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Calpionellid biostratigraphy of the Upper Tithonian–Upper Valanginian interval in Western Sicily (Italy)

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ABSTRACT

A revision of the calpionellid bio-chronostratigraphy in Western Sicily (Italy) was carried out, in order to update the taxonomy of this group, through the identification of some genera (*Borziella*, *Longicollaria*, *Chitinoidella*, *Dobeniella*, *Sturiella*, *Borzaiella* and *Praecalpionellites*) and species (*Remaniella catalanoi* POP, *Remaniella duranddelgai* POP, *Remaniella colomi* POP, *Remaniella borzai* POP, *Remaniella filipescui* POP) recorded for the first time in the area. The studied sections, belonging to the Trapanese and Saccense Domains (Western Sicily), include at the base the upper portion of the Rosso Ammonitico Unit (Upper Tithonian), followed by the Lattimusa Formation (Lower Cretaceous). The quantitative and biostratigraphic analysis of the calpionellid assemblages allowed us to identify 13 assemblages and to define some important bioevents for the Upper Tithonian–Valangianian interval. The recorded calpionellid bioevents allowed us to recognize Zone/Subzone schema, which have been correlated with the bio-chronostratigraphy previously proposed for the Western Tethys.

RIASSUNTO

Una revisione della biostratigrafia a Calpionellidi in sezioni della Sicilia Occidentale ha permesso di aggiornare la tassonomia di questo gruppo, con l'identificazione di generi (*Borziella*, *Longicollaria*, *Chitinoidella*, *Dobeniella*, *Sturiella*, *Borzaiella* e *Praecalpionellites*) e delle specie (*Remaniella catalanoi* Pop, *Remaniella duranddelgai* Pop, *Remaniella colomi* Pop, *Remaniella borzai* Pop, *Remaniella filipescui* Pop) rinvenuti per la prima volta in Sicilia Occidentale. Le sezioni studiate appartengono ai Domini Saccense e Trapanese. Tali sezioni sono caratterizzate alla base dell' Unità Rosso Ammonitico e successivamente dalla Formazione della Lattimusa. L'analisi biostratigrafica e quantitativa delle associazioni a Calpionellidi ha permesso di identificare 13 associazioni e di caratterizzare alcuni eventi principali, nell'intervallo Titoniano superiore–Valanginiano. I bioeventi registrati hanno consentito di riconoscere Zone e Sottozone, che sono state corrrelate con gli schemi biostratigrafici proposti in precedenza per la Tetide occidenatale..

Introduction

The calpionellids, calcareous microplankton protists, characterize the Tithonian–Hauterivian interval in the Tethyan realm, with a potential biostratigraphic application from the Upper Tithonian to the Upper Valanginian. Apart from the pioneer works by Deflandre (1936), Colom (1948), Andrusov (1950), Pokorny (1954) and Bonet (1956), a standard calpionellid zonation was first established in the 2nd Conference on Planktonic Organism in 1970 in Rome (Allemann et al. 1971). In the 1980´s, at the Sümeg Meeting (Hungary), Remane et al. (1986) together with Trejo (1980) and Altiner & Özkan (1991), proposed an updated bio-cronostratigraphic scheme at the Subzonal level. Recently, Pop (1994b, 1996), Oloriz et al. (1995), Grün & Blau (1997) and Reháková & Michalík (1997) worked out an alternative calpionellid Subzonal scheme, although detailed long-distance bio-chronostratigraphic correlations are still unclear.

The Jurassic–Cretaceous pelagic successions in Western Sicily are dominated by the typical condensed "Rosso Ammonitico" Unit, overlain by the expanded "Calcari a Calpionelle" Unit, locally named Lattimusa Formation (equivalent to the Southalpina Maiolica Formation). Some studies on calpionellid biostratigraphy have been carried out in Tithonian to Valanginian successions of Western Sicily during the 1960´s and 1970´s (Catalano & Lima 1964; Catalano 1965; Catalano & Li-

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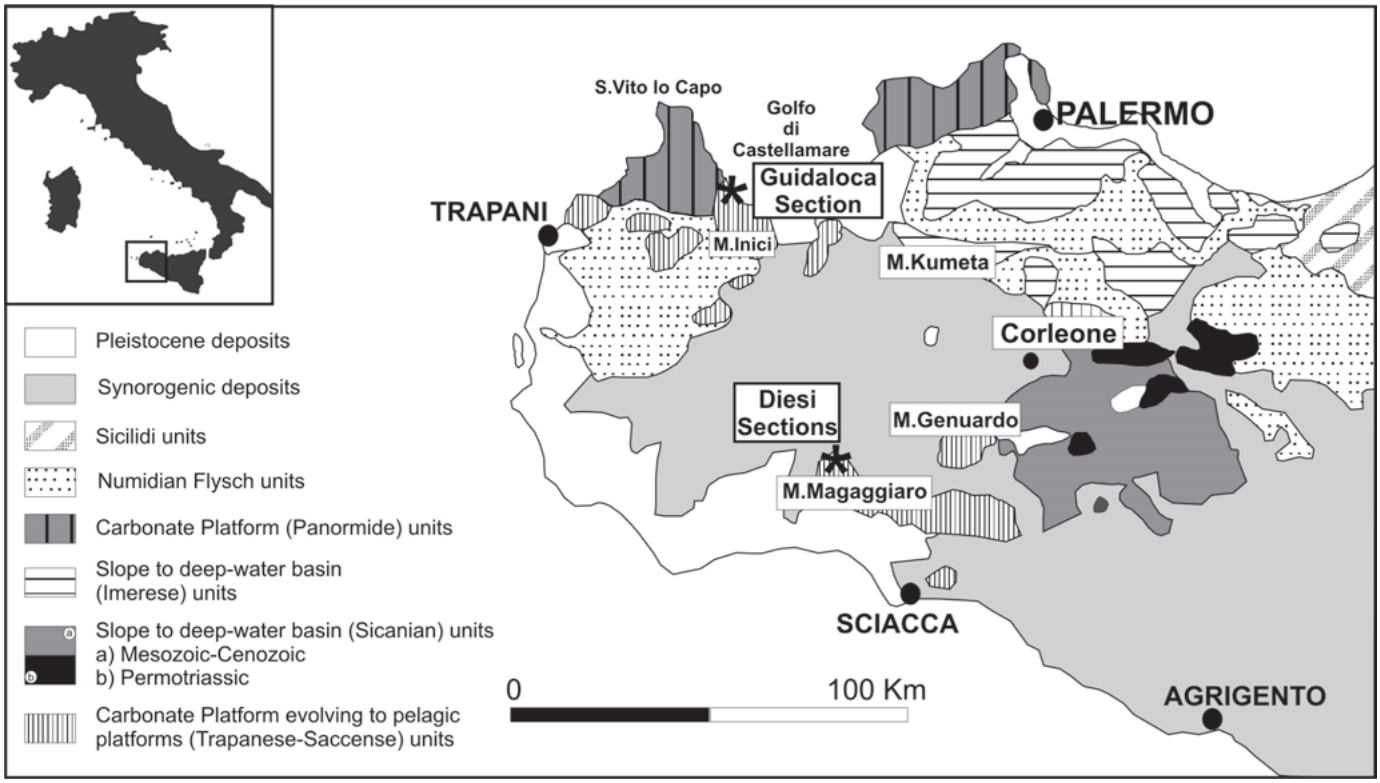

Fig. 1. Geological map of Western Sicily (Italy), with location of the studied sections (after di Stefano 2002, modified).

guori 1971) and recently by Cecca et al. (2001) and Marino et al. (2004).

The present work deals with the revision of the calpionellid taxonomy, considering recently defined genera and species, in order to update the bio-chronostratigraphy for Western Sicily.

Geological and stratigraphic setting

During the Middle Jurassic, part of the Sicilian-Tunisian Platform drowned, due to active listric faults (di Stefano 2002). Consequently, the area was structured in a complex system of small basins, swells and tilted blocks, which characterize the Panormide, Trapanese, Saccense and Hyblean palaeogeographic domains. In the Trapanese and Saccense Domains, the Jurassic succession starts with shallow water carbonates of the Inici Formation, followed by a regional drowning unconformity during most of the Pliensbachian. Later on, during the Toarcian and Middle–Upper Jurassic, the sedimentation is mainly represented by condensed limestones, Rosso Ammonitico, including, sometimes, siliceous marls. In the uppermost Tithonian, started the deposition of the Lattimusa Formation, equivalent to the Southalpina and Northapenninic Maiolica Formation (Fm.) in the Trapanese Domain, the Rosso Ammonitico Unit is subdivided into two members, separated by a siliceous radiolaritic interval, while in the Saccense Domain this siliceous interval is absent (di Stefano & Mindszenty 2000; Chiari et al. 2004; Marino et al. 2004).

Studied sections

The studied sections belong to the Trapanese (Guidaloca section) and Saccense (Diesi sections) Domains. The Guidaloca area has been interpreted, palaeogeographically, as the upper part of a talus related to the structural high of the Monte Inici area (Caracuel et al. 2002; Cecca et al. 2001), while the Diesi area belongs to a complex horst-graben system related to the structural high of the Monte Magaggiaro (di Stefano et al. 2002; Marino et al. 2004) (Fig. 1).

Guidaloca section

The section crops out along the Guidaloca Beach, 3 km from Castellamare del Golfo (Fig. 1). The Upper Jurassic succession lies unconformably over the Inici Fm. and is composed by 12.5 m of alternating cherty marly/calcarenitic layers, followed by 20 m of Kimmeridgian-Tithonian p.p. marly Rosso Ammonitico (Caracuel et al. 2002). The Rosso Ammonitico Unit is overlain by more than 90 m of white rhytmic limestone with chert, rich in calpionellids (Lattimusa Fm.), dated as latest Tithonian to Valanginian (Fig. 2).

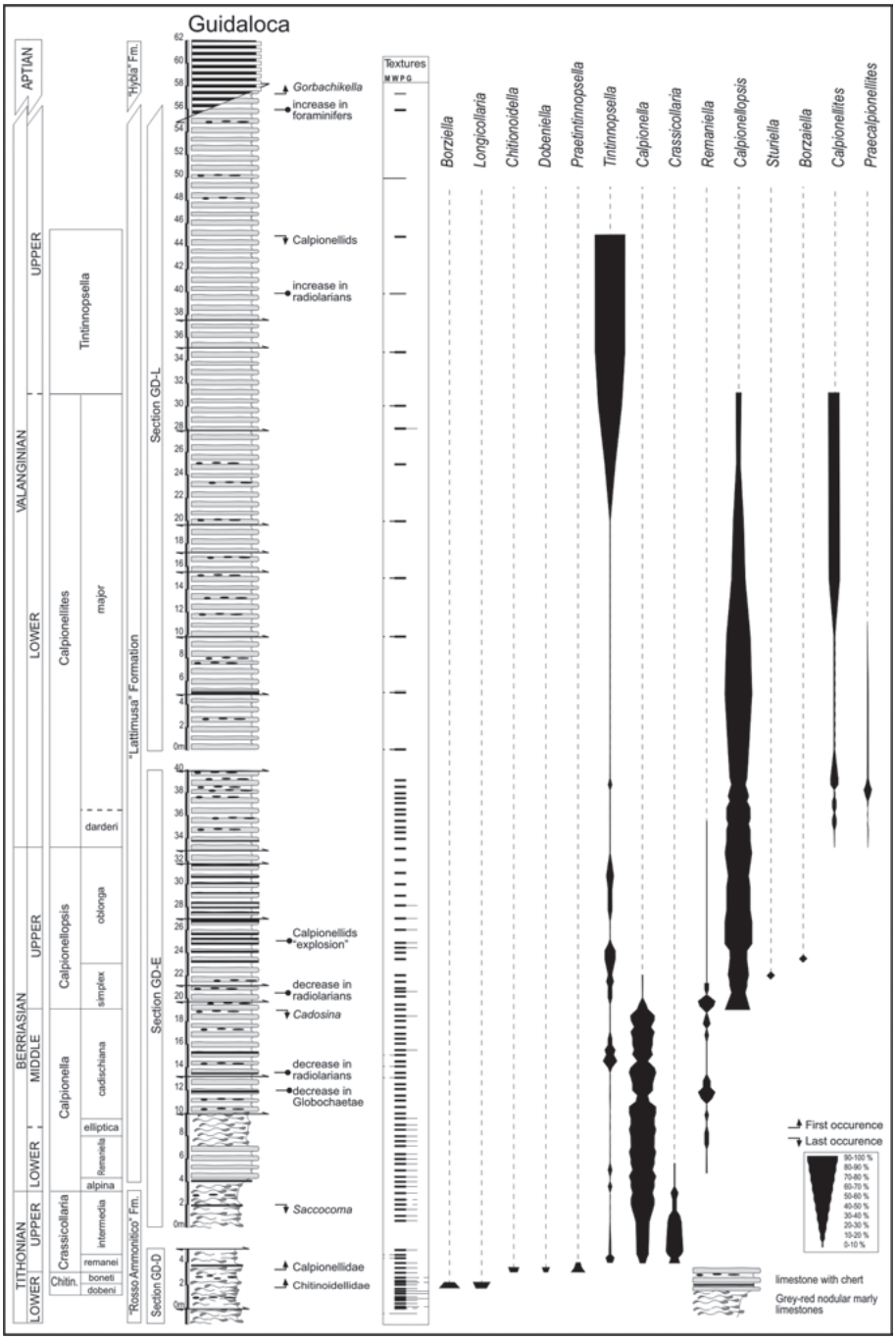

Fig. 2. Age, lithostratigraphy and calpionellid biostratigraphy of the Guidaloca section and quantitative distribution of the recorded calpionellid genera.

The lower part of this section (Rosso Ammonitico Unit) is ammonite-poor, and it was dated by calcareous nannofossils, calpionellids and radiolarians as Lower Tithonian p.p. uppermost Tithonian.

Textures are peloidal wackestones and packstones enriched in Saccocoma, radiolarians, calpionellids, *Globochaeta, Cadosina, Stomiosphaera,* with subordinate thin-shelled bivalves ("filaments"), and benthic foraminifers (mainly *Lenticulina*). Bioturbation by Thalassinoides, small *Chondrites* and *Planolites* is widespread at the top of the nodular intervals.

This Rosso Ammonitico Unit evolves gradually to more than 90 m of monotonous white cherty limestones in thin irregular beds (Lattimusa Fm.). No trace fossils have been recognized and macroinvertebrates are scarce, only represented by ammonites, aptychi, brachiopods and echinoderm fragments. Textures range from calpionellid-bearing mudstones to wack-

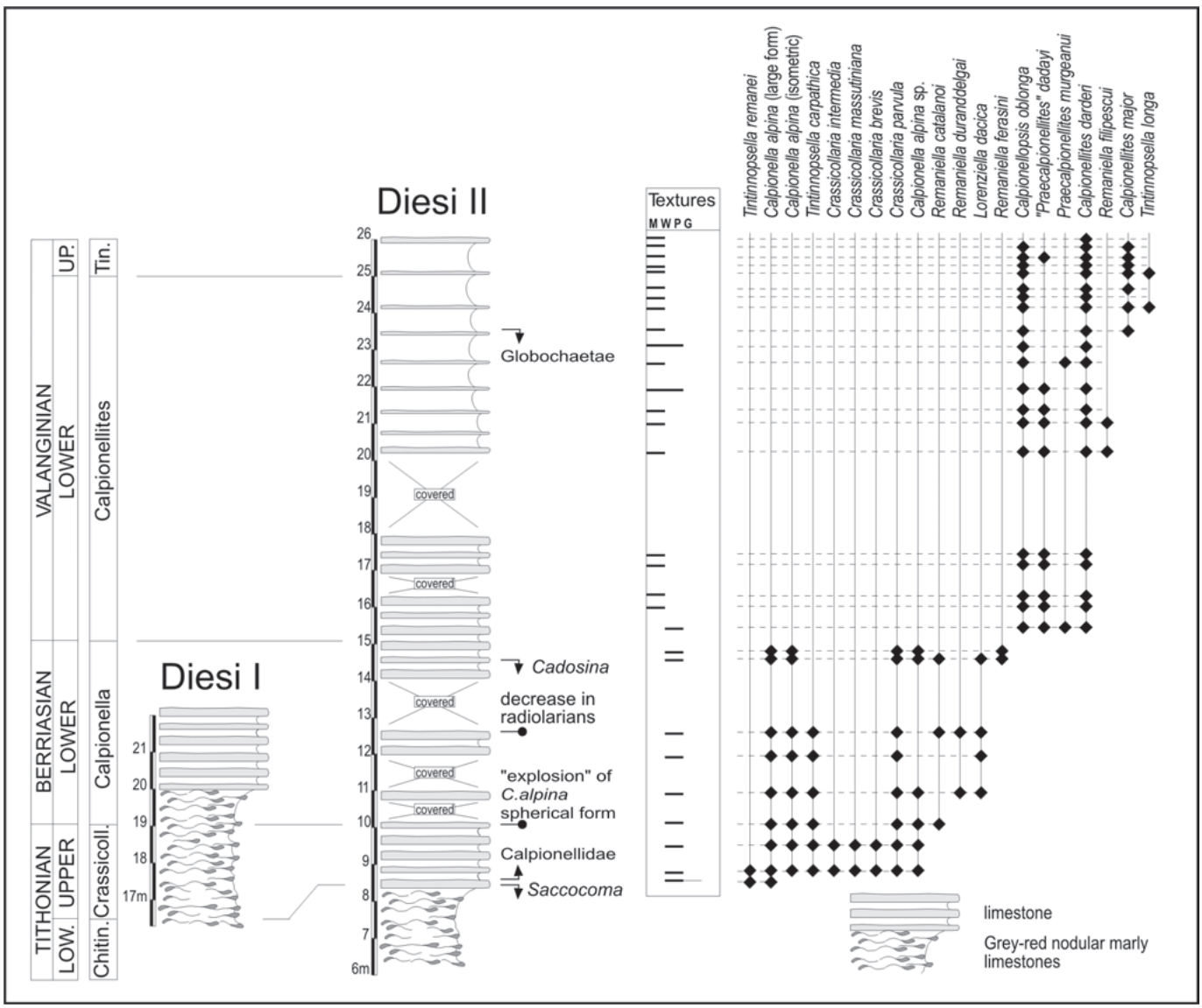

Fig. 3. Age, lithostratigraphy and calpionellid biostratigraphy of the Diesi I and II sections and distribution of the recorded taxa.

stones (occasionally packstones) with radiolarians, *globochaetes, cadosinas,* "filaments" and foraminifers. On the base of calpionellid biostratigraphy, this unit encompasses the Uppermost Tithonian-Valanginian interval. Upward, the Lattimusa Fm. is tectonically overlain by the Hybla Fm. (Barremian-Albian).

Diesi sections

The Mesozoic succession in the Saccense Domain starts with several thousand metres of platform limestone and dolostone of the Late Triassic, formally named Sciacca Fm. (same as the Gela Fm. of the Hyblean Plateau). It is overlain by 200–300 m of shallow water carbonates of Early Jurassic age (Inici Fm.) (Schmidt di Frieberg 1965; Ronchi et al. 2000). This unit is followed upward by the Buccheri Fm. (or Rosso Ammonitico Unit), made of condensed pelagites with abundant ammonites, which range from the Lower Jurassic to the Lower Tithonian. Similarly to the Guidaloca area, during the interval from the latest Jurassic to the Early Cretaceous, the Lattimusa Fm replaces the Buccheri Fm.

The succession is well exposed in the quarry at Contrada Diesi, near Sciacca, on the northernslope of Mt. Magaggiaro (Fig. 1). Two complementary sections were studied, characterized at the base by a grey-red nodular limestone (Rosso Ammonitico Unit) reduced in thickness, and followed by a thin, white well-bedded limestone (Lattimusa Fm.) in the upper part (Fig. 3). As a whole, this interval includes wackestone and

mudstone with abundant calpionellids, foraminifers (textulariids and valvulinids), rare radiolarians, echinoid fragments and some ammonites. *Saccocoma* disappears at the base of this unit, during the uppermost Tithonian, close to the first occurrence (FO) of spherical forms of *Calpionella alpina* LORENZ (Marino et al. 2004). The nodular limestones are packstones with crinoidal debris, internal moulds of ammonites and aptychi. Nodules are made of mudstone/wackestone, often with stylolithic contact. Microfossils include foraminifers, mainly *Lenticulina* sp. and *Spirillina* sp., radiolarians, Cadosinids and *Saccocoma* sp.

Calpionellid assemblages

The analysis of the taxon distribution in the studied sections, and the quantitative analyses of the calpionellid assemblages in the Guidaloca section (Fig. 4), allow us to identify 13 successive assemblages from the uppermost Lower Tithonian to the Valanginian. The thin sections were studied counting all the specimens in a constant area of 6 cm^2 to obtain statistical significance. The observations are made using a ×100 magnification.

Assemblage I

The calpionellid assemblages in the lower part of the studied interval are characterized by scarcity and low diversity (5% of the microbiofacies). The first appearance of calpionellids is characterized by rare presence of chitinous specimens of *Borziella slovenica* (BORZA) (Pl. I: figs. 1a, b) and *Longicollaria* cf. *dobeni* (BORZA) (Pl. I: figs. 2a, b).

Assemblage II

The assemblage is characterized by the first occurence of chitinous specimens with composite collar, represented by *Dobeniella bermudezi* (FURRAZOLA-BERMÚDEZ) (Pl. I: figs. 6a, b; 7a, b) and *Dobeniella cubensis* (FURRAZOLA-BERMÚDEZ) (Pl. I: figs. 8a, b); there is also *Chitinoidella boneti* DOBEN (Pl. I: figs. 3a, b; 4a, b; 5a, b).

Assemblage III

This is the first assemblage with hyaline calpionellids. It is characterized by rare *Praetintinnopsella andrusovi* BORZA (Pl. I: fig. 9), low diversified *Crassicollaria* (group *intermedia* (DURAND-DELGA)-*brevis* REMANE), small *Calpionella alpina* LORENZ (Pl. I: fig. 10) and small, badly preserved *Tintinnopsella*, doubtfully assigned to *Tintinnopsella carpathica* (MURGEANU & FILIPESCU)-*remanei* (BORZA). Due to the bad preservation of delicate parts as collars, typical for the condensed nodular limestones of the Rosso Ammmonitico facies, it is difficult to make a species-based characterization of *Crassicollaria* and *Tintinnopsella*. Moreover the identification of the double-walled tests (hyaline and microgranulare) of *Praetintinnopsella* is also difficult (Olóriz et al. 1995).

Assemblage IV

A sharp increase in abundance and diversity (both at the genus and species level) is registered starting from this assemblage and moving upward (70% of the microbiofacies). This assemblage is characterized by abundant large forms of *Calpionella alpina* LORENZ (Pl. I: fig. 13), *Calpionella* sp. (Pl. I: figs. 14, 15, 33) and, in the middle part, by the occurrence of small spherical forms of the *C. alpina* LORENZ (Pl. I: figs. 11, 12). According to Olóriz et al. (1995), there is a significant record of *Calpionella* with lenght/width ratio ranging from 1.25 to 1.35, referred to as *Calpionella* homeomorph *elliptica*. These forms were already noted by Remane (1985) along the boundary of the A/B Zones, and by Altiner & Özkan (1991), who called them *Calpionella* sp. as a transitional form beetwen *C. alpina* LORENZ and *C. elliptica* CADISCH. The genus *Crassicollaria* is diverse, including *Cr. intermedia* (DURAND-DELGA) (Pl. I: figs. 28, 29), *Cr. brevis* REMANE (Pl. I: figs. 19, 20), *Cr. colomi* DOBEN (Pl. I: figs. 26, 27), *Cr. massutiniana* (COLOM) (Pl. I: figs. 23–25) and *Cr. parvula* REMANE (Pl. I: figs. 21, 22), decreasing from common at the base to rare at the top of the assemblage. The assemblage is also composed by rare *T. carpathica* (MURGEANU & FILIPESCU) (Pl. I: figs. 16–18; Pl. II: figs. 14, 15).

Assemblage V

This assemblage is characterized by the explosion in abundance (Allemann et al. 1971) of *C. alpina* LORENZ, with a variable morphology, but dominated by small spherical forms, which define the base of this assemblage. *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) is still present in this assemblage, and *Calpionella* sp. is frequent. The genus *Crassicollaria* is represented only by *Cr. parvula* REMANE, that disappears in the uppermost part of the assemblage.

Assemblage VI

The base of this assemblage is marked by the FO of the genus *Remaniella* (well preserved specimens, although rare) with the species *R. catalanoi* POP (Pl. I: figs. 32a, b; Pl. II: figs. 4a, b) and *R. ferasini* (CATALANO) (Pl. I: figs. 30a, b; 31a, b). The genus *Remaniella* is also represented by *R. duranddelgai* POP (Pl. II: figs. 3a, b; 6a, b) in the uppermost part. Moreover, the assemblage is characterized by common *C. alpina* LORENZ (small spherical forms), *Calpionella* sp. and rare *T. carpathica* (MURGEANU & FILIPESCU).

Assemblage VII

The base is defined by the apperance of *Calpionella elliptica* CADISCH (Pl. II: figs. 1, 2) and this assemblage is clearly dominated by *C. elliptica* CADISCH together with *C. alpina* LORENZ (including abundant small spherical forms), very rare *C.* sp., and rare *T. carpathica* (MURGEANU & FILIPESCU), and the genus *Remaniella* with *R. duranddelgai* POP, *R. catalanoi* POP and *R. ferasini* (CATALANO).

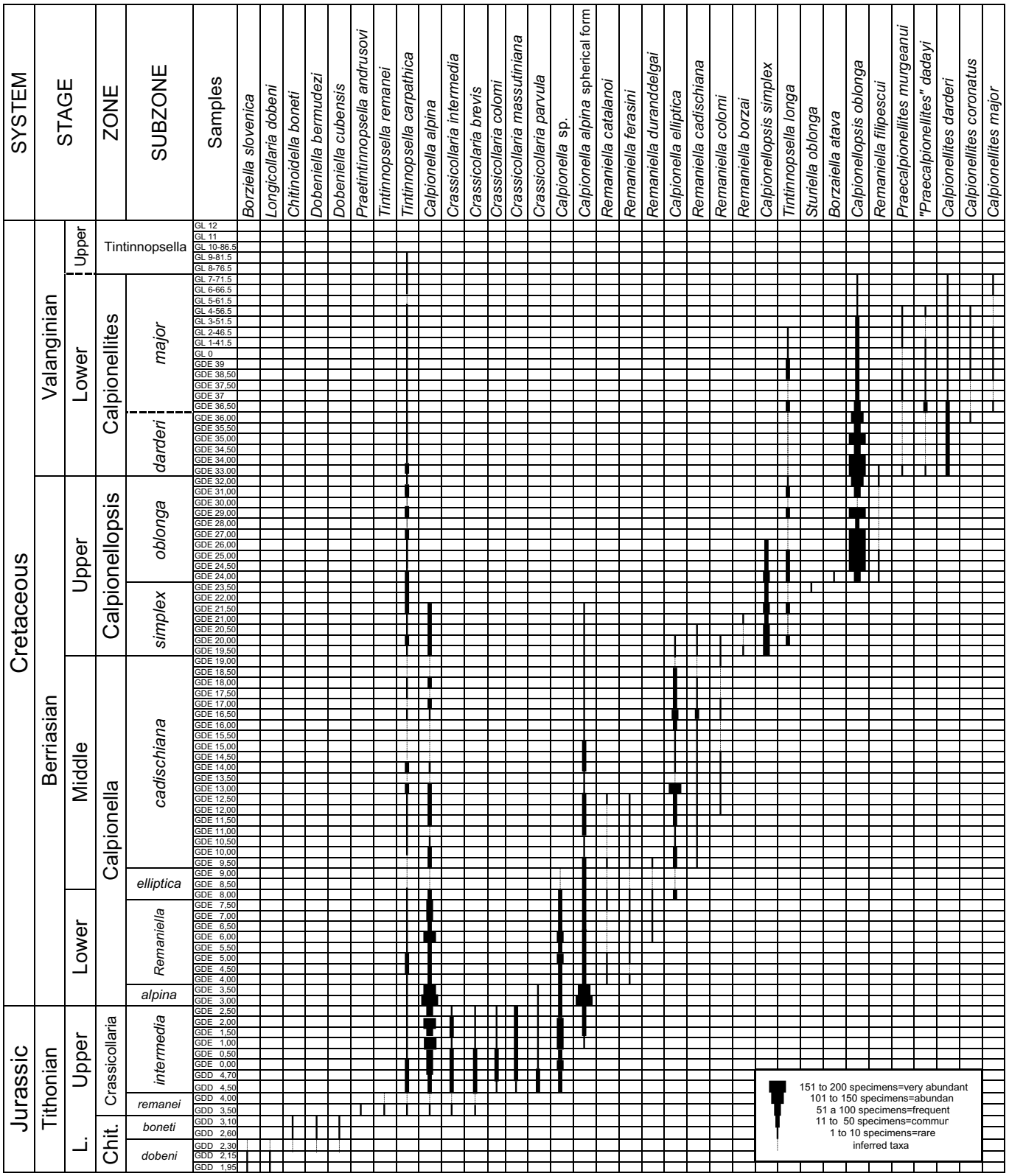

Fig. 4. Range chart of the calpionellid species recorded in the Guidaloca section. The thin sections were studied counting all the specimens in at least 100 visual fields (magnification of x100), to obtain statistical significance.

Assemblage VIII

The first occurence of *Remaniella cadischiana* (COLOM) (Pl. II: figs. 7; 8a, b) defines the base of this assemblage. The assemblage is also dominated by *C. elliptica* CADISH, *meanwhile C. alpina* LORENZ is also present with large variety, including spherical forms, but decreasing upward; rare *T. carpathica* (MURGEANU & FILIPESCU) can be found. The genus *Remaniella* is scarcely represented, although well diversified toward the lower part of the assemblage, with *R. duranddelgai* POP, *R. catalanoi* POP, *R. ferasini* (CATALANO). In the upper part of the assemblage, only *R. cadischiana* (COLOM) and *R. colomi* (Pl. II: figs. 9a, b) persisted.

Assemblage IX

This assemblage is tipically characterized by a low abundance of calpionellids, dominated by *Calpionellopsis simplex* (COLOM) (Pl. II: figs. 10, 11). The genus *Tintinnopsella* is represented by *T. longa* (COLOM) (Pl. III: fig. 3) and *T. carpathica* (MURGEANU & FILIPESCU). *Remaniella cadischiana* (COLOM) and *R. colomi* POP are scarce and present only in the lower part of the assemblage, as well as *C. elliptica* CADISCH and *C. alpina* LORENZ (large variety, including spherical forms). Toward the top of the assemblage, *Sturiella oblonga* BORZA (Pl. II: figs. 18a, b) is recorded.

Assemblage X

It is dominated by *Calpionellopsis oblonga* (CADISH) (Pl. II: figs. 12, 13) (reaching up to 90%), together with common *Cs. simplex* (COLOM), *T. longa* (COLOM), *T. carpathica* (MURGEANU & FILIPESCU), and rare *Remaniella filipescui* (POP) (Pl. II: figs. 20; 22a, b) and *Borzaiella atava* GRÜN & BLAU (Pl. II: figs. 23a, b).

Assemblage XI

This assemblage is charaterized by the appearance of *Calpionellites darderi* (COLOM) (Pl. III: fig. 5) and is dominated by *Cs. oblonga* (CADISCH), and subordinately *Cs. coronatus* (TREJO) (Pl. III: figs. 4a, b), "*Praecalpionellites" dadayi* (KNAUER) (Pl. II: figs. 21a, b) and *Praecalpionellites murgeanui* (POP) (Pl. II: figs. 17a, b; Pl. III: figs. 1a, b; 6). *Tintinnopsella longa* (COLOM) and *R. filipescui* POP are very rare.

Assemblage XII

This assemblage is similar to assemblage XI, except for the record of *Calpionellites major* (COLOM) (Pl. II: fig. 16; Pl. III: figs. 2a, b) and the progressive decreasing of *Cs. oblonga* (CADISCH) toward the upper part, which determines an impoverishment in calpionellids.

Assemblage XIII

The younger assemblage recognized in the studied sections in Western Sicily is composed only by rare *Tintinnopsella* gr. *carpathica* (MURGEANU & FILIPESCU), after the Last Occurrence (LO) of *Calpionellites* and *Praecalpionellites*.

Biostratigraphy and chronostratigraphy

These successive assemblages provide the first calpionellid biochronostratigrafic framework for Western Sicily, which can be correlated with the previous works for other Perimediterranean areas (Remane 1971; Olóriz et al. 1995; Pop 1994b; Grün & Blau 1997; Reháková & Michalík 1997) (Fig. 5).

A detailed quantitative calpionellid analysis in sections belonging to the Trapanese and Saccense Domains allowed us to propose a high-resolution bio-chronostratigraphic scheme for the Upper Tithonian–Hauterivian interval of Western Sicily successions.

The assemblage I defines the lower part of the Chitinoidella Zone, Dobeni Subzone, according to Pop (1997), Reháková & Michalík (1997) and Reháková (2002), who recently revisited these chitinous forms.

The genera and species (not reported previously from Sicily) which define the assemblage II are distributed in the upper part of the Chitinoidella Zone, Boneti Subzone, according to Pop (1997), Reháková & Michalík (1997) and Reháková (2002) .

The lower boundary of the assemblage III coincides with the first occurence of Calpionellidae BONET (hyaline Calpionellids), the upper boundary (the base of assemblage IV) is marked by the record of large specimens of *C. alpina* LORENZ.

This assemblage III fits well with the Remanei Subzone of the Crassicollaria Zone, characterized from Remane et al. (1986) to Grün & Blau (1997) by the presence of primitive forms of *Crassicolaria*, together with *Tintinnopsella* and small sized *Calpionella*.

The first occurence of *C. alpina* large variety marks the base of the assemblage IV. This main event defines the base of the Intermedia Subzone (Crassicollaria Zone). According to Olóriz et al. (1995) and Remane et al. (1986), the maximum diversification of the genus *Crassicollaria* occurred in the Intermedia Subzone. Pop (1994b, 1996) and Reháková & Michalík (1997) divided the middle-upper part of the Crassicollaria Zone into two subzones, although using different criteria; Pop (1994b, 1996) defined the Intermedia Subzone on the base of the FO of *C. alpina* LORENZ (large form) and the Colomi Subzone upwardly, while Reháková & Michalík (1997) called the intermediate interval of the Crassicollaria Zone as Brevis Subzone (for the first occurence of *Cr. brevis* REMANE), before the FO of *Cr. colomi* DOBEN which defines the upper Colomi Subzone (Fig. 5).

Remane (1963, 1964, 1971) and Le Hégarat & Remane (1968) recognized the A2 and A3 Subzones in the Vocontian Trough; the base of A2 Subzone is marked by the predomi-

nance of *Cr. intermedia* (DURAND-DELGA) on *Cr. brevis* REMANE, while the base of A3 is marked by the predominance of *Cr. brevis* REMANE over *Cr. intermedia* (DURAND-DELGA). Unfortunately, due to the constant abundance of *Crassicollaria* species in this interval, it is not possible to apply quantitative abundance as a parameter to refine the biostratigraphy at the Subzone level, as proposed by Pop (1996) and Reháková & Michalík (1997). Moreover, the record of *R. catalanoi*, which appears lately, does not permit to define a subzone in the upper part of the Crassicollaria Zone, based on the genus *Remaniella* according to Grün & Blau (1997).

According to the record of the well-known "explosion" in the Mediterranean region of *C. alpina* LORENZ (small and spherical forms), the assemblage V is referred to the Calpionella Zone, Alpina Subzone. Thus, the base of this subzone is equivalent to that of the Alpina Subzone in Reháková & Michalík (1997), Pop (1994b, 1996) and Olóriz et al. (1995). This assemblage has been also recorded in the Umbria-Marche area, Central Italy (Micarelli et al. 1977; Hou_a et al. 2004). Similarly, in the Vocontian Trough, the base of the B Zone was defined by the "explosive" extension of a smaller and more spherical form of *C. alpina* LORENZ (Remane 1963, 1971), which coincides with the Jurassic/Cretaceous boundary.

The base of assemblage VI is defined by the first occurence of calpionellids with composite collars, which allows to identify the Remaniella Subzone of the Calpionella Zone.

This assemblage is referred to the Remaniella Subzone (Olóriz et al. 1995) or the Ferasini Subzone by Reháková & Michalík (1997) and Pop (1994b, 1996). Grün & Blau (1997) registered the older specimens of *Remaniella* in the Ra Stua area (Italy) within the Crassicollaria Zone and used this record to define the Catalanoi Subzone in the upper part of this Zone. In the studied sections, the FO of the genus *Remaniella* is already found in the Berriasian, after the explosion of *C. alpina* LORENZ.

The studied assemblage VII with abundant *C. elliptica* CADISCH and diverse *Remaniella* is therefore referred to the Elliptica Subzone of the Calpionella Zone. As traditionally noted from Catalano & Liguori (1971) to Reháková & Michalík (1997), the FO of *C. elliptica* CADISCH defines the Elliptica Subzone.

In the assemblage VIII**,** according to Grün & Blau (1997) for the Ra Stua area, the FO of *R. cadischiana* (COLOM) defines also the base of the Cadischiana Subzone in the upper part of the Calpionella Zone. Pop (1994b, 1996) defined the Longa Subzone, in the upper part of the Calpionella Zone, on the basis of the FO of *T. longa* (COLOM), which occurs upwards, together with *Cs. simplex* (COLOM) in Western Sicily.

For the Vocontian Trough, Remane (1971) defined the C Zone in the upper part of the Calpionella Zone (Remane et al. 1986), on the basis the predominance of large forms of *T. carpathica* (MURGEANU & FILIPESCU). Toward the middle part of the assemblage VIII recorded in Western Sicily, there is also an occurence of large forms of *T. carpathica* (MURGEANU & FILIPESCU) in significant percentage (40%), but only punctually reached in one level. Thus, we do not agree with the use of this bioevent to define the base of C Zone as in the Vocontian Through (Remane 1971). The studied sections in Western Sicily revealed a heterochrony within two events, which have been traditionally considered isochronous: the FO of *R. cadischiana* (COLOM) (base of Cadischiana Subzone; Grün & Blau 1997) and the increase of *T. carpathica* (MURGEANU & FILIPESCU) with mostly large forms (base of the C Zone in Remane 1971).

Similarly to other Tethyan palaeomargins (Pop 1994b, 1996; Grün & Blau 1997; Reháková and Michalík 1997), the FO of *Cs. simplex* (COLOM) without *Cs. oblonga* (CADISCH) in the assemblage IX**,** permits to identify the Simplex Subzone of the Calpionellopsis Zone.

The FO of *Cs. oblonga* marks the base of the assemblage X**,** that is attributed to the *Oblonga* Subzone of the Calpionellopsis Zone. According to Grün & Blau (1997), after the FO *Cs. oblonga* (CADISCH), which coincides with the FO of *R. filipescui* (POP), *Cs. simplex* (COLOM) is rapidly counterbalanced by *Cs. oblonga* (CADISCH). Similarly to the record in Ra Stua (Italy) (Grün & Blau 1997), the studied sections show that the FO of *Cs. oblonga* (CADISCH) occurs together with the first record of *R. filipescui* (POP).

In the assemblage XI, as traditionally noted in many other Tethyan palaeomargins (Betic, Appennines, Alps, Carpathes), the FO of *Ct. darderi* (COLOM) permits to identify the *Darderi* Subzone within the Calpionellites Zone. The base of Calpionellites Zone coincides with the Berriasian/Valanginian boundary, according to Aguado et al. 2000.

The base of the assemblage XII is marked by the occurrence of *Ct. major* (COLOM), that characterizes the Major Subzone within the upper part of the Calpionellites Zone, according to Pop (1994b, 1996), Grün & Blau (1997), Reháková & Michalík (1997).

The Assemblage XIII corresponds to the Tintinnopsella Zone. The exclusive presence of *T.* gr. *carpathica* (COLOM) fits well with the typical record for the uppermost part of the calpionellid-bearing interval, already in the Hauterivian (Pop 1994b, Rehákova & Michalík 1997).

Conclusions

A detailed calpionellid study on sections belonging to Western Sicily allowed us to propose a bio-chronostratigraphic scheme for the Tithonian–Valanginian interval in the region.The calpionellid abundance is maintaned, although variable in detail, but the diversity decreases toward the upper part of the Calpionella Zone, with the only record of the *Tintinnopsella*, *Calpionella* and *Remaniella* genera. The interval with the greatest richness of calpionellids (95% of the microbiofacies) is the Oblonga Subzone (Calpionellopsis Zone), after which the abundance and diversity decrease in the *Calpionellites*, and even more in the Tintinnopsella Zone.

Eight genera are reported for the first time in Western Sicily: *Chitinoidella*, *Dobeniella*, *Borziella*, *Longicollaria*, *Praetintinnopsella, Praecalpionellites*, *Sturiella* and *Borzaiella* (see

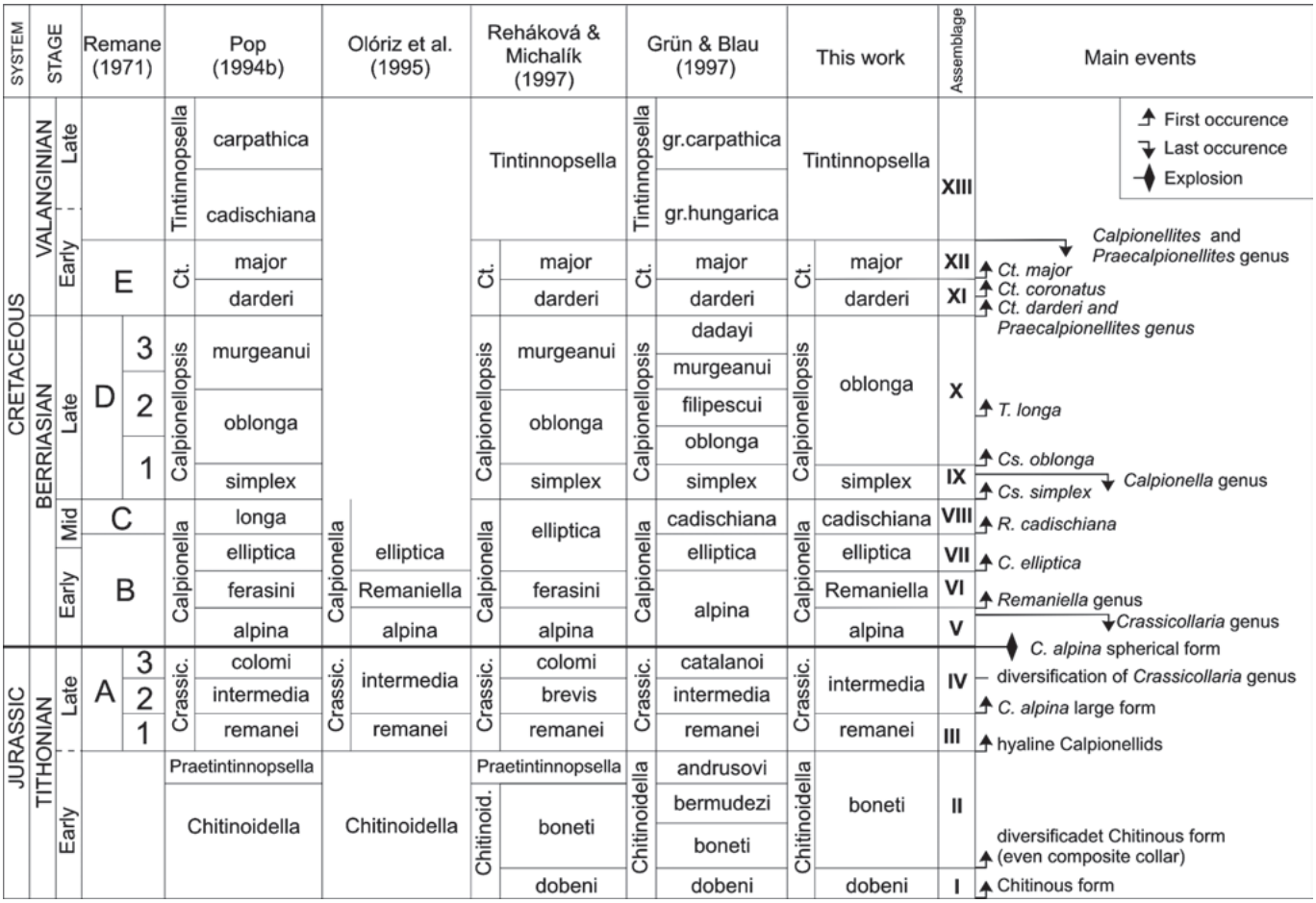

Fig. 5. Comparative chart of the proposed calpionellid zonation for Western Sicily with the previous works of Remane (1971), Pop (1994b), Olóriz et al. (1995), Grün & Blau (1997) and Reháková & Michalík (1997).

Appendix 1). According to Pop (1997) and Reháková (2002), the record of diverse chitinous-test calpionellids (*Chitinoidella*, *Dobeniella*, *Borziella* and *Longicollaria*) permitted to precise the Dobeni and Boneti Subzone of the Chitinoidella Zone. The record of the cryptic genus *Praetintinnopsella* (double-walled forms), together with hyaline calpionellids of the Remanei Subzone (Crassicollaria Zone), prevent the differentiation of the Bermudezi and Andrusovi Subzone, as proposed by Pop 1996, Grün & Blau 1997 and Reháková & Michalik 1997.

The calpionellid assemblages of Crassicollaria Zone allow to recognize two Subzones: Remanei and Intermedia. The FO of hyaline calpionellids characterizes the base of the Remanei Subzone, while the predominance of diverse *Crassicollaria* marks the base of the Intermedia Subzone.

According to many previous proposals, we accepted that the Tithonian/Berriasian boundary is defined by the sudden "explosion" of *C. alpina* LORENZ spherical forms (Remane 1986), marking the base of the Calpionella Zone. This Zone can be well subvidided in four Subzones (Alpina, Remaniella, Elliptica and Cadischiana) in Western Sicily, as in Pop's proposal (1996) for the Western Carpathes.

The upper part of the Calpionellopsis Zone in the Guidaloca section is slightly tectonized and this could explain why the Murgeanui and Dadayi Subzone (in Pop 1994b; Reháková & Michalík 1997) or the Filipescui, Murgeanui and Dadayi Subzone (in Grün & Blau 1997) have not been recognized. In Western Sicily, the markers *Pct. murgeanui* (POP) and "*Pct." dadayi* (KNAUER) have their FO synchronous with *Ct. darderi* (COLOM).

An atypical record in Western Sicily is the LO of *Cs. oblonga*, which has been recorded up to the top of the Calpionellites Zone, whereas Remane (1998) refers it to the base of the Calpionellites Zone. The LO of *Cs. oblonga* is highly variable from Pop (1994b) and Reháková & Michalík (1997), who placed it within the Calpionellites Zone and Grün & Blau (1997) who extended it until the lower part of Tintinnopsella Zone.

The Subzone definition of the Tintinnopsella Zone is difficult because of the low abundance of calpionellids in the upper part of the studied sections. Thus, the Late Valanginian, as well as the Valanginian/Hauterivian boundary, cannot be defined. The calpionellid disappearance in the upper part of the sections prompted an Hauterivian age, as commonly accepted by Remane et al. (1986). The *Lorenziella* genus is not present in the studied sections, although this rare genus was recorded in the Inici Mount (Trapanese Domain) by Cecca et al. (2001).

Thirteen successive calpionellid assemblages characterize the record in Western Sicily for the uppermost Lower Tithonian–Hauterivian. The registered calpionellid bioevents lead to recognize a bio-chronostratigraphic scheme at the Zone/Subzone level, correlable on a long-distance, and based with the previous works of Remane (1971), Olóriz et al. (1995), Pop (1994b), Grün & Blau (1997), and Reháková & Michalík (1997) for the Western Tethys.

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Appendix 1: Calpionellid taxonomy

This appendix is focused on the taxonomical description of some genera of chitinous (*Borziella*, *Longicollaria, Chitinoidella* and *Dobeniella*) and hyaline calpionellids (*Remaniella*, *Sturiella*, *Borzaiella* and *Praecalpionellites*), recorded for the first time in the succession of Western Sicily.

Family Chitinoidinellidae TREJO 1975

As usually elsewhere, the record of chitinous calpionellids in Western Sicily is retricted to the upper part of the Lower Tithonian. Although they are quite scarce, very small, bad-preserved, and then, difficult to identify, it was possible to recognize specimens of the genus *Borziella*, *Longicollaria* and *Dobeniella*, recently defined by Pop (1997), along with the emended genus *Chitinoidella* DOBEN.

Genus *Borziella* POP 1997

Ovoidal to spheroidal lorica with a rounded aboral pole and a small constriction in the preoral part. This is followed by a relatively short and outwardly deflected collar (Pop 1997).

Borziella slovenica (BORZA 1969)
(Pl. I: figs. 1a, b)

1969 *Chitinoidella slovenica* n. sp. – Borza: 76–77, pl. 66, figs. 8, 9.
1997 *Borziella slovenica* (BORZA) – Pop: 935, pl. 2, figs. 14, 15.
2002 *Borziella slovenica* (BORZA) – Reháková: 371, pl. 2, figs. 9, 12.

Ovoidal to spheroidal lorica with a rounded aboral pole. The lorica is 40–48 mm in length, and 28–32 μm in width. Its preoral part bears a small constriction followed by a relatively short outwardly deflected collar, similar to that of *Tintinnopsella remanei* BORZA or *Lorenziella hungarica* KNAUER (Reháková 2002). In Western Sicily, the common dimensions are 40–54 μm in length and 40–43 μm in width. The species appears rarely in the Dobeni Subzone.

Genus *Longicollaria* POP 1997

Elongated ovoidal lorica, with a conical aboral pole ended by a caudal appendage and a slight constriction in the preoral segment. The lorica, still showing a large opening, is continued by an elongated cylindrical or subcylindrical collar with progressively thicker walls towards the distal end. Generally, the collar length is comparable to that of the lorica (Pop 1997).

Longicollaria dobeni (BORZA 1966)
(Pl. I: figs. 2a, b)

1966 Chitinoidella dobeni n. sp. – Borza: 259–261, pl. IX, figs. 1, 2.
1997 Longicollaria dobeni (BORZA) – Pop: 935, pl. 2, figs. 12, 13.
2002 Longicollaria dobeni (BORZA) – Reháková: 371, pl. 4, figs. 4–6.

Cup-shaped or ovoidal lorica with a conical aboral pole ended by a caudal appendage. The preoral segment of the lorica has a slight constriction followed by an elongated cylindrical or subcilyndrical collar, with a progressive thickening of the wall towards the distal end. The lorica is 48–65 μm in length, and 34–42 μm in width. Our specimens range from 40–54 μm in length and 40–43 μm in width. The FO of this species is at the base of Dobeni Subzone.

Genus *Chitinoidella* DOBEN 1963

Variably bell-shaped (ovoid to subcylindrical or cylindrical) lorica with an aboral pole ended by a caudal appendage and a large oral opening surrounded by a collar, constituting a more or less outwardly deflected lorica (Pop 1997).

Chitinoidella boneti DOBEN 1963
(Pl. I: figs. 3a, b; 4a, b; 5a, b)

1963 Chitinoidella boneti n. sp. – Doben: 42–44, pl. 6, figs. 1–5.
2002 Chitinoidella boneti DOBEN – Reháková: 371, pl. 2, figs. 1–4.

Microgranular calcitic, bell-shaped lorica, with a slight preoral constriction and a length / width ratio smaller than 1.5. Commonly, dimensions are 55–83 μm in length and 40–50 μm in width. The Western Sicily specimens recorded in the studied sections have a lorica length of 50–66 μm and width of 36–48 μm. This rare species is restricted to the Boneti Subzone.

Genus *Dobeniella* POP 1997

Elongated bell-shaped or cylindrical lorica, sometimes having a preoral constriction, with a caudal appendage and a large oral opening surrounded by a composite collar. The collar consists of two circumoral parts: the outer is outwardly deflected, the inner one is detached and ring-like with different cross-sections.

Dobeniella bermudezi (FURRAZOLA-BERMÚDEZ 1965)
(Pl. I: Figs. 6a, b; 7a, b)

1965 *Tintinnopsella bermudezi* n. sp. – Furrazola-Bermúdez: 17–20, 28, pl. 1, figs. 2a–c; pl. 2, figs. 6–8; pl. 3, fig.1; pl. 5, fig. 2.
1966 *Chitinoidella bermudezi* (FURRAZOLA-BERMÚDEZ) – Borza: pl. 10, fig. 11.
2002 *Dobeniella bermudezi* (FURRAZOLA-BERMÚDEZ) – Reháková: 371, pl. 3, figs. 7–9.

Bell-shaped, elongated to subcylindrical lorica with an aboral pole ended by a caudal appendage and a large oral opening surrounded by a composite collar in which the elongated inner ring has a comma- or lens-like form (Pop 1997). The recorded specimens have a lorica length of 61–65 μm and width of 40–45 μm. The species is rarely registered in the Boneti Subzone.

Dobeniella cubensis (FURRAZOLA-BERMÚDEZ 1965)
(Pl. I: figs. 8a, b)

1965 *Tintinnopsella* cubensis n. sp. – Furrazola-Bermúdez: 13–16, 27, 28, pl. 1, fig. 1a–c; pl. 2, figs. 1–5; pl. 5, fig. 1.
1966 *Chitinoidella cubensis* (FURRAZOLA-BERMÚDEZ) – Borza: pl. 10, fig. 10.
1997 *Dobienella bermudezi* (FURRAZOLA-BERMÚDEZ) – Pop: 935, pl. 2, figs. 5, 6.

Bell-shaped elongated lorica with composite collar, in which an inner ring-like structure, almost rounded in cross-section, is developed. Our recorded specimens, always in the Boneti Subzone, range from 47–50 μm in length to 36–40 μm in width.

Family Calpionellidae BONET 1956
Genus *Remaniella* CATALANO 1965

Calpionellids with three diagnostic characters: 1) ovoid, bell-shaped, cylindroid or cylindrical differently elongated loricas; 2) collar consisting of two circumoral, normally detached pieces (rings); c) aboral part ended with highly or slightly marked caudal appendage. According to Catalano (1965), the composite collar is the most important morphological feature of this genus. The two rings of the collar have a divergent and oblique position with respect to the oral end of the lorica. Particularly in transitional specimens to other calpionellids with composite collar, the oral end of the lorica may present an extremely small hollow located in the inner part, where the internal ring of the collar is jointed (articuled) (Pop 1994a). To characterize this genus, the morphology of both the collar and the lorica should be taken into account. In the studied sections, this genus appears in the Lower Berriasian, Remaniella Subzone (Calpionella Zone), with a maximum abundance and diversity in the Lower–Middle Berriasian (Cadischiana Subzone).

Remaniella catalanoi POP 1996
(Pl. I: figs. 32a, b; Pl. II: figs. 4a, b)

1996 *Remaniella catalanoi* n. sp. – Pop: 320, figs. 10–15.
1998 *Remaniella catalanoi* POP – Reháková: 446, pl. 1, figs. 3–5.

Bell-shaped to slightly ovoidal lorica with a conical aboral pole ended by a short caudal appendage. The lorica is about 80 mm in length and 60 mm in width. The collar consists of two unequal circumoral rings. The outer ring developes a lenticular-shaped form, while the inner is filiform, marked by two simmetrical points in thin section. The identified specimens have a lorica length of 86–90 μm and a width of 50–54 μm. *R. catalanoi* POP, appears at the base of the Remaniella Subzone, up to the last record in the Cadischiana Subzone.

Remaniella ferasini (CATALANO 1965)
(Pl. I: figs. 30a, b; 31a, b)

1965 *Calpionellites ferasini* n. sp. – Catalano: pl. II, figs. 1–5; pl. III, figs. 5–7.
1998 *Remaniella ferasini* (CATALANO) – Reháková: 446, pl. 1, figs. 1–2.

Small ovoidal lorica ended with a short caudal appendage or with acute aboral zone. Lorica dimensions (without aboral appendage) are approximately 65–80 μm in length and 48–60 μm in width, having the maximum width in its upper third. The collar consits of two detached circumoral rings with almost equal and triangular-shaped profiles in trasversal sections. The inner ring appears as an inward extension of the oral part of the lorica, whereas the outer ring is more or less divergent. In polarized light, the inner ring reveals extinction at 45° if compared to the oral part of the lorica.

Common dimensions of our specimens are 60–74 μm in length and 40–55 μm in width. *Remaniella ferasini* (CATALANO) appears, as a rare component, from the base of Remaniella Subzone. The younger specimens were observed in the middle part of the Cadischiana Subzone.

Remaniella duranddelgai POP 1996
(Pl. II: figs. 3a, b; 6a, b)

1996 *Remaniella duranddelgai* n. sp. – Pop: 320, pl. 2, figs. 1–6.
1998 *Remaniella duranddelgai* POP – Reháková: 446, pl. 1, figs. 6–7.

Bell-shaped to slightly ovoid lorica with a conical aboral part ending with a short caudal appendage and a detached bipartite collar composed of two unequal circumoral rings. In cross-section, the inner ring is triangular-shaped in the direction of the oral part, sometimes slightly inwardly oriented, whereas the outer ring is more or less lenticular-shaped.

The identified specimens are 82–90 μm in length and 46–53 μm in width. The first appearence of this rare species occurred in the middle part of the Remaniella Subzone, and the last occurrence was observed in the lower part of the Cadischiana Subzone.

Remaniella colomi POP 1996
(Pl. II: figs. 9a, b)

1996 *Remaniella colomi* n. sp. – Pop: 320, pl. 2, figs. 7–9.
1998 *Remaniella colomi* POP – Reháková: 446, pl. 1, figs. 8–10.

Cylindrical lorica with a conical aboral part ending with a short caudal appendage and a detached bipartite collar consisting of two unequal circumoral rings. In cross-section, the inner ring is clearly triangular-shaped placed in continuity with the oral part, sometimes slightly inwardly directed; the outer ring is more developed and broadly-lenticular shaped.

The studied specimens are 86–90 μm in length and 61–65 μm in width, remarkably wider than *Remaniella duranddelgai* POP. The species was recorded in the Simplex Subzone.

Remaniella borzai POP 1994
(Pl. II: figs. 19a, b)

1994 *Remaniella borzai* n. sp. – Pop: 329, pl. 1, figs. 13–16.
1998 *Remaniella borzai* POP – Reháková: 446, pl. 1, figs. 11–12.

Cylindrical highly to slightly elongated lorica with aboral appendage. The loricas reach 90–110 mm in length and 60–70 mm in width. The oral part ends with a composite collar, with the outer ring broadly lenticular-elongated, sometimes slightly curved and obliquely placed, with respect to the lorica wall. The inner ring is filiform (punctiform in transverse section), showing extincion at 45° from the lorica under polarized light.

The identified specimens have a lorica length of 81–118 µm and width of 50–70 µm. This species is extremely rare and difficult to separate from *Tintinnopsella carpathica* due to the similarity of the lorica, although the *R. borzai* has clearly two rings. The species ranges from the upper part of the Cadischiana Subzone to the Simplex Subzone

Remaniella cadischiana (COLOM 1948)
(Pl. II: figs. 7; 8a, b)

1948 *Tintinnopsella cadischiana* n.sp. – Colom: 247, pl. 12, figs. 34–35.
1965 *Remaniella cadischiana* (COLOM) – Catalano: pl. I, figs. 6, 7, 11–14; pl. III, fig. 1.
1996 *Remaniella cadischiana* (COLOM) – Grün & Blau: 591, pl. I, figs. 4–7.

Cylindrical or nearly cylindrical elongated lorica with acute aboral part, or more often with well-developed caudal appendage; they reach 90–150 mm in length and 60–80 mm in width. The collar consists of two circumoral detached rings, frequently oblique-divergent. Frequently, the outer ring is slightly curved and leans on the inner one. Generally, the inner ring is shorter than the outer, although they occasionally can be equal, forming a V-shaped collar. Rarely, in the inner oral end of the lorica a small hollow is preserved, where the internal ring is inserted.

Dimensions of our specimens are 98–112 µm in length and 52–56 µm in width. The species occurs from the base of the Cadischiana Subzone to the lower part of Simplex Subzone.

Remaniella filipescui POP 1994
(Pl. II: figs. 20; 22a, b)

1994 *Remaniella filipescui* n.sp. – Pop: 329, pl. I, Figs. 7–12.
1996 *Praecalpionellites filipescui* (POP) – Grün & Blau: 593, pl. II, figs. 10.
1998 *Remaniella filipescui* POP – Reháková: 446, pl. 1, figs. 13–15.

Cup- or bell-shaped lorica with an aboral appendage and a composite collar with two unequal divergent circumoral rings highly to slightly oblique with respect to the oral extremity. The maximum width is placed near the oral part. Commom dimensions are 75–95 µm in length and 65–80 µm in width (holotype = 90×87 µm); length / width ratio is below 1.5 (Pop 1994a).

In the studied sections, the species ranges from the upper part of Oblonga Subzone to the end of the Major Subzone, with dimensions of 84–98 µm in length and 70–82 µm in width.

Genus *Sturiella* BORZA 1981

Cylindrical hyaline lorica with funnel-shaped double collar, connected to the lorica. The inner collar is parallel to the lorica, while the outer one is longer (Borza 1981).

Sturiella oblonga BORZA 1981
(Pl. II: figs. 18a, b)

1981 *Sturiella oblonga* n.sp. – Borza: 97, pl. XXXV, figs. 1–9.
1996 *Sturiella oblonga* BORZA – Grün & Blau: 593, pl. II, figs. 13.
1998 *Sturiella oblonga* BORZA – Reháková: 446, pl. 1, figs. 18–19.

Cylindrical lorica with funnel-shaped double collar connected to the lorica walls. The inner collar, nearly parallel to the lorica, is smaller than the outer, which is highly divergent.

Our forms of this species, which is extremely rare elsewhere (in Western Sicily in particular) have a dimension of 155 µm in length and 76 µm in width, slightly bigger than the specimens from Ra Stua (Italy) (Grün & Blau 1996) and from Western Carpathians (Reháková 1998). Differently from Grün & Blau (1996) (upper part of Oblonga Subzone) and Reháková (1998) (Early to Middle Berriasian), *Sturiella oblonga* BORZA in Western Sicily is restricted to the upper part of the Simplex Subzone.

Genus *Borzaiella* GRÜN & BLAU 1996

Amphora-shaped lorica with a caudal appendage. The diagnostic feature is the comma-shaped collar, adjacent to the terminal part of the lorica (Grün & Blau 1996).

Borzaiella atava GRÜN & BLAU 1996
(Pl. II: figs. 23a, b)
1996 *Borzaiella atava* gen. n., n. sp. – Grün & Blau: 593, pl. II, figs. 1, 2, 6.

Amphora-shaped lorica with a marked caudal appendage. The single comma-shaped collar is arranged with variable orientation at the end of the lorica, although the convex side is always adjacent to the terminal part of the lorica. *Borzaiella atava* GRÜN & BLAU is an extremely rare species, previously recorded only in the Ra Stua section, Belluno Basin, Italy (Grün & Blau 1996). The registered specimens in Western Sicily (mean values of 120×80 µm) are slightly bigger than the holotype. This species is recorded only at the base of the Oblonga Subzone.

Genus *Praecalpionellites* POP 1986

Parabolic or cylindric loricas with pointed aboral zone in longitudinal section. The tripartite collar is the most important character and it is diagnostic to separate this genus from others with composite collar (*Remaniella, Calpionellites*); it has two rings, inner and outer, with the extreme of the lorica outwards in between. The extreme of the lorica has a concave thinner part, in which the inner ring is situated. This inner ring is lenti-

cular, similar to that of *Calpionellites darderi* (COLOM), and can be joined to the lorica or detached from it. The outer ring is also lenticular, divergent and highly to slightly curved upwards. Generally, the dimension of the lorica ranges from 50–130 μm in length and 40–100 μm in width (Pop 1986).

Praecalpionellites murgeanui (POP 1974)
(Pl. II: figs. 17a, b; Pl. III: figs. 1a, b; 6)
1974 *Calpionellites murgeanui* n. sp. – Pop: 105, pl. 1, figs. 1–5, 7–9.
1997 *Praecalpionellites murgeanui* (POP) – Grün & Blau: 211, pl. 2, fig. 4.

The axial section of the lorica is amphora-shaped with an acute caudal pole. The collar apparatus consists of two rings, developed? from below the oral end of the lorica. Well-preserved specimens show the lorica converging at the base of the inner collar ring. This particular collar structure, was called "tripartite" by Knauer (1963) and Pop (1974). Average dimensions for the specimens registered in Western Sicily are 108–122 μm in length and 72–83 μm in width.

This species usually occurs in the upper part of the Oblonga Subzone (Grün & Blau 1997; Reháková 1998) while in the studied sections it appears at the base of the Darderi Subzone and the last occurence was recorded in the upper part of the Major Subzone.

"Praecalpionellites" dadayi (KNAUER 1963)
(Pl. II: figs. 21a, b)
1963 *Calpionellites dadayi* n.sp. – Knauer: 157, pl. 1, figs. 4–5, 12–13.
1974 *Remaniella dadayi* (KNAUER) – Pop: pl. 4, figs. 16.
1997 *Praecalpionellites dadayi* (KNAUER) – Grün & Blau: 211, pl. 2, fig. 5.

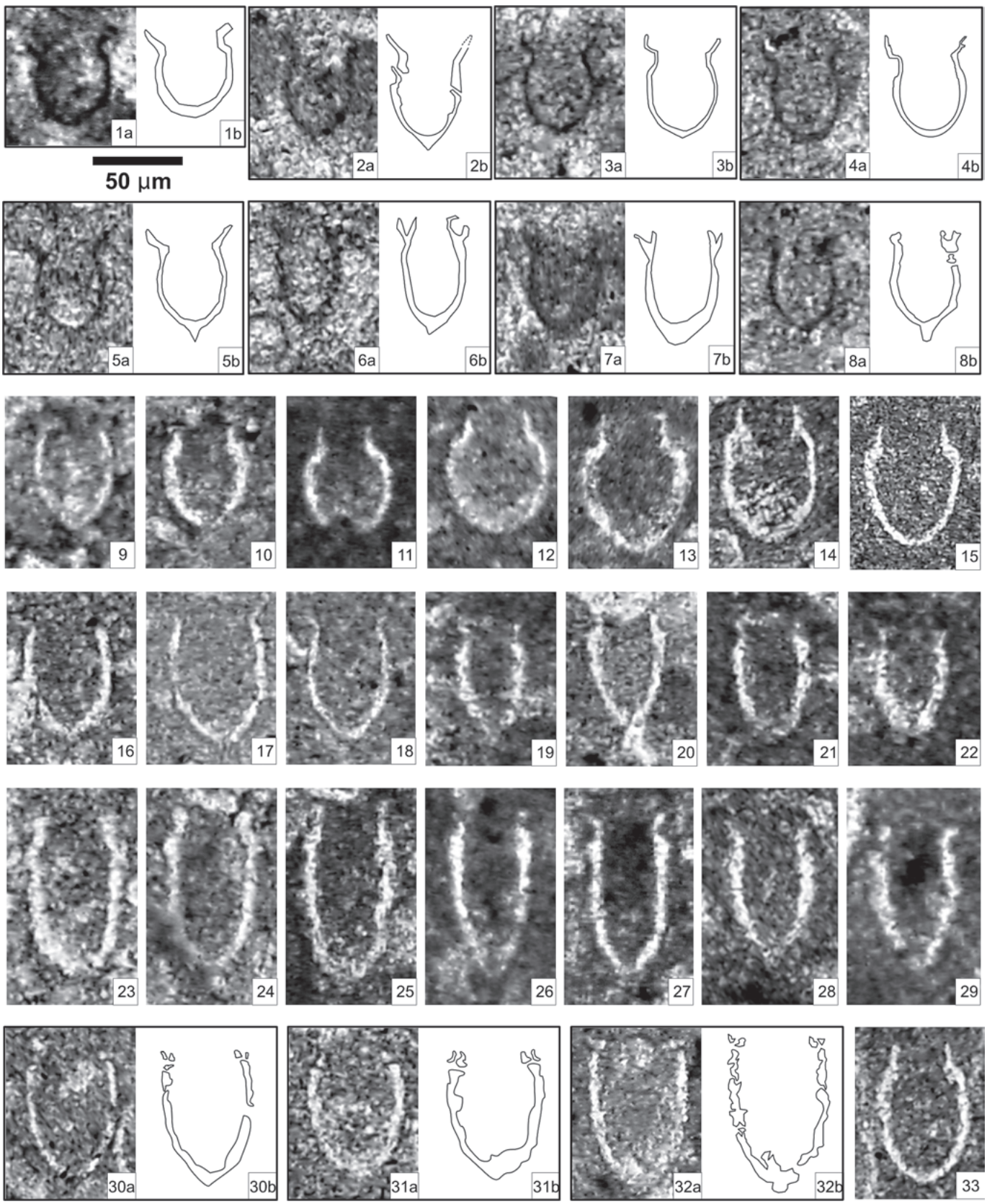
Cylindrical lorica that widens remarkably in correspondence of the oral opening, where the walls end with a moderate inflexion. Lorica height ranges from 145 to 165 μm and width from 75 to 92 μm. Conversely to *Praecalpionellites murgeanui* (POP), the two rings of the collar apparatus are placed above the lorica end ("bipartite collar" in the terminology of Knauer 1963), and this makes the apparatus quite similar to those of *Remaniella* or *Calpionellites*. The convergence of inner ring and the divergence of the outer one separate the species from *Calpionellites.* Nevertheless, doubt remains about the inclusion of this species in the genus *Remaniella*, following Pop (1997) and Reháková (1998), or in the genus *Praecalpionellites*, according to Grün & Blau (1999).

The common dimensions of our specimens are 144–155 μm in length and 76–83 μm in width. The species ranges from the base of Darderi Subzone to the upper part of the Major Subzone.

Plate I

Transmitted light micrographs and drawings of calpionnelids from samples of the Guidaloca section (Western Sicily), in thin sections. Scale bar: 50 μm.

1a, b) *Borzaiella slovenica* (BORZA), GDD, 2.15. 2a, b) *Longicollaria dobeni* (BORZA), GDD, 2.15. 3a, b) *Chitinoidella boneti* DOBEN, GDD, 2.60. 4a, b) *Chitinoidella boneti* DOBEN, GDD, 2.60. 5a, b) *Chitinoidella boneti* DOBEN, GDD, 2.60. 6a, b) *Dobeniella bermudezi* (FURRAZOLA-BERMUDEZ), GDD, 2.60. 7a, b) *Dobeniella bermudezi* (FURRAZOLA-BERMUDEZ), GDD, 2.60. 8a, b) *Dobeniella cubensis* (FURRAZOLA-BERMUDEZ), GDD, 2.60. 9) *Praetintinnopsella andrusovi* BORZA, GDD, 3.50. 10) *Calpionella alpina* LORENZ, GDD, 3.50. 11) *Calpionella alpina* LORENZ spherical form, GDE, 14.50. 12) *Calpionella alpina* LORENZ isometric form, GDE, 5.00. 13) *Calpionella alpina* LORENZ, GDE, 5.00. 14, 15) *Calpionella* sp., GDE, 9.00. 16) *Tintinnopsella carpathica* (MURGEANU-FILIPESCU), GDE, 1.00. 17) *Tintinnopsella carpathica* (MURGEANU-FILIPESCU), GDE, 7.50. 18) *Tintinnopsella carpathica* (MURGEANU-FILIPESCU), GDE, 7.50. 19) *Crassicollaria brevis* REMANE, GDE, 0.00. 20) *Crassicollaria brevis* REMANE, GDE, 0.00. 21) *Crassicollaria parvula* REMANE, GDE, 2.50. 22) *Crassicollaria parvula* REMANE, GDE, 2.50. 23) *Crassicollaria massutiniana* (COLOM), GDE, 0.50. 24) *Crassicollaria massutiniana* (COLOM), GDE, 0.50. 25) *Crassicollaria massutiniana* (COLOM), GDE, 1.50. 26) *Crassicollaria colomi* DOBEN, GDE, 1.50. 27) *Crassicollaria colomi* DOBEN, GDE, 2.00. 28) *Crassicollaria intermedia* (DURAND-DELGA), GDE, 0.50. 29) *Crassicollaria intermedia* (DURAND-DELGA), GDE, 1.00. 30a, b) *Remaniella ferasini* (CATALANO), GDE, 4.50. 31a, b) *Remaniella ferasini* (CATALANO), GDE, 6.00. 32a, b) *Remaniella catalonoi* POP, GDE, 4.00. 33) *Calpionella* sp., GDE, 9.00.


1a
1b
50 µm
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8a
8b
9
10
11
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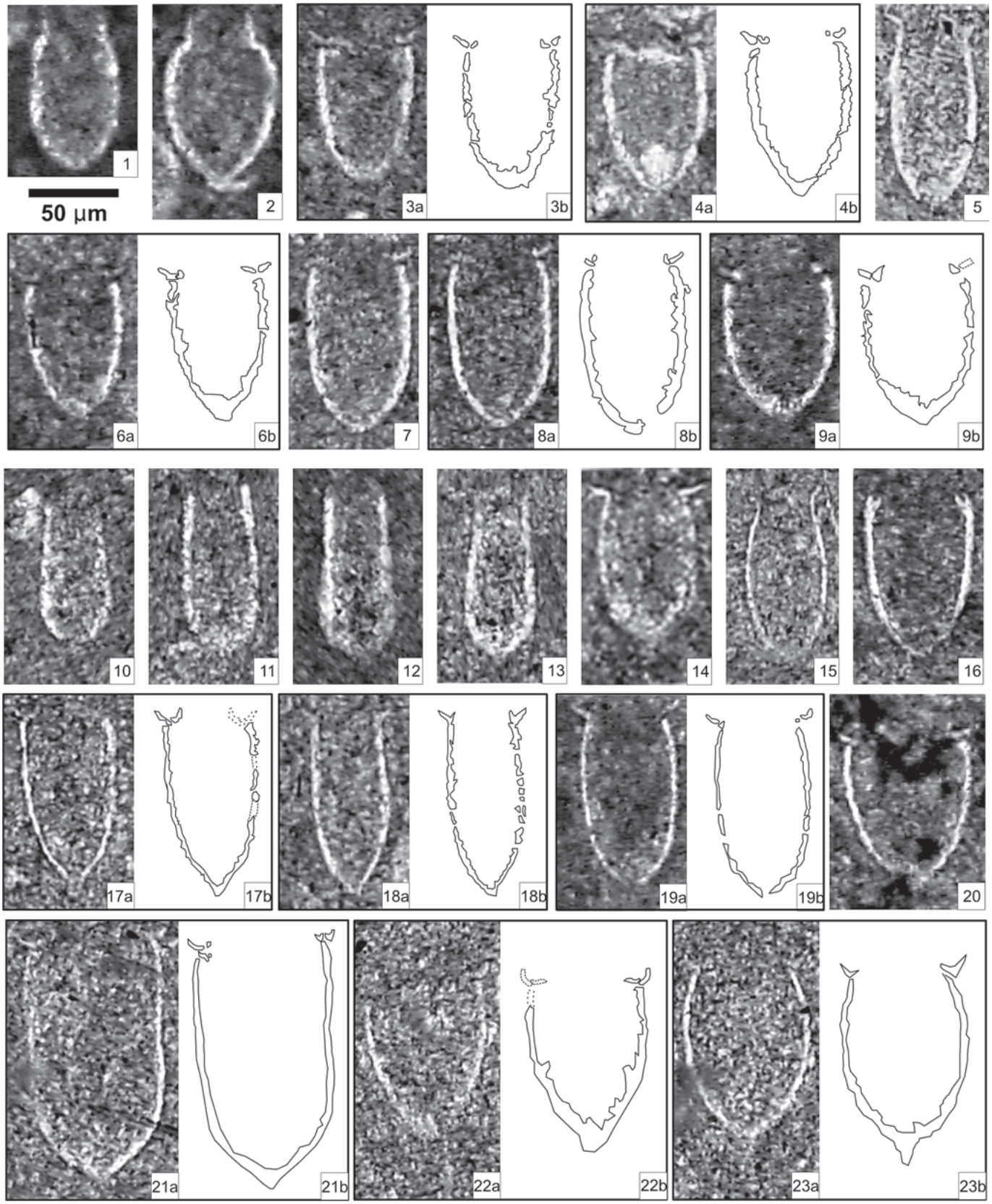
30a
30b
31a
31b
32a
32b
33

Plate II

Transmitted light micrographs and drawings of calpionnelids from samples of the Guidaloca section (Western Sicily), in thin sections. Scale bar: 50 μm.

1) *Calpionella elliptica* CADISCH, GDE, 14.50. 2) *Calpionella elliptica* CADISCH, GDE, 18.50. 3a, b) *Remaniella duranddelgai* POP, GDE, 9.50. 4a, b) *Remaniella catalanoi* POP, GDE, 4.00. 5) *Tintinnopsella carpathica* (MURGEANU- FILIPESCU), GL, 8. 6a, b) *Remaniella duranddelgai* POP, GDE, 9.50. 7) *Remaniella cadischiana* (COLOM), GDE, 9.50. 8a, b) *Remaniella cadischiana* (COLOM), GDE, 9.50. 9a, b) *Remaniella colomi* POP, GDE, 19.50. 10) *Calpionellopsis simplex* (COLOM), GDE, 23.50. 11) *Calpionellopsis simplex* (COLOM), GDE, 23.50. 12) *Calpionellopsis oblonga* (CADISCH), GDE, 29. 13) *Calpionellopsis oblonga* (CADISCH), GDE, 29. 14) *Tintinnopsella carpathica* (MURGEANU-FILIPESCU), GL, 8. 15) *Tintinnopsella carpathica* (MURGEANU-FILIPESCU), GDE, 32. 16) *Calpionellites major* (COLOM), GDE, 38.50. 17a, b) *Praecalpionellites murgeanui* (POP), GDE, 33. 18a, b) *Sturiella oblonga* BORZA, GDE, 23.50. 19a-b) *Remaniella borzai* POP, GDE, 12.00. 20) *Remaniella filipescui* POP, GDE, 32.00. 21a, b) "*Praecalpionellites" dadayi* (KNAUER), GDE, 36.50. 22a, b) *Remaniella filipescui* POP, GDE, 24.00. 23a, b) *Borzaiella atava* GRÜN & BLAU, GDE, 24.00.


1
50 µm
2
3a
3b
4a
4b
5
6a
6b
7
8a
8b
9a
9b
10
11
12
13
14
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20
21a
21b
22a
22b
23a
23b

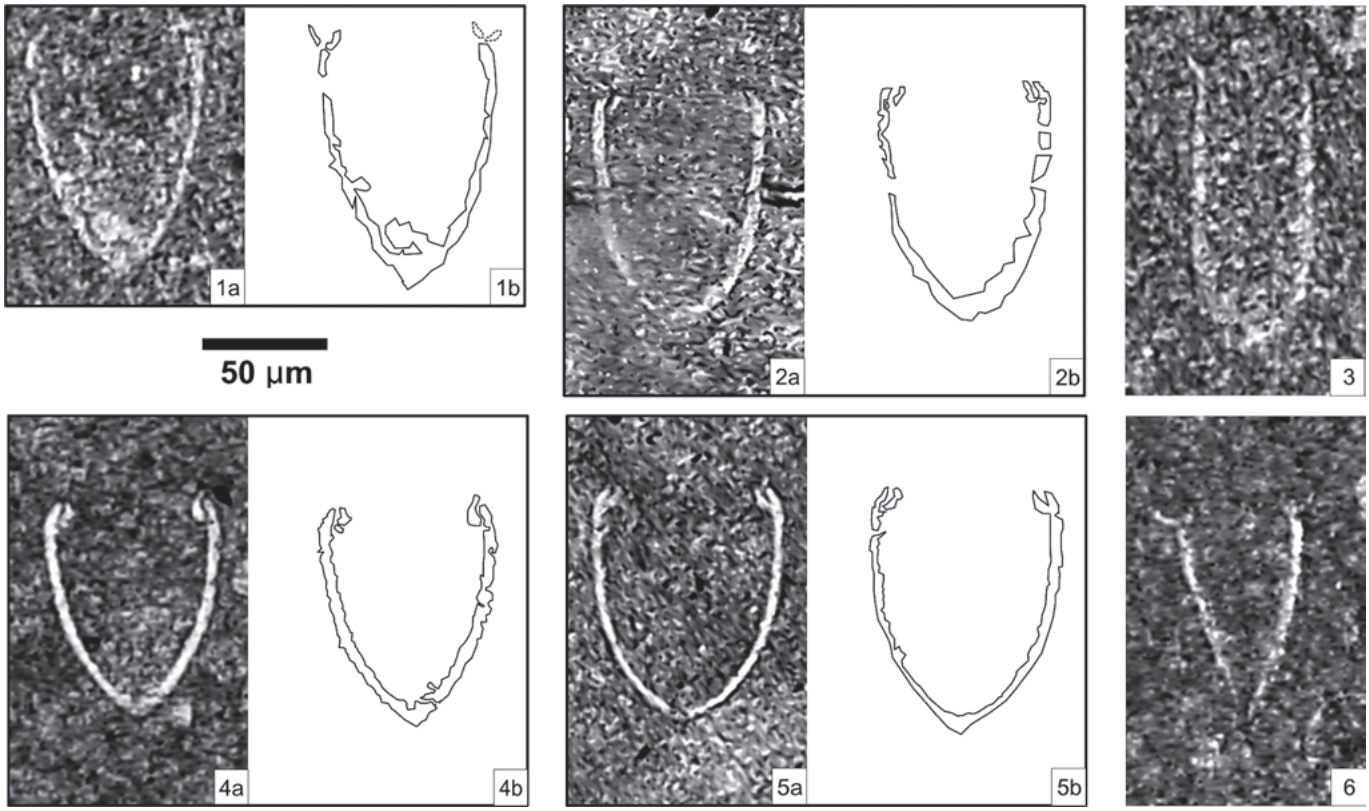

Plate III

Transmitted light micrographs and drawings of calpionnelids from samples of the Guidaloca section (Western Sicily), in thin sections. Scale bar: 50 µm.

1a, b) *Praecalpionellites murgeanui* (Pop), GDE, 36.50. 2a, b) *Calpionellites major* (Colom), GL, 6. 3) *Tintinnopsella longa* (Colom), GDE, 24.00. 4a, b) *Calpionellites coronatus* (Trejo), GDE, 38.50. 5a, b) *Calpionellites darderi* (Colom), GL, 6. 6) *Praecalpionellites murgeanui* (Pop), GDE, 36.50.