the east of the Mid Tuscan Ridge and it is characterised by a continental sedimentary filling which has been included, by Benvenuti *et al.* (1995, 2001) into two synthem: Synthem 1 is made of several different lithostratigraphic units and testifies the progressive filling of the basin by lacustrine, fluvial-lacustrine and fluvial deposits. It is related to the Middle/Late Tortonian-early Messinian interval (Turolian) due to the recovery of several fossiliferous layers which yielded rich mammal assemblages (Rook *et al.*, 1999, with references), mollusc assemblages (Esu & Girotti, 1989, with references) and of an ash layer dated, by means of $^{40}\text{Ar}/^{39}\text{Ar}$ 7.55 ± 0.03 Ma (Rook *et al.*, 2000). Synthem 2 is made by grain-supported conglomerates of fluvial origin, related by the authors to the late Messinian. The basin sedimentary filling is covered by marine Lower Pliocene deposits related to the Early Pliocene transgression.

The continental sediments included in the lower synthem have been sampled in detail and ostracod faunas have been analysed. In particular, *Tavanicythere* valves have been recovered from sample BA56 (Passonaio section, correlatable with the mammal level V1 – Late Tortonian), samples BA4 – BA 17 (Trasubbie section, correlatable with the mollusc level F1 – Late Tortonian), BA38 – BA52 (Passonaio section, correlatable with the mollusc level F1, below and above the ash level – Late Tortonian), BA74-BA75 (Ribaldella 2 Section, correlatable with the mammal level V3- early Messinian) COP7 and PV12-PV15 (respectively from Coppai Section and Poggio Vannini Section, both referable to the mollusc level F2 – early Messinian). All these samples are characterised by brackish ostracod assemblages made of *Cyprideis* spp., *Heterocypris* sp. and Loxoconchidae.

TAXONOMY

Class OSTRACODA Latreille, 1806
Order PODOCOPIDA Sars, 1866
Suborder CYTHEROCOPINA Gründel, 1967
Superfamily CYTHEROIDEA Baird, 1850
Family LEPTOCYTHERIDAE Hanai, 1957
Subfamily LEPTOCYTHERINAE Hanai, 1957
Genus *TAVANICYTHERE* Bossio, 1980

TAVANICYTHERE LEPIDA Bossio, 1980

1980 *Tavanicythere lepida* n. sp., BOSSIO, p.38, Pl.1, Figs 1-5, 10.

Several specimens of *Tavanicythere lepida* have been collected in the Volterra Basin (Radicondoli area) and in the Baccinello-Cinigiano Basin. For the illustration and the description of this species see Bossio (1980). The presence of this species inside the deposits of the lower part of the Argille del Torrente Fosci Fm. and at Baccinello-Cinigiano extends the stratigraphical distribution of *Tavanicythere lepida*, previously limited to the early Messinian, down to the Late Tortonian.

Dimensions (in mm)

Female LV -	L: 0.38-0.46;	H: 0.20-0.23
Female RV -	L: 0.41-0.46;	H: 0.21-0.25
Male LV -	L: 0.44-0.49;	H: 0.19-0.23
Male RV -	L: 0.41-0.47;	H: 0.19-0.23

Studied material - Samples RA 107, RA 107 RIL (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm. near Poggio Macignano, along the road to Monteguidi, Late Tortonian): 16 male and 28 female carapaces.

BA 38 - BA 52 (Cinigiano-Baccinello Basin, Passonaio section, central eastern sector of the basin, Late Tortonian): 1 female carapace, 31 female RV, 29 female LV, 2 male RV, 5 male LV.

BA 74 - BA 75 (Cinigiano-Baccinello Basin, Ribaldella 2 section, central western sector of the basin, early Messinian): 2 female and 2 male carapaces, 4 female RV, 2 male RV, 1 male LV.

COP 7 (Cinigiano-Baccinello Basin, Coppai section, north-eastern sector of the basin, early Messinian): 3 female carapaces.

PV 12 - PV 15 (Cinigiano-Baccinello Basin, Poggio Vannini section, north-eastern sector of the basin, early Messinian): 1 female and 1 male carapaces, 5 female RV, 2 female LV, 5 male LV.

Age - Late Tortonian-early Messinian.

TAVANICYTHERE ETRUSCA Bossio, 1980

1980 *Tavanicythere etrusca* n. sp., BOSSIO, pp. 40-42, Pl.2, Figs 1-4.

Few specimens of *Tavanicythere etrusca* have been collected in the Volterra Basin (both Volterra and Radicondoli areas). For the illustration and the description of this species see Bossio (1980). The presence of this species inside the deposits of the lower part of the Argille del Torrente Fosci Fm. extends the stratigraphical distribution of *Tavanicythere etrusca* down to the Late Tortonian.

Dimensions (in mm)

Female LV -	L: 0.49-0.53;	H: 0.27-0.29
Female RV -	L: 0.48-0.55;	H: 0.24-0.29
Male LV -	L: 0.50-0.54;	H: 0.25-0.28
Male RV -	L: 0.51-0.54;	H: 0.24-0.29

Studied material - Sample GT 125 (Volterra Basin, Volterra area, upper portion of the Argille del Torrente Fosci Fm. near Orciatice, early Messinian): 1 male and 4 female carapaces.

RA 88 1 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm. near Poggio Macignano, along the road to Monteguidi, late Tortonian): 5 male and 3 female carapaces.

RA 88 2 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm. near Poggio Macignano, along the road to Monteguidi, late Tortonian): 2 male and 1 female carapaces.

RA II 242 RIL (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. along the Vallone Ameli, early Messinian): 3 male and 5 female carapaces.

Age - Late Tortonian-early Messinian.

TAVANICYTHERE PULCHRA Bossio, 1980

1980 *Tavanicythere pulchra* n. sp., BOSSIO, pp. 38-40, Pl. 1, Figs 6-9, 11; Pl. 2, Figs 5-9.

Several specimens of *Tavanicythere pulchra* have been collected in the Volterra Basin (Radicondoli and Volterra areas). For the illustration and the description of this species see Bossio (1980). The presence of this species inside the deposits of the lower part of the Argille del Torrente Fosci Fm. extends the stratigraph-

ical distribution of *Tavanicythere pulchra* down to the Late Tortonian.

Dimensions (in mm)

Female LV -	L: 0.40-0.51 mm;	H: 0.21-0.24 mm
Female RV -	L: 0.39-0.44 mm;	H: 0.21-0.26 mm
Male LV -	L: 0.40-0.44 mm;	H: 0.23-0.26 mm
Male RV -	L: 0.40-0.50 mm;	H: 0.21-0.24 mm

Collected material - Sample RA 21 (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. early Messinian): 3 female carapaces.

Sample RA 102 (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., early Messinian): 1 male carapace and 1 male LV.

Sample RA 126 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 2 male and 2 female carapaces.

Sample RA 132 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 5 female carapaces.

Sample RA 132 TG (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 3 female carapaces and 1 female LV.

Sample RA 133 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 2 male carapaces.

Sample RA133 TG (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 2 male carapaces.

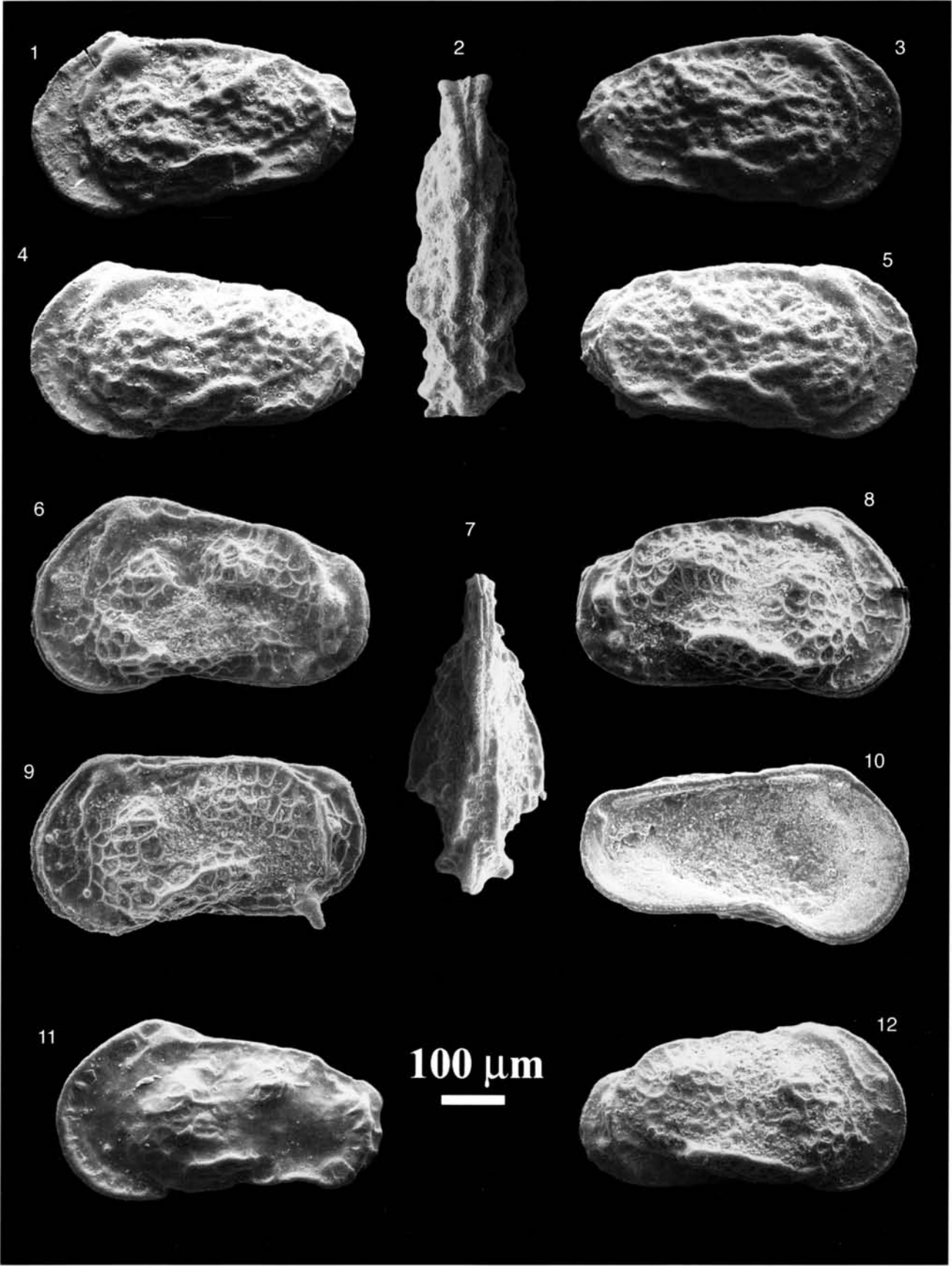
Sample RA 134 (Volterra Basin, Radicondoli area, lower portion of the Argille del Torrente Fosci Fm., 300 m to the W of Casa Mandria, Late Tortonian): 8 male and 9 female carapaces, 2 female RV.

Sample RA 152 RIL (Volterra Basin, Radicondoli area, 500 m to the SW of Casa Materno): 3 female carapaces.

Sample RA II 252 (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Fosci

EXPLANATION OF PLATE 1

- Figs 1-5 - *Tavanicythere varieornata* nov. sp.
1) holotype, female left valve, external view, sample RA II 262 4853; 2) female carapace, dorsal view, sample RA II 262; 3) female right valve, external view, sample RA II 133; 4) female left valve, external view, sample RA II 262; 5) male right valve, external view, sample RA II 262.
- Figs 6-10 - *Tavanicythere persculpta* nov. sp.
6) holotype, female left valve, external view, sample RA 142 4515; 7) female carapace, dorsal view, sample RA 142; 8) female right valve, external view, sample RA 142; 9) male left valve, external view, sample RA 142; 10) female left valve, internal view, sample RA 142.
- Figs 11-12 - *Tavanicythere posteroalata* nov. sp.
11) female left valve, external view, sample RA 118; 12) holotype, female right valve, external view, sample RA 114 4486.



Fm., along the Vallone Ameli, early Messinian): 1 male carapace.

Sample RA II 261 RIL (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Foschi Fm., near Podere Olli, early Messinian): 6 male and 22 female carapaces, 2 female RV and 3 female LV.

Sample RA II 262 (Volterra Basin, Radicondoli area, upper portion of the Argille del Torrente Foschi Fm., near Podere Olli, early Messinian): 1 male, 5 female and 6 juveniles carapaces.

Sample GB 216 (Volterra Basin, Volterra area, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 1 female carapace.

Sample Pozzo Gello 86.10-86.25 m (Volterra Basin, Volterra area, lower portion of the Argille del Torrente Foschi Fm., 1 km to the W of Ponteginori, Late Tortonian): 1 broken female carapace.

Age - Late Tortonian-early Messinian.

TAVANICYTHERE VARIEORNATA nov. sp.
Pl. 1, figs 1-5

Derivatio nominis - From Latin *varius*, *a*, *um* + *ornatus*, *a*, *um*, variously ornamented.

Holotype - Female left valve figured in Pl. 1, fig. 1 (L: 0.53 mm; H: 0.30 mm).

Locus typicus - Volterra Basin, Radicondoli area (Siena, Tuscany).

Stratum typicum - RA II 262 4853, upper portion of the Argille del Torrente Foschi Fm. near Podere Olli, early Messinian.

Diagnosis - Middle-sized *Tavanicythere* with rather laterally depressed carapace, short and rounded posterior margin and strong and rounded reticulation.

Description - Rather strong carapace. In dorsal view it is anteriorly depressed, while posteriorly two slightly inflated zones are visible, divided by a latero-dorsal depression. Posteriorly, the carapace is characterised by two alar expansions.

In lateral view, the valves show a subrectangular shape, with dorsal and ventral margins rather conver-

gent posteriorly. Valves are preplete, with maximum height in correspondence of the anterior cardinal angle. The anterior margin is widely rounded and thickened, the posterior one is short, rectilinear in the upper third and then slightly rounded. Both margins join the ventral one without angularities.

The surface of the valve is irregularly and strongly ornamented. Both the dorsal and ventral margins are thickened by rounded ribs. The anterior area is depressed and smooth, limited anteriorly by a peripheral rounded rib, from which short wrinkles alternate with small rounded papillae. The depressed anterior area is limited posteriorly by a strong rounded rib, which starts from the smooth and well developed eye tubercle. Beyond this keel the valve surface become more inflated and strongly reticulated with polygonal meshes limited by rounded muri. Two inflated areas are visible, one anteriorly and the other in the postero-dorsal region, divided by a marked dorsal depression faintly reticulated. Posteriorly, the inflated surface is divided from the posterior depressed margin by a strong rounded and C-shaped ridge. On the surface, the reticulation is interrupted by strong longitudinal ribs: the more dorsal one starts near the postero-dorsal angle and crosses the latero-dorsal surface; the second one is located mid-ventrally and consists of a horizontal and opened anteriorly Y-shaped ridge.

Sexual dimorphism is the one typical of the genus: male valves show in correspondence of the postero-ventral margin a stout spine, triangular in shape.

The hinge, muscle scars and marginal pore-canals are typical of the genus. On the anterior depression and scattered on the stouter muri of the reticulation, some normal pore-conuli are present.

Dimensions (in mm)

Female LV -	L: 0.50-0.54;	H: 0.30-0.32
Female RV -	L: 0.49-0.55;	H: 0.26-0.32
Male RV -	L: 0.55;	H: 0.30

Studied material - Sample RA 133 (Radicondoli area, lower portion of the Argille del Torrente Foschi Fm. 300 m to the W of Casa Mandria, late Tortonian): 1 female juvenile LV.

Sample RA II 261 (Radicondoli area, upper portion of the Argille del Torrente Foschi Fm. near Podere Olli, early Messinian): 1 female carapace.

Sample RA II 262 (Radicondoli area, upper por-

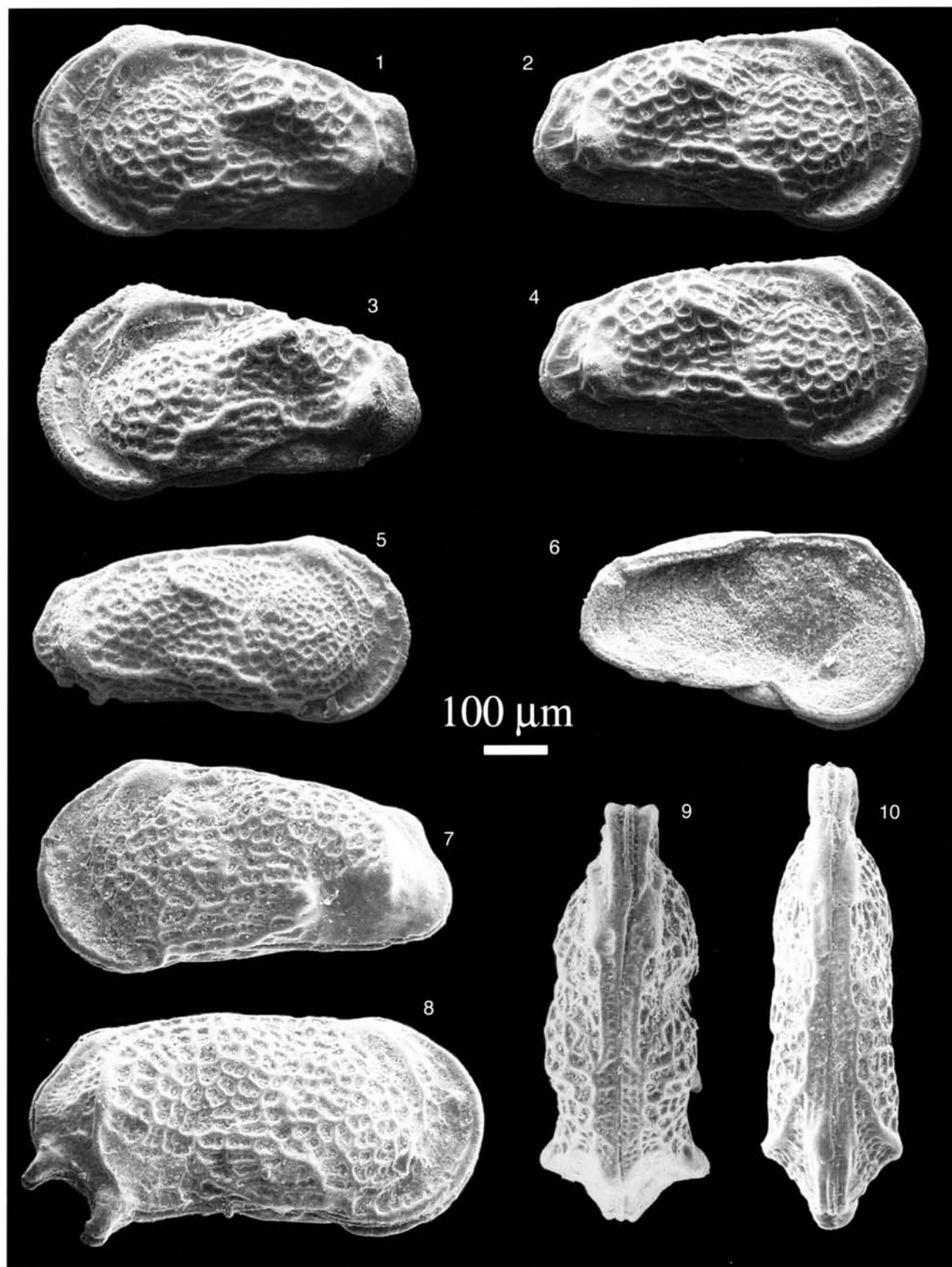
EXPLANATION OF PLATE 2

Figs 1-6 - *Tavanicythere sulcata* nov. sp.

1) holotype, female left valve, external view, sample RA 111 4483; 2) female right valve, external view, sample RA 111 3) female left valve, external view, sample RA 111; 4) female right valve, external view, sample RA 111 4483; 5) male right valve, external view, sample RA 111; 6) female left valve, internal view, sample RA 111.

Figs 7-10 - *Tavanicythere magna* nov. sp.

7) holotype, female left valve, external view, sample GB 198; 8) male right valve, external view, sample GB 198; 9) female carapace, dorsal view, sample GB 198; 10) male carapace, dorsal view, sample GB 198.



tion of the Argille del Torrente Fosci Fm. near Podere Olli, early Messinian): 10 female carapaces.

Sample RA II 262 4853 (Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. near Podere Olli, early Messinian): 1 male carapace, 18 female carapaces and 1 female juvenile RV.

Age – Late Tortonian-early Messinian.

Comparisons – *Tavanicythere varieornata* nov. sp. is comparable with *Tavanicythere persculpta* nov. sp., *Tavanicythere posteroalata* and *Tavanicythere sulcata* nov. sp. from which differs in the shorter posterior margin, in the less protruding antero-ventral margin and in the more delicate ornamentation. Moreover, in dorsal view both female and male carapace are not inflated centrally. In comparison with *Tavanicythere sulcata* nov. sp. it shows smaller dimensions.

TAVANICYTHERE PERSCULPTA nov. sp.
Pl. 1, figs 6-10

Derivatio nominis – From Latin *per* + *sculptus*, *a, um*, very sculptured.

Holotype – Female left valve figured in Pl. 1, fig. 6 (L: 0.52 mm; H: 0.30 mm).

Locus typicus – Volterra Basin, Radicondoli area (Siena, Tuscany).

Stratum typicum – Sample RA 142 4515, upper portion of the Argille del Torrente Fosci Fm. 500 m to the SW of Casa Materno, early Messinian.

Diagnosis – Middle-sized *Tavanicythere* with strongly inflated carapace, depressed anteriorly and posteriorly. Surface strongly reticulated and characterised in the middle of the valve by an upside-down T sulcus.

Description – Rather heavy carapace. In dorsal view, it is arrow shaped and posteriorly, characterised by two expansions.

In lateral view, the valves show a subrectangular shape, with dorsal and ventral margins convergent posteriorly. Valves are preplete, with maximum height at the anterior cardinal angle. The anterior margin is thickened and irregularly rounded with major convexity downward. It joins the ventral margin with an obtuse, rounded angle. The posterior margin is short and slightly convex. It joins the ventral margin without angularities. The ventral margin shows a marked concavity at about 1/3 of the length.

The surface of the valve is irregular and strongly ornamented. The anterior area is depressed and smooth, sometimes reached by thin wrinkles. Posteriorly this area is limited in the antero-dorsal portion, by an evident rounded rib, which starts from the smooth and well developed eye tubercle.

The surface of the valve is characterised by three inflated areas, one located antero-centrally, the second postero-dorsally and the third mid-ventrally. These areas are strongly reticulated with shallow polygonal meshes and are divided by an upside-down T-shaped sulcus in which the reticulation is less evident. Three longitudinal ribs are evident on the lateral surface of the valves: a dorsal one, which underlines the dorsal margin starting from the eye tubercle. At 3/4 of the length, it abruptly changes its direction ventrally, forming a right angle and disappearing almost at mid height. The second longitudinal keel, not always present, is rounded and starts from the postero-dorsal protuberance, going forwards, slightly inclined ventrally. The third rib is short, strong and rounded and is located subventrally in the middle of the valve. In the posterior area, the valve forms an abrupt step and one or two smooth posterior tubercles are visible. The posterior margin is flattened and smooth.

Sexual dimorphism is the typical of the genus: male valves in correspondence of the postero-ventral margin show a stout smooth spine, slightly bending posteriorly.

The hinge, muscle scars and marginal pore-canals are typical of the genus. On the anterior depression and scattered on the network of the reticulation, some normal pore-conuli are present.

Dimensions (in mm)

Female LV -	L: 0.50-0.57;	H: 0.28-0.33
Female RV -	L: 0.48-0.59;	H: 0.29-0.32
Male LV -	L: 0.54;	H: 0.29
Male RV -	L: 0.49-0.50;	H: 0.26-0.27

Studied material – Sample RA 142 4515 (Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. 500 m to the SW of Casa Materno, early Messinian): 3 male and 9 female carapaces.

Age – early Messinian.

Comparisons – *Tavanicythere persculpta* nov. sp. is comparable with *Tavanicythere varieornata* nov. sp., and *Tavanicythere posteroalata* nov. sp. from which differs by the stronger reticulation, the presence of stouter ribs and by the more tuberculated surface of the valve. In comparison with *Tavanicythere sulcata* nov. sp. it shows smaller dimensions.

TAVANICYTHERE POSTEROALATA nov. sp.
Pl. 1, figs 11-12

Derivatio nominis – From Latin *postero*, *is* + *alatus*, *a, um* referring to the posterior alar expansion.

Holotype – Female right valve figured in Pl. 1, fig. 12 (L: 0.52 mm; H: 0.29 mm).

Locus typicus – Volterra Basin, Radicondoli area (Siena, Tuscany).

Stratum typicum – RA 114 4486, upper portion of the Argille del Torrente Foschi Fm. near Poggio Macignano along the road to Monteguidi, early Messinian.

Diagnosis – Middle-sized *Tavanicythere* with rather inflated carapace and variable ornamentation, from delicate reticulation to rather smooth tuberculated and carinated surface.

Description – Rather strong and elongated carapace. In dorsal view it is strongly depressed anteriorly and posteriorly and rather inflated in the middle. Posteriorly it is characterised by two alar expansions.

In lateral view, the valves show an elongated subrectangular shape, with dorsal and ventral margins rather convergent posteriorly. Valves are preplete, with maximum height in correspondence to the anterior cardinal angle. The anterior border is widely rounded and thickened, the posterior one is short and slightly rounded. Often both margins join the ventral one without angularities.

The surface of the valve is irregular and faintly reticulated, with shallow polygonal meshes. Some specimens are almost smooth and only the ribs are evident. The anterior area is depressed and smooth. This area is characterised by short wrinkles alternated with small rounded papillae. Posteriorly the valve becomes inflated and reticulated. In the antero-dorsal area, a smooth rib starting from the eye tubercle is evident. Two blunt reticulated tubercles are visible in the mid-anterior and postero-dorsal areas, divided by a transversal sulcum with less evident reticulation. Ventrally, in the mid part of the valve, a strong rounded rib is developed, bending anteriorly. Dorsally, from the eye-tubercle a sharp rib is developed, which goes posteriorly, underlining the dorsal margin.

Only female valves of this species have been collected, so nothing is known about its sexual dimorphism.

The hinge, muscle scars and marginal pore-canal are typical of the genus. In the anterior depression and scattered in the network of the reticulation, some normal pore-conuli are present.

Dimensions (in mm)

Female LV -	L: 0.45-0.52;	H: 0.27-0.31
Female RV -	L: 0.44-0.53;	H: 0.26-0.31

Studied material – Sample RA 114 4486 (Radicondoli area, upper portion of the Argille del Torrente Foschi Fm. near Poggio Macignano along the road to Monteguidi, early Messinian): 5 female carapaces.

Sample RA 118 (Radicondoli area, lower portion of the Argille del Torrente Foschi Fm. 300 m to the NW of Casa Mandria, upper Tortonian): 7 female carapaces.

Age – Late Tortonian-early Messinian.

Comparisons – *Tavanicythere posteroalata* nov. sp. is comparable with *Tavanicythere varieornata* nov. sp., *Tavanicythere persculpta* nov. sp. and *Tavanicythere sulcata* nov. sp. It differs from *Tavanicythere varieornata* nov. sp. for it shows a more inflated carapace, a different outline and more sharpened ribs. In comparison with *Tavanicythere persculpta* nov. sp. it is more elongated and shows a different outline and a less developed reticulation, with *Tavanicythere sulcata* nov. sp. shows a different outline and smaller dimensions.

TAVANICYTHERE SULCATA nov. sp.

Pl., 2 figs 1-6

Derivatio nominis – From Latin *sulcatum*, sulcated, excavated.

Holotype – Female left valve illustrated in Pl. 2, fig. 1 (L: 0.61 mm; H: 0.35 mm).

Locus typicus – Volterra Basin, Radicondoli area (Siena, Tuscany).

Stratum typicum – Sample RA 111 4483 upper portion of the Argille del Torrente Foschi Fm. near Poggio Macignano along the road to Monteguidi, early Messinian.

Diagnosis – Large-sized *Tavanicythere* with strongly reticulated and irregular surface characterised by deep sulci. Males are characterised by two posterior spines.

Description – Rather heavy and elongated carapace. In dorsal view, it is strongly depressed anteriorly and posteriorly. From the anterior area, the carapace becomes progressively inflated, and at nearly 3/4 of the length it becomes again abruptly depressed. Posteriorly, the carapace is characterised by two expansions.

In lateral view, the valves show a subtrapezoidal shape, with backward convergent dorsal and ventral margins. The ventral margin shows a marked re-entrance at about 1/3 of the length. Valves are preplete, with maximum height in correspondence of the anterior cardinal angle. The anterior margin is widely rounded and thickened. It joins the ventral border with an obtuse, rounded angle. The posterior margin is very short, sinuous in shape (slightly concave in the upper half and convex in the lower one) and slightly inclined posteriorly. It joins the ventral margin without angularities.

The surface of the valve is irregular and strongly ornamented. The anterior area is depressed and smooth or very finely reticulated, subdivided by small wrinkles which, sometimes, are joined forming strong subrounded meshes; posteriorly the anterior area is limited in the antero-dorsal portion, by an evident rounded rib which starts from the eye tubercle, smooth and

well developed. The surface of the valve is characterised by three inflated areas, one located antero-centrally, the second postero-dorsally and the third mid-ventrally. These areas are strongly reticulated and divided by an upside-down T-shaped sulcus. Often, the ventral protuberance extends beyond the ventral margin. Three longitudinal ribs are evident on the lateral surface of the valves: a dorsal one, which underlines the dorsal margin starting from the eye tubercle. At 3/4 of the length, it abruptly changes its direction, forming an obtuse angle, paralleling the posterior margin; then it is broadly curved and directed anteriorly. In correspondence of this curvature, often a smooth and stout tubercle is developed. The first rib joins the ventral protuberance at about 2/3 of the total length. The second longitudinal rib is rounded and short; it starts from the postero-dorsal protuberance, going forwards, slightly inclined ventrally. Finally the third rib is short, strong and rounded and is located ventrally in the middle of the valve. The posterior margin is flattened and smooth or finely reticulated. Sometimes it is crossed by three short ribs.

Sexual dimorphism is the one typical of the genus: in correspondence of the postero-ventral margin, the male valves show two stout, smooth spines, slightly bending posteriorly.

The hinge, muscle scars and marginal pore-canals are typical of the genus. In the anterior depression some normal pore-conuli are present.

Dimensions (in mm)

Female LV -	L: 0.54-0.64;	H: 0.31-0.37
Female RV -	L: 0.54-0.62;	H: 0.28-0.36
Male LV -	L: 0.58-0.62;	H: 0.31-0.34
Male RV -	L: 0.58;	H: 0.30

Collected material - Sample RA 21 (Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. near Poggio Macignano along the road to Monteguidi, early Messinian): 3 female carapaces.

Sample RA 23 (Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. near Poggio Macignano along the road to Monteguidi, early Messinian): 2 male and 9 female carapaces.

Sample RA 111 (Radicondoli area, upper portion

of the Argille del Torrente Fosci Fm. near Poggio Macignano along the road to Monteguidi, early Messinian): 6 female carapaces.

Sample RA 111 4483 (Radicondoli area, upper portion of the Argille del Torrente Fosci Fm. near Poggio Macignano along the road to Monteguidi, early Messinian): 2 male and 12 female carapaces.

Age - early Messinian.

Comparisons - *Tavanicythere sulcata* nov. sp. is comparable with *Tavanicythere varieornata* nov. sp., *Tavanicythere persculpta* nov. sp. and *Tavanicythere posteroalata* nov. sp. from which it differs in the greater dimensions, in the stronger reticulation and for the presence of two spines on the posterior ventral margin of the male valves. It shares this character with *Tavanicythere magna* nov. sp. from which differs in the smaller dimensions and for the presence, in the ornamentation, of longitudinal elements.

TAVANICYTHERE MAGNA nov. sp.

Pl. 2, figs 7-10; Pl. 3, figs 1, 3

Derivatio nominis - From Latin *magnus*, *a*, *um*, large.

Holotype - Left female valve figured in Pl. 2, fig. 7 (L: 0.65 mm; H: 0.34 mm).

Locus typicus - Volterra basin (Tuscany).

Stratum typicum - Sample GB 198, Spicchiola Fm., to the S of Mazzolla, early Messinian.

Diagnosis - Large-sized *Tavanicythere* with slender female and male carapaces flattened anteriorly. Valves are characterised by strong reticulation. Male valves show the presence of two postero-ventral spines.

Description - Large, rather heavy and elongated carapace. In dorsal view, it is strongly depressed anteriorly and posteriorly. From the anterior area, the female carapace become progressively enlarged, and shows two blunt inflated areas. Posteriorly, the cara-

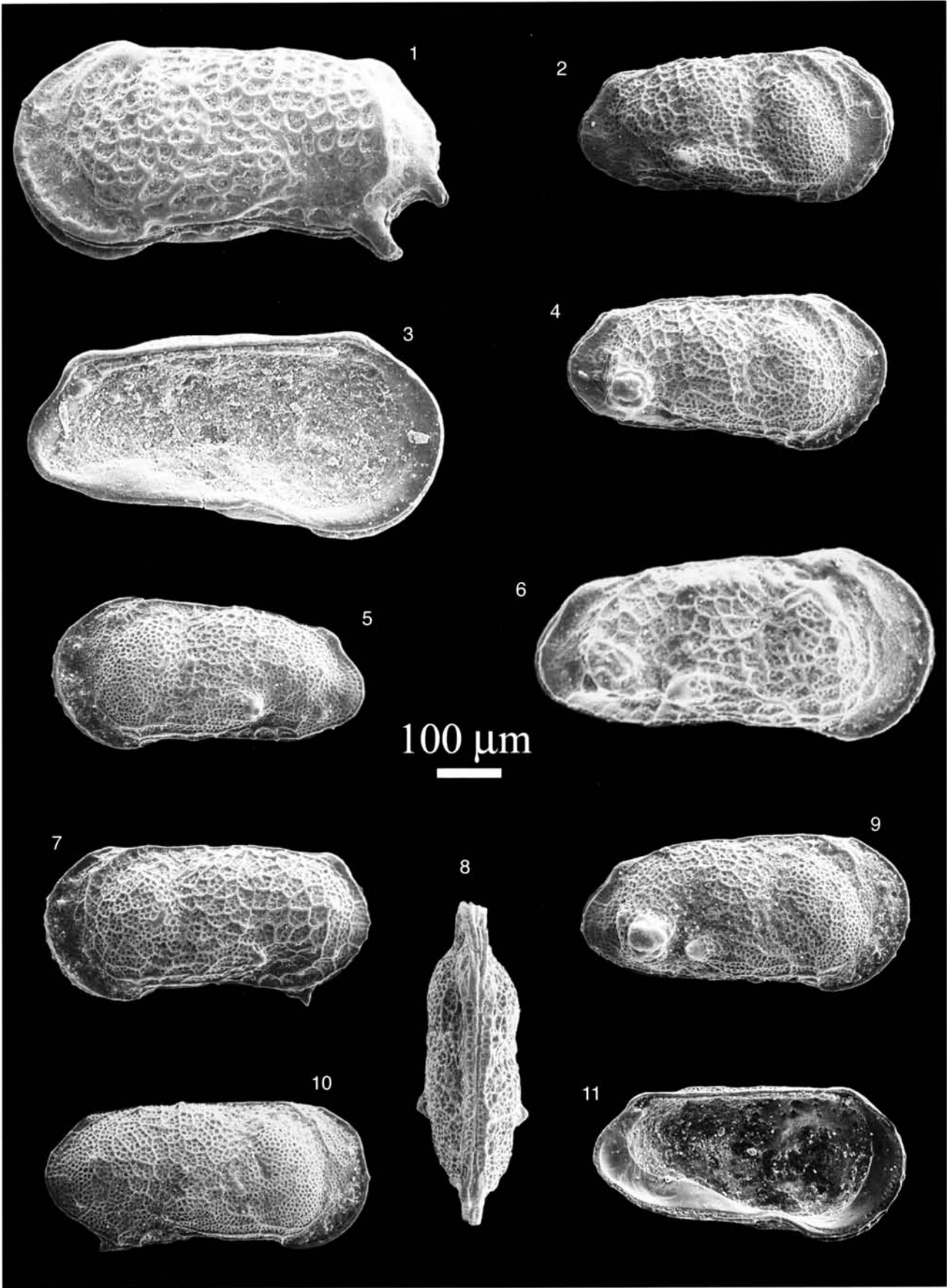
EXPLANATION OF PLATE 3

Figs 1, 3 - *Tavanicythere magna* nov. sp.

1) male left carapace, left external view, sample GB 198; 3) female left valve, internal view, sample GB 198.

Figs 2, 4-11 - *Tavanicythere nodosa* nov. sp.

2) female right carapace, right external view, specimen without posterior tubercle, sample FD 88; 4) holotype, female carapace, right external view, specimen with well developed posterior tubercle, sample GB 205; 5) female left valve, external view, specimen without posterior tubercle, sample GB 206; 6) female carapace, right external view, specimen with slightly developed posterior tubercle, sample BA 5; 7) male left valve, external view, sample GB 205; 8) female carapace, dorsal view (specimen without posterior tubercle), sample FD 88; 9) female right valve, external view, specimen with well developed posterior tubercle, sample GB 206; 10) male right valve, external view, sample GB 206; 11) female left valve, internal view, sample GB 206.



pace is characterised by two alar expansions. The male carapace is less inflated.

In lateral view, the valves show an elongated, subtrapezoidal shape, with dorsal and ventral margins slightly convergent posteriorly. The ventral margin shows a slight re-entrance at about 1/3 of the length. Valves are preplete, with maximum height in correspondence of the anterior cardinal angle. The anterior margin is thickened and rounded. It joins the ventral margin with an obtuse, rounded angle. The posterior margin is short, sinuous in shape and inclined posteriorly. It joins the ventral margin without angularities.

The surface of the valve is irregular and reticulated. The anterior surface is depressed and smooth, sometimes innerly underlined by small wrinkles; posteriorly it is limited, in the antero-dorsal portion, by an evident rounded rib, which starts from the smooth and well developed eye tubercle. The surface of the female valve is characterised by two inflated areas, one located antero-centrally and the second one postero-dorsally. These areas are strongly reticulated and divided by a mid-dorsal sulcus. Ventrally, in the middle of the valve, the surface is limited by a rounded rib, which ends posteriorly in a stout, smooth spine projected posteriorly. The posterior protuberance is bordered posteriorly by an evident rounded rib, which parallels the posterior margin, and, often, it is thickened ventrally by a stout, smooth tubercle. The posterior margin is flattened and smooth.

Sexual dimorphism typical of the genus: in correspondence of the postero-ventral border the male valves bear two stout, smooth spines, slightly bending posteriorly. The male valve surface is less irregular, and the middle-dorsal sulcus is only slightly visible. Often the latero-ventral spine is absent.

The hinge, muscle scars and marginal pore-canals are typical of the genus. On the anterior depression, one normal pore-conule is present.

Dimensions (in mm)

Female LV -	L: 0.62-0.67;	H: 0.33-0.37
Female RV -	L: 0.63-0.67;	H: 0.33-0.38
Male LV -	L: 0.65-0.71;	H: 0.32-0.38
Male RV -	L: 0.66-0.69;	H: 0.33-0.37

Studied material – Sample GB 198 (Volterra basin, Spicchiaiola Fm., to the S of Mazzolla, early Messinian): 14 male and 22 female carapaces.

Age – early Messinian.

Comparisons – *Tavanicythere magna* nov. sp. is the largest species of *Tavanicythere* recognised up to now. Moreover, it differs from the other species assigned to this genus for the more rectangular shape and the regular polygonal ornamentation.

TAVANICYTHERE NODOSA nov. sp.

Pl. 3, figs 2, 4-11

Derivatio nominis – From Latin *nodosus*, a, um, with nodes.

Holotype – Right female valve figured in Pl. 3, fig. 4 (L: 0.48 mm; H: 0.25 mm).

Locus typicus – Volterra Basin (Tuscany).

Stratum typicum – GB 205, Spicchiaiola Fm., to the W of Mazzolla, early Messinian.

Diagnosis – Middle-sized *Tavanicythere* with slender carapace flattened anteriorly and posteriorly. Elongated valves with broadly rounded posterior margin. Surface covered by strong primary reticulation with polygonal meshes and fine secondary reticulation with small rounded or quadrangular meshes. Sometimes a posterior globose smooth node is well developed.

Description – Slender carapace, strongly flattened anteriorly and slightly posteriorly. The lateral surface is divided by a very shallow dorsal sulcus located in front of the mid length. At 3/4 of the length, two spines are visible, protruding laterally. The dorsal margin is characterised by a faint rib, heavily reticulated.

In lateral view, the valves are moderately elongated and subtrapezoidal in shape. Valves are preplete, with maximum height in correspondence of the anterior cardinal angle. The dorsal and ventral margins converge weakly posteriorly. The anterior margin is widely rounded and thickened; the posterior one is con-

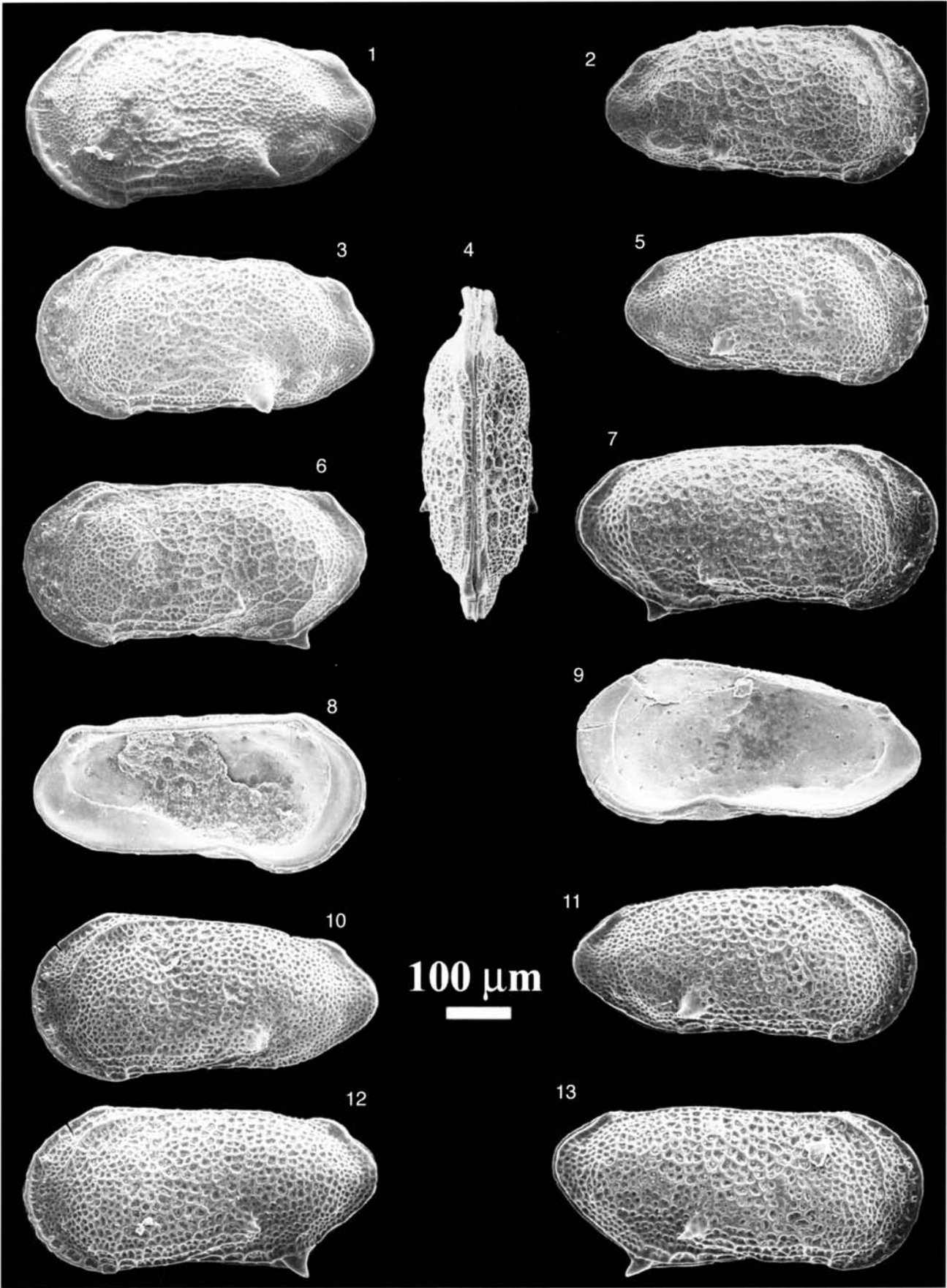
EXPLANATION OF PLATE 4

Figs 1-8 – *Tavanicythere armata* nov. sp.

1) female left valve, external view, specimen with spine, sample POZZO GELLO 112.0-112.1 m; 2) female right valve, external view, specimen without spine, sample GB 210; 3) holotype, female left valve, external view, specimen with tubercle and blunt spine, sample GB 213; 4) female carapace, dorsal view, sample GB 207; 5) female right valve, external view, specimen with spine, sample GB 214; 6) male left valve, external view, sample GB 210; 7) male right valve, external view, sample GB 212; 8) female left valve, internal view, sample GB 207.

Figs 9-13 – *Tavanicythere ioachinoi* nov. sp.

9) female right valve, internal view, sample GB 216; 10) holotype, female left valve, external view, sample GB 216; 11) female right valve, external view, sample GB 214; 12) male left valve, external view, sample GB 216; 13) male right valve, external view, sample GB 214.



cave in its dorsal half and then is broadly rounded, joining the ventral margin without angularities. In male valves the posterior margin is more rounded.

The anterior and posterior surfaces of the valve are flattened and more or less finely reticulated. The surface of the valve is characterised by two or three moderately inflated areas, divided by one or two dorso-ventral sulci, the anterior one slightly more marked than the posterior. Sometimes a longitudinal mid-ventral sulcus evidences a moderately inflated ventral area, which ends posteriorly with a spine. In some specimens, posteriorly to this spine a globose smooth node is developed.

The valves are reticulated with a moderately strong primary reticulation with polygonal meshes and a fine secondary reticulation with small and irregular quadrangular meshes.

Sexual dimorphism is the typical of the genus. The male valves, near the postero-ventral angle show a small flattened triangular spine, protruding ventrally.

The hinge, muscle scars and marginal pore-canals are typical of the genus. On the anterior depression and scattered on the primary network of the reticulation, some normal pore-conuli are present.

Internally, the duplicature is wide anteriorly and posteriorly, where its inner border is rather undulated.

Dimensions (in mm)

Female LV -	L: 0.46-0.56;	H: 0.23-0.29
Female RV -	L: 0.48-0.56;	H: 0.23-0.27
Male LV -	L: 0.52-0.59;	H: 0.24-0.28
Male RV -	L: 0.51-0.55;	H: 0.24-0.25

Studied material - Sample FD 88 (along the Torrente Caprugine, 3 km SW of Il Castagno locality, upper part of the Argille del Torrente Foschi Fm., early Messinian): 2 male and 16 female carapaces.

GB 205 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 1 male and 11 female carapaces.

GB 206 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 4 male and 12 female carapaces.

BA 4, BA 5, BA 6, BA 7, BA 10, BA 13 (Torrente Trasubbie section, SE sector of the Cinigiano-Baccinello

lo Basin, Late Tortonian): on the whole 2 female LV, 3 female RV, 1 male RV and 2 male LV.

Age - Late Tortonian-early Messinian.

Comparisons - *Tavanicythere nodosa* nov. sp. is comparable with *Tavanicythere armata* nov. sp. and *Tavanicythere ioachinoi* nov. sp. from which differs for the more rounded posterior margin, particularly in the male valves, for the less developed posterior lateral spine and for the slightly smaller dimensions (except for the Cinigiano-Baccinello specimens which are larger).

TAVANICYTHERE ARMATA nov. sp.

Pl. 4, figs 1-8; Pl. 6, fig. 1

Derivatio nominis - From Latin *armatus*, *a*, *um*, armored, referring to the elaborated ornamentation.

Holotype - Left female valve figured in Pl. 4, fig. 3 (L: 0.52 mm; H: 0.27 mm).

Locus typicus - Volterra Basin (Tuscany).

Stratum typicum - GB 213, Spicchiaiola Fm., to the W of Mazzolla, early Messinian.

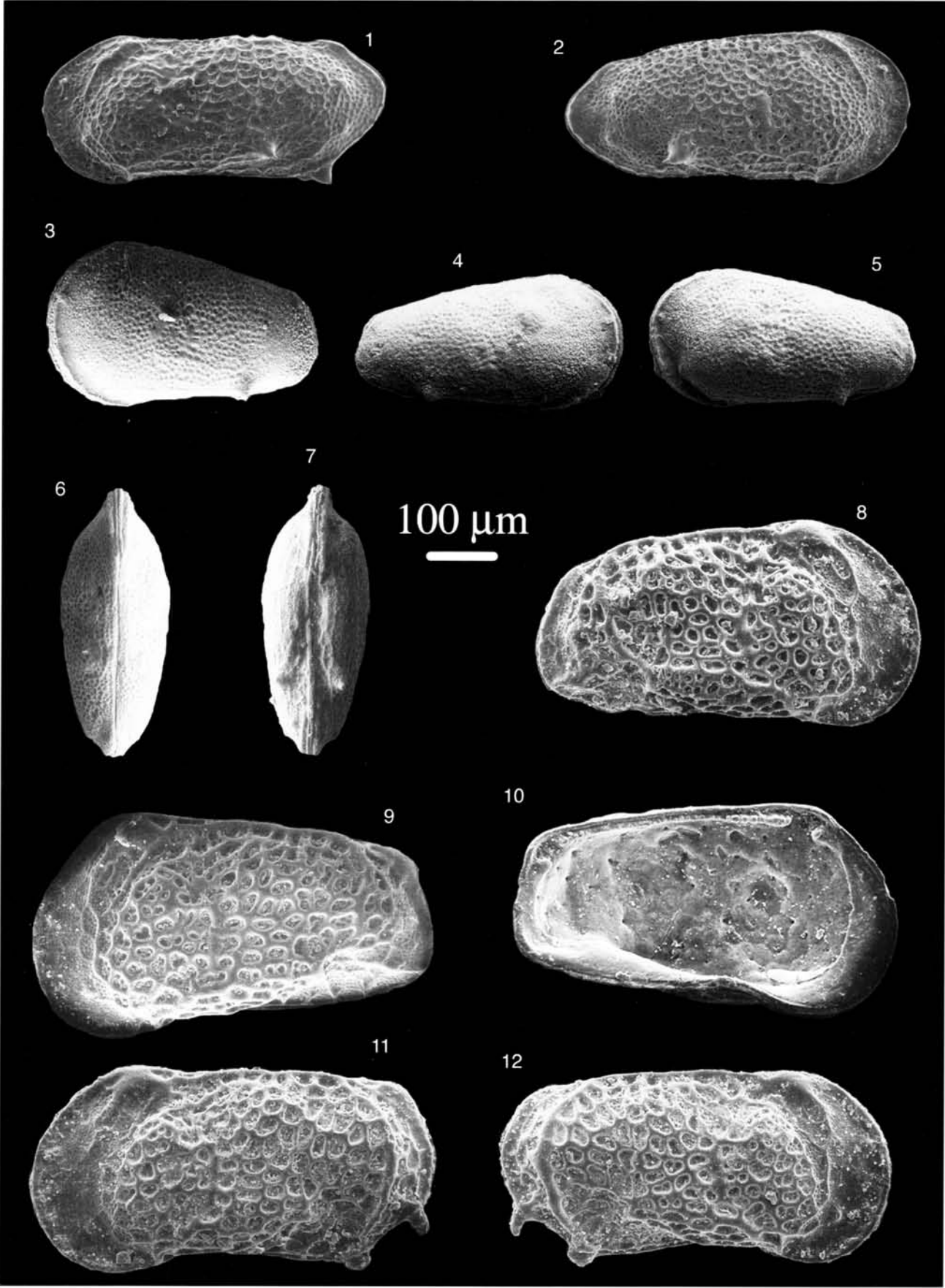
Diagnosis - Middle-sized *Tavanicythere* with slender carapace, primary and secondary fine reticulation and slightly pointed and short posterior margin.

Description - Elongated carapace, slender, strongly depressed anteriorly and posteriorly. One weak dorsal sulcus, located slightly in front of the mid length, divides the anterior zone from the posterior. At 3/4 of the length, two latero-ventral spines are visible, projecting posteriorly.

In lateral view, the valves are elongated and sub-trapezoidal. They are preplete, with maximum height in correspondence of the anterior cardinal angle. Dorsal and ventral margins are sub-parallel, the anterior one is widely rounded and thickened. The ventral margin is faintly concave, and joins the posterior one without angularities. The posterior margin is very short,

EXPLANATION OF PLATE 5

- Figs 1-2 - *Tavanicythere ioachinoi* nov. sp.
1) male left valve, external view, sample ALC FIZZANO; 2) female right valve, external view, sample ALC FIZZANO.
- Figs 3-7 - *Tavanicythere* l.
3) carapace, left external view, sample RA II 251 RIL; 4) carapace, right external view, sample RA II 251 RIL; 5) carapace, left external view, sample RA II 251 RIL; 6) carapace, dorsal view, sample RA II 251 RIL; 7) carapace, ventral view, sample RA II 251 RIL.
- Figs 8-12 - *Tavanicythere julianii* nov. sp.
8) female right valve, external view, sample RA 107; 9) holotype, female left valve, external view, sample RA 107; 10) female left valve, internal view, sample RA 107; 11) male left valve, external view, sample RA 107; 12) male right valve, external view, sample RA 107.



concave in its dorsal half and then rather pointed.

The anterior area is strongly depressed; its surface is smooth, or finely reticulated. The lateral surface of the valve is characterised by two slightly inflated areas, divided dorsally by a shallow transversal sulcus. Sometimes the posterior inflated zone is more developed and extends beyond the dorsal margin. Near the postero-ventral zone, a little smooth spine is present, projected posteriorly. Ornamentation is rather variable. Generally is made of primary and secondary reticulation. Both are present in the central lateral surface, while anteriorly and posteriorly only secondary reticulation is present. Anyway, in some valves the primary reticulation is absent and only secondary reticulation is evident, with more marked network. Generally, meshes are wider dorsally and ventrally.

Sexual dimorphism is the typical of the genus. The male valves have near the postero-ventral angle a small, flattened triangular spine projected posteriorly.

The hinge, muscle scars and marginal pore-canal are typical of the genus. On the anterior depression and scattered on the primary network of the reticulation, some normal pore-conuli are present.

Internally, the duplicature is wide both anteriorly and posteriorly, where its inner margin is rather undulated.

Dimensions (in mm)

Female LV -	L: 0.51-0.56;	H: 0.26-0.30
Female RV -	L: 0.50-0.54;	H: 0.24-0.27
Male LV -	L: 0.55;	H: 0.27
Male RV -	L: 0.52;	H: 0.25-0.26

Studied material – GB 207 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 3 male and 16 female carapaces.

GB 210 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 3 carapaces.

GB 213 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 1 female LV and 1 broken male LV.

GB 214 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 1 broken male LV and 1 broken female LV.

GB 216 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 6 juvenile valves.

Pozzo Gello 112.0-112.1m (Volterra basin, lower part of the, "Argille del Torrente Foschi Fm.", about 1 km W of Ponteginori, Late Tortonian): 1 female carapace.

Age – Late Tortonian-early Messinian.

Comparisons – *Tavanicythere armata* nov. sp. is very similar to both *Tavanicythere nodosa* nov. sp. and *Tavanicythere ioachinoi* nov. sp. in the general shape and in the ornamentation. It differs from the first for the slightly larger dimensions, and for a more pointed posterior margin, while, in comparison with *Tavani-*

cythere ioachinoi nov. sp. it shows a shorter and less pointed posterior margin and a more polygonal reticulation.

TAVANICYTHERE IOACHINOI nov. sp.
Pl. 4, figs 9-13; Pl. 5, figs 1-2

Derivatio nominis – This species is devoted to the memory of our colleague and friend Gioacchino Bonaduce.

Holotype – Left female valve figured in Pl. 4, fig. 10 (L: 0.54 mm; H: 0.27 mm).

Locus typicus – Volterra Basin (Tuscany).

Stratum typicum – GB 216, Spicchiaiola Fm., to the W of Mazzolla, early Messinian.

Diagnosis – Middle-sized *Tavanicythere* characterised by an elongated and strongly pointed posterior margin and by a fine reticulation made by delicate primary polygonal meshes and stronger secondary rounded meshes.

Description – Elongated carapace, moderately inflated, strongly depressed anteriorly and posteriorly. One weak dorsal sulcus divides the anterior zone from the posterior, located slightly in front of the mid length. At 3/4 of the length, two very little latero-ventral spines are visible, projecting posteriorly.

In lateral view, the valves are subtrapezoidal and very elongated. They are preplete, with maximum height in correspondence of the anterior cardinal angle. Dorsal and ventral margins are subrectilinear and inclined posteriorly, the anterior margin is widely rounded and thickened. The ventral margin posteriorly rises very inclined towards the posterior one and joins it at almost half height of the valve, without angularities. The posterior margin is very short, concave and remarkably inclined backwards in its dorsal half and then strongly pointed.

The anterior and posterior margins are strongly depressed. Both surfaces are finely reticulated. The lateral surface of the valve is characterised by two slightly inflated areas, divided dorsally by a shallow transversal sulcus located slightly in front of the middle of the valve. Near the postero-ventral zone, a little smooth spine is present, projected posteriorly. Ornamentation is made of a fine reticulation in the anterior and posterior areas, while in the middle-dorsal surface it is coarser.

Sexual dimorphism is the one typical of the genus. The male valves near the postero-ventral angle show a small flattened triangular spine, slightly projected posteriorly.

The hinge, muscle scars and marginal pore-canal are typical of the genus. On the anterior depression and scattered on the primary network of the reticula-

tion, some normal pore-conuli are present.

Internally, the duplicature is wide anteriorly and posteriorly.

Dimensions (in mm)

Female LV -	L: 0.46-0.57;	H: 0.24-0.30
Female RV -	L: 0.46-0.55;	H: 0.24-0.30
Male LV -	L: 0.55-0.56;	H: 0.25-0.30
Male RV -	L: 0.49-0.57;	H: 0.23-0.28

Studied material - GB 214 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 2 male and 3 female carapaces.

GB 216 (Volterra basin, Spicchiaiola Fm., to the W of Mazzolla, early Messinian): 5 male LV, and 5 female carapaces.

ALC Fizzano (Valdelsa Basin, Borro Strolla area, along the Torrente Strolla near Fizzano locality, Late Tortonian-early Messinian): 15 female LV, 10 female RV, 5 male LV and 4 male RV.

Age - Late Tortonian-early Messinian.

Comparisons - *Tavanicythere ioachinoi* nov. sp. is comparable with *Tavanicythere nodosa* nov. sp. and *Tavanicythere armata* nov. sp. It shares with those species the elongated shape, the fine primary and secondary reticulation and the triangular shape of the postero-ventral spine on the male valves. Anyway, it is distinguishable from them for its posterior margin, which is elongated and strongly pointed.

TAVANICYTHERE sp. I

Pl. 5, figs 3-5

Six carapaces of *Tavanicythere* sp. I have been recovered from Upper Tortonian samples collected in the Radicondoli area (Volterra Basin). They are characterised by a sub-trapezoidal and short carapace, finely pitted. The anterior and posterior areas are depressed and smooth. A pore-conule is always present in the mid anterior margin. The recovered valves show different L/H ratios, which suggest eventually the presence of both male and female valves, but all of them are characterised by a postero-ventral spine which is considered a male character.

The scarcity of the character suggests to leave this species in open nomenclature, till the recovery of some other specimens could confirm its peculiar morphological characters.

Dimensions (in mm)

LV -	L: 0.41-0.43;	H: 0.22-0.23
RV -	L: 0.43-0.45;	H: 0.22-0.23

Collected material - RA 251 Ril (Volterra basin, Radicondoli area, upper part of the Argille del Torrente Foschi Fm., along Vallone Ameli, early Messinian): 6 carapaces.

Age - early Messinian.

TAVANICYTHERE JULIANII nov. sp.

Pl. 5, figs 8-12

Derivatio nominis - This species is devoted to the memory of our "Maestro" Giuliano Ruggieri.

Holotype - Female left valve figured in Plate 5, fig. 9 (L: 0.61 mm; H: 0.35 mm).

Locus typicus - Volterra Basin, Radicondoli area (Siena, Tuscany).

Stratum typicum - RA 107 Radicondoli area, lower portion of the Argille del Torrente Foschi Fm., near Poggio Marcignano, along the road to Monteguidi, Late Tortonian.

Diagnosis - Large-sized *Tavanicythere*, characterised by strong reticulation made by rounded meshes divided by thick rounded network. Male valves bear two postero-ventral spines.

Description - Rather strong and elongated carapace rather inflated in the central area and flattened anteriorly and posteriorly.

In lateral view, the valves show an elongated sub-trapezoidal shape, with dorsal and ventral margins slightly convergent posteriorly. Valves are preplete, with maximum height in correspondence of the anterior cardinal angle. The anterior margin is widely rounded and shows a marginal ridge, the posterior one is shorter, sub-rectilinear in the upper third and then slightly rounded. Both margins join the ventral one without angularities.

The surface of the valve is irregular and strongly ornamented. The anterior area is depressed and smooth or finely pitted. Posteriorly it is limited by a bifurcated ridge, which starts from the eye-tubercle that is well developed. Backwards, the valve becomes inflated and reticulated. Two inflated areas are visible, one in the mid-anterior and the second one in the postero-dorsal area, divided by a transverse sulcus. Dorsally, from the eye-tubercle a sharp rib starts which goes posteriorly, underlining the dorsal margin. At almost 3/4 of the length it curves ventrally with a round angle and directs forwards, paralleling the ventral border. The posterior area is depressed and finely pitted.

Sexual dimorphism is the typical of the genus. The male valves near the postero-ventral angle have two spines, one horn-like and the other short and stout.

The hinge, muscle scars and marginal pore-canals are typical of the genus. On the anterior surface some normal pore-conuli are present.

Dimensions (mm)

Female LV -	L: 0.59-0.61;	H: 0.31-0.35
Female RV -	L: 0.60;	H: 0.34-0.35

Male LV - L: 0.63; H: 0.33
 Male RV - L: 0.61; H: 0.30

Studied material – RA 107 and RA 107 RIL (Volterra basin, Radicondoli area, lower portion of the Argille del Torrente Foschi Fm., near Poggio Marcignano, along the road to Monteguidi, Late Tortonian): 2 male LV and 6 carapaces.

BA 4, BA 7, (Torrente Trasubbie section, SE sector of the Cinigiano-Baccinello Basin, Late Tortonian): 2 female LV.

Age – Late Tortonian.

Comparisons – *Tavanicythere julianii* nov. sp. is comparable with *Tavanicythere magna* nov. sp. for the large size, the strong ornamentation and the presence of two postero-ventral spines on the male valves. It differs from that species for the less pointed and short posterior margin and for the ornamentation, which is made by more rounded meshes. In addition, it is slightly smaller.

TAVANICYTHERE PARVA nov. sp.
 Pl. 6, figs 2-9

Derivatio nominis – From Latin *parvus*, *a*, *um*, small.

Holotype – Left female valve figured in Plate 6, fig. 3 (L: 0.45 mm; H: 0.25 mm).

Locus typicus – Volterra basin, Radicondoli area (Siena, Tuscany).

Stratum typicum – RA II 248, upper portion of the Argille del Torrente Foschi Fm., along the Vallone Ameli, early Messinian.

Diagnosis – Small-sized *Tavanicythere* characterised by a slender carapace and by a marked concavity of the ventral margin.

Description – Small carapace, strongly depressed anteriorly and posteriorly, very slightly inflated ante-

ro- and postero laterally. A shallow median sulcus is visible in dorsal view.

In lateral view, the valves are subtrapezoidal. They are preplete, with maximum height in correspondence of the anterior cardinal angle. The dorsal margin is subrectilinear, the ventral one concave; both are inclined posteriorly.

The anterior margin is widely rounded and thickened. The ventral margin rises posteriorly very inclined towards the posterior one which is very short, concave and remarkably inclined backwards in its dorsal half and then rounded.

The anterior and posterior surfaces are strongly depressed. The anterior surface is reticulated, while the posterior is smooth or, sometimes, crossed by few, short ribs.

The lateral surface of the valve is characterised by two slightly inflated areas, divided by a shallow transversal sulcus. Sometimes the posterior inflated zone is more developed and extends beyond the dorsal margin. In some valves, near the postero-ventral zone a little smooth spine is present, projected posteriorly. The posterior protuberance is limited backwards by a strong, high and smooth rib. The reticulation of the surface is rather variable. Some specimens are characterised by strong primary reticulation, with polygonal meshes delimited by a thick network. Other are characterised by finer primary and secondary reticulations.

Sexual dimorphism is evidenced particularly by the presence of the postero-ventral spine slightly projected posteriorly, while the sex ratio of female and male valves is very similar.

The hinge, muscle scars and marginal pore-canal are typical of the genus. On the anterior depression normal pore-conuli are present.

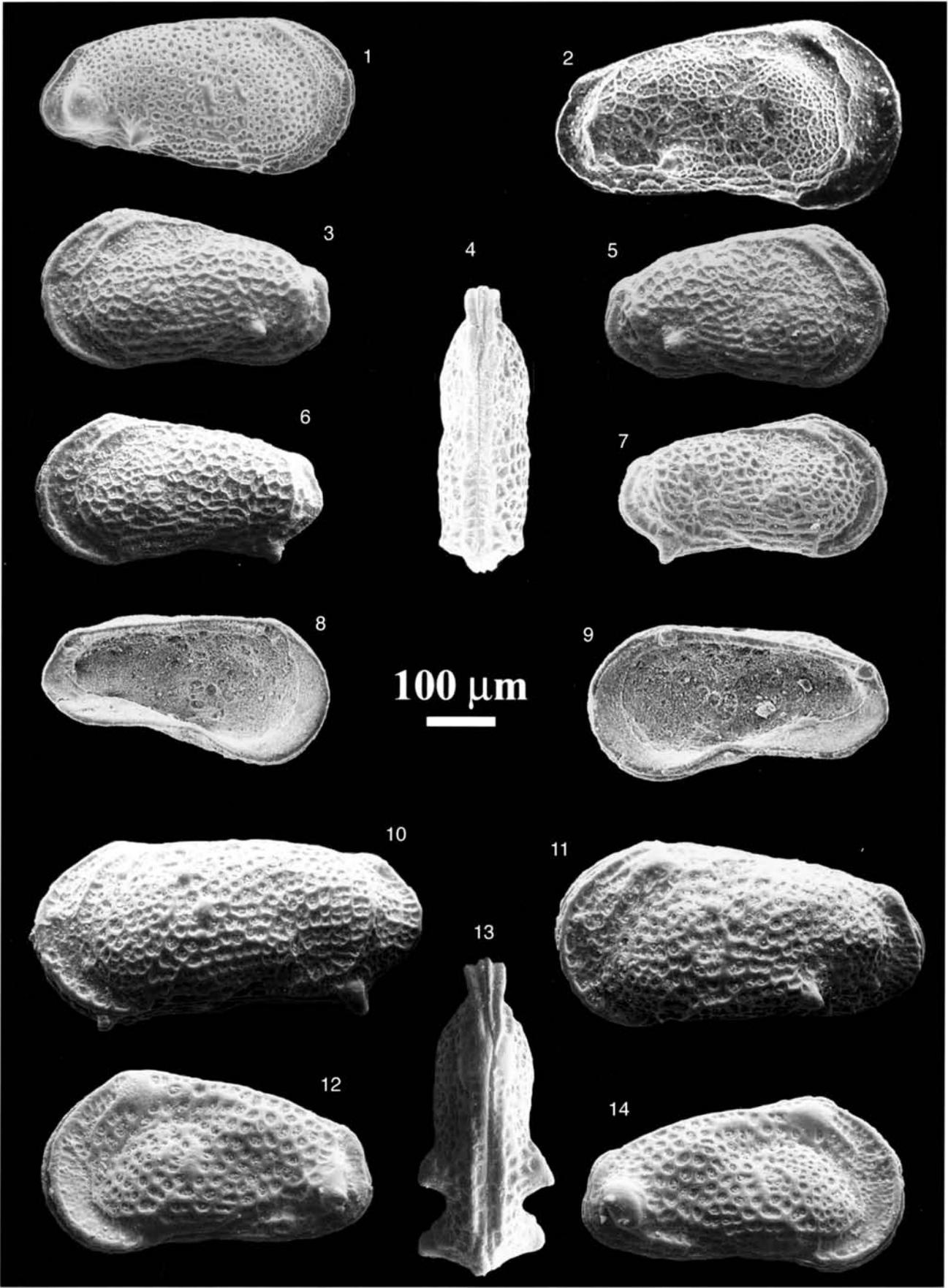
Internally, the duplicature is wide anteriorly and very wide posteriorly.

Dimensions (in mm)

Female LV - L: 0.41-0.46; H: 0.23-0.27
 (at Baccinello the valves are slightly larger: L=0.52)
 Female RV - L: 0.41-0.45; H: 0.22-0.26
 (at Baccinello the valves are slightly larger: L=0.50-0.58)

EXPLANATION OF PLATE 6

- Fig. 1. - *Tavanicythere armata* nov. sp., juvenile right valve, external view, sample GB 214.
 Figs 2-9 - *Tavanicythere parva* nov. sp.
 2) female right valve, external view, sample BA 7; 3) holotype, female left valve, external view, sample RA II 248; 4) female carapace, dorsal view, sample RA II 252; 5) female right valve, external view, sample RA II 248; 6) male left valve, external view, sample RA II 251 RIL; 7) male right valve, external view, sample RA II 252; 8) female left valve, internal view, sample RA II 252; 9) female right valve, internal view, sample RA II 252.
 Figs 10-11 - *Tavanicythere* M.
 10) male carapace, left external view, sample POZZO GELLO 75.70-76.20 m; 11) female carapace, left external view, sample POZZO GELLO 75.70-76.20 m.
 Figs 12-14 - *Tavanicythere* N.
 12) female carapace, left external view, sample RA 118; 13) carapace, dorsal view, sample RA 118; 14) female carapace, right external view, sample RA 118.



Male LV - L: 0.41-0.44; H: 0.21-0.26
(at Baccinello the valves are slightly larger: L=0.61)
Male RV - L: 0.39-0.43; H: 0.21-0.23

Studied material – RA II 252 (Volterra basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., along the Vallone Ameli, early Messinian): 3 male and 8 female carapaces.

RA II 252 RIL (Volterra basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., along the Vallone Ameli, early Messinian): 13 male and 31 female carapaces.

RA II 251 RIL (Volterra basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., along the Vallone Ameli, early Messinian): 4 male and 10 female carapaces.

RA II 248 (Volterra basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., along the Vallone Ameli, early Messinian): 3 female carapaces.

BA 4, BA 6, BA 7, (Torrente Trasubbie section, SE sector of the Cinigiano-Baccinello Basin, Late Tortonian): on the whole 1 male LV, 1 female LV, and 4 female RV.

Age – Late Tortonian-early Messinian.

Comparisons – *Tavanicythere parva* nov. sp. is the smallest species of the genus recorded up to now. For its general shape, it is comparable with *Tavanicythere lepida* from which it differs for the more undulated ventral margin and the shorter posterior margin.

TAVANICYTHERE sp. M
Pl. 6, figs 10-11

Four carapaces of *Tavanicythere* sp. M have been recovered from the Gello borehole, in the Volterra Basin, from one sample located at 75.70-76.20 m of depth in the sediment core, referable to the Late Tortonian. The general outline is similar to *T. etrusca*, but it differs from this species in the more elongated proportions of both males and females and in the flattened posterior area, which is more developed. Moreover, in the male carapace, besides the postero-ventral spine, which is typical of all the *Tavanicythere* males, there is another small and stout spine in correspondence to the antero-ventral angle. This feature has not yet been observed in any other *Tavanicythere* species.

Anyway, the scarcity of the valves suggest to leave this species in open nomenclature, till the recovery of some other specimens could confirm its peculiar morphological characters.

Dimensions (in mm)

Female LV - L: 0.54; H: 0.29
Female RV - L: 0.54; H: 0.29-0.30
Male LV - L: 0.54; H: 0.29

Studied material – Pozzo Gello 75.7-76.2 m (Volterra basin, lower part of the, "Argille del Torrente Fosci Fm.", about 1 km W of Ponteginori, Late Tortonian): 1 male and 3 female carapaces.

Age – Late Tortonian.

TAVANICYTHERE sp. N
Pl. 6, figs 12-14

Five carapaces of *Tavanicythere* sp. N, referable only to female specimens, have been recovered from the Upper Tortonian sediments of the Radicondoli area. The general lateral outline is similar to *Tavanicythere parva* nov. sp., but it differs from this species in the larger dimensions, in a more articulated surface of the valves and in a stronger reticulation with flattened network. Moreover, *Tavanicythere* sp. N lacks the latero-posterior spine while it shows a developed smooth tubercle located in the postero-ventral area. In some carapaces, a blunt tubercle is developed also in the postero-dorsal area, slightly in front of the posterior one.

The scarcity of the valves suggests to leave this species in open nomenclature, till the recovery of some other specimens could confirm its peculiar morphological characters.

Dimensions (in mm)

Female LV - L: 0.49-0.54; H: 0.27-0.32
Female RV - L: 0.46-0.55; H: 0.25-0.31

Studied material – RA II 248 (Volterra basin, Radicondoli area, upper portion of the Argille del Torrente Fosci Fm., along the Vallone Ameli, early Messinian): 3 female carapaces.

RA 118 (Volterra basin, Radicondoli area lower part of the Argille del Torrente Fosci Fm., 300 m to

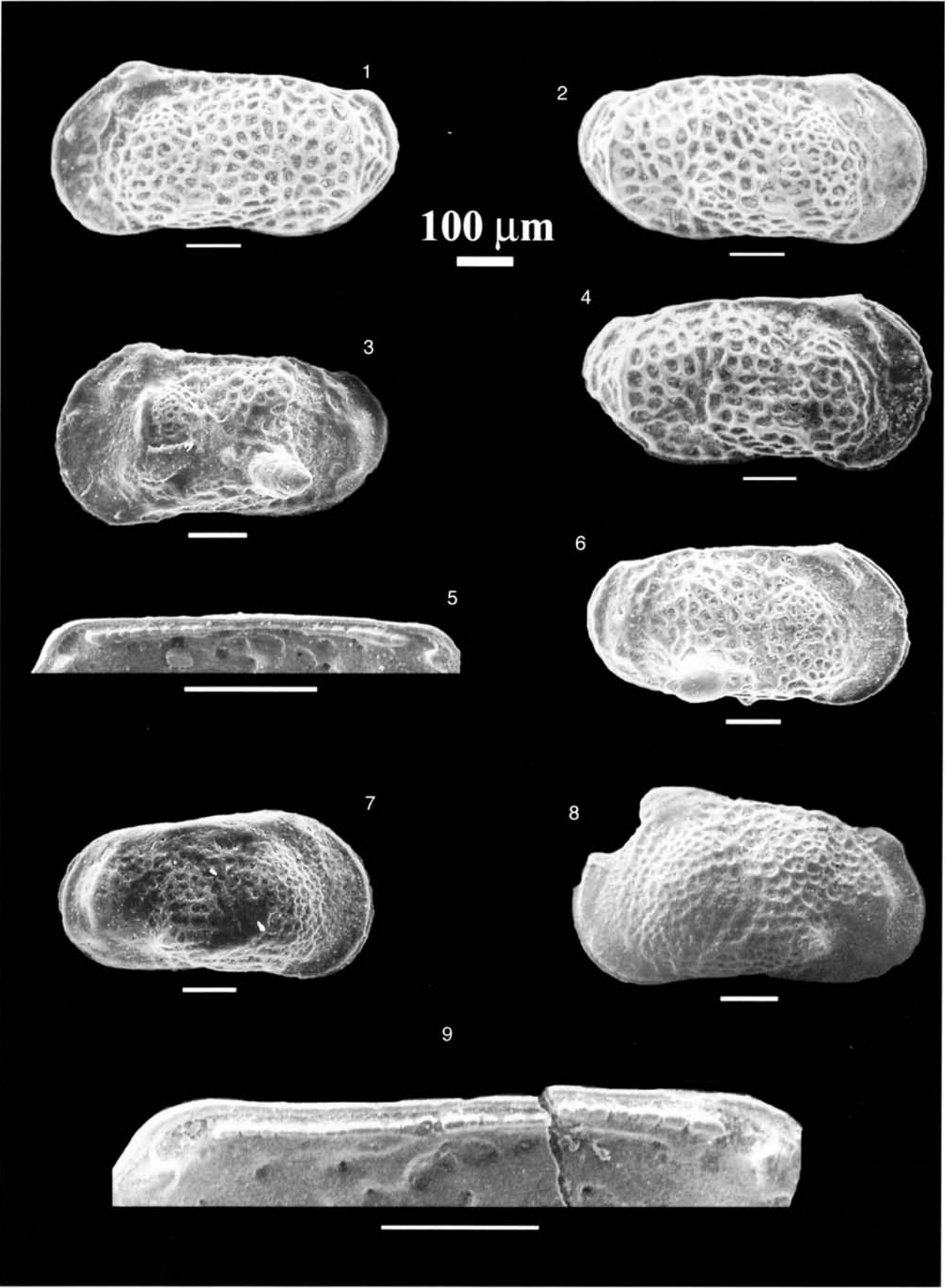
EXPLANATION OF PLATE 7

Figs 1-6 - *Tavanicythere irregularis* nov. sp.

1) holotype, female left valve, external view, sample BA 4; 2) female right valve, external view, sample BA 4; 3) juvenile female left valve with anomalous spine, external view, sample BA 10; 4) female right valve, external view, sample BA 56; 5) detail of the left hinge, sample BA 56; 6) female right valve with anomalous spine, external view, sample BA 56.

Figs 7-9 - *Tavanicythere* Q.

7) female right valve, external view, sample BA 7; 8) female left broken valve, external view, sample BA 10; 9) detail of the left hinge, sample BA 10.



Basin, Late Tortonian): respectively 1 female LV and 2 female R and L valves.

BA 56 (Passonaio section, central eastern sector of the Cinigiano-Baccinello Basin, Late Tortonian): 1 female LV and 4 female RV.

Age – Late Tortonian.

Comparisons – *Tavanicythere irregularis* nov. sp. is rather peculiar in shape, not comparable with other species of the genus. The general outline is more similar to *Mediocytherideinae* but the hinge structure leaves no doubt for the attribution of this species to genus *Tavanicythere*.

TAVANICYTHERE sp. Q
Pl. 7, figs 7-9

Two valves of *Tavanicythere* sp. Q, referable only to female specimens, have been recovered from the Upper Tortonian sediments of the Cinigiano-Baccinello Basin. The general lateral outline is similar both to *Tavanicythere irregularis* nov. sp. and to *Tavanicythere etrusca* but it differs from the first one in the less subrectangular shape (the dorsal border is slightly inclined backwards and the posterior border is uniformly convex) and for the less evident reticulation and from the second one for the larger dimensions and for the more wide anterior depressed surface. On the contrary, *Tavanicythere* sp. Q is rather similar to *Tavanicythere* sp. A Nachite 1993, from the Late Messinian of the Sorbas Basin (Spain); it differs from this species in the relatively higher proportions.

The scarcity of the valves suggests to leave this species in open nomenclature.

Dimensions (in mm)

Female LV -	L: 0.58;	H: 0.31
Female RV -	L: 0.60;	H: 0.32

Studied material - BA 7, BA 10, (Torrente Tra-subbie section, SE sector of the Cinigiano-Baccinello Basin, Late Tortonian): 1 female LV and 1 female RV.

Age – Late Tortonian.

STRATIGRAPHICAL AND PALAEOGEOGRAPHICAL DISTRIBUTION OF GENUS *TAVANICYTHERE*

The three species established by Bossio (1980) (*T. lepida*, *T. etrusca* and *T. pulchra*) came all from lower Messinian deposits of the Radicondoli area, thus, before the '90s, the stratigraphical distribution of *Tavanicythere* was considered to be limited to this time-interval. Sarti & Testa (1994) recorded the presence of *Tavanicythere* spp. in some brackish deposits of the Volterra Basin correlatable with the gypsum deposition interval during the Mediterranean "salinity crisis" (Hsü *et al.*, 1973) thus referable to the late Messinian.

Nachite (1993) recorded the presence of *Tavanicythere* sp. A in the upper Messinian Lago-Mare deposits of the Sorbas Basin (Spain) associated with several species of Paratethyan affinity. Finally, Gliozzi & Tassone (2001) reported several *Tavanicythere* species from the Late Tortonian of the Baccinello-Cinigiano Basin.

In the present paper, it has been possible to verify the Late Tortonian-early Messinian distribution of *Tavanicythere*. As far as we know, during this interval the maximum diversification of this genus was attained with at least 14 species. Unfortunately it has been not possible to check neither the chronostratigraphical attribution made by Sarti & Testa (1994) nor the identifications of Nachite's specimens which, according to the author (Nachite, 1993) seems slightly peculiar as the male valves lack the postero ventral spines typical of the genus. Anyway, during Late Messinian *Tavanicythere* showed a very decreased diversity, as it was represented only by two or three species. In Text-fig. 2 the stratigraphical range of each *Tavanicythere* species is reported, suggesting that *Tavanicythere* represents a valuable tool for the biochronology of the Late Miocene brackish facies.

As far as we know at present, the palaeogeographical distribution of *Tavanicythere* during the Late Tortonian-early Messinian interval is restricted to the Tuscan region, thus it could be considered an endemic genus for this period. Anyway, no studies are available in other areas of Italy concerning the ostracod faunas of brackish environment, so this peculiar palaeogeographic distribution could be only apparent. On the contrary, the only one quotation of *Tavanicythere* outside Italy is *Tavanicythere* sp. A Nachite 1993, from the late Messinian Lago-Mare interval of the Sorbas basin. The supposed attribution to the genus *Tavanicythere* of *Leptocythere* (*Amnocythere*) *servica* Krstić, *Leptocythere* (*Amnocythere*) *lacunoidea* Krstić, *Leptocythere* (*Amnocythere*) *larga* Krstić and *Leptocythere* (*Amnocythere*) *lacunosa* (Reuss) from the Pontian of the Paratethyan realm, suggested by Bossio (1980), is not confirmed, owing to the observation of their hinge median element which is smooth as in *Amnocythere*.

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