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CHITINOIDELLA TREJO, 1975 IN MIDDLE TITHONIAN CARBONATE PELAGIC SEQUENCES OF THE WEST CARPATHIAN TETHYAN AREA

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Abstract: Detailed microfacies analysis of Tithonian pelagic carbonate sequences from the Central West Carpathian and Pieniny Klippen Belt areas allows us to recognize several differences in chitinoidellid morphology on the basis of which several chitinoidellid genera — *Chitinoidella* Doben, 1963; *Borziella* Pop, 1997; *Carpathella* Pop, 1998a; *Longicollaria* Pop, 1997; *Daciella* Pop, 1998a; and *Dobeniella* Pop, 1997 could be recognized among the Middle Tithonian chitinoidellids of the Dobeni and Boneti Subzones. The new *Popiella* n.gen. was introduced, and in the framework of it, the new *Popiella oblongata* n.sp. was described. On the basis of the chitinoidellid vertical distribution, they were included into the Dobeni and the Boneti Subzones of the standard Chitinoidella Zone where they can be utilized for High Resolution Stratigraphy (HIRES) of the Middle Tithonian carbonate pelagic sequences. From the point of view of chitinoidellid phylogeny, this paper regards *Longicollaria dobeni* as the ancestor of *Dobeniella* and *Crassicollaria* species; *Dobeniella tithonica* could have been the ancestor of *Remaniella ferasini*. The newly described *Popiella oblongata* could have been in phylogenetic lineage with *Calpionellopsis simplex* and *Calpionellopsis oblonga*.

Key words: Tithonian, Western Carpathians, Tethys, evolution, phylogeny, taxonomy, biozonation, bioevents, chitinoidellids.

Introduction

Chitinoidellids represent a very small group of ancient planktonic ciliates with microgranular, axially symmetrical lorica. The genus *Chitinoidella* was established by Doben (1962). It comprised all ciliate forms showing a dark wall in transmitted light. For this reason, Doben supposed that chitinoidellid wall is built of chitinous matter. Borza (1966, 1969) and Remane (1969) stated that chitinoidellids have microgranular calcitic loricas. Later, Reháková & Michalík (1992, 1993) confirmed this hypothesis in their studies of the chitinoidella wall ultrastructure by SEM method. Their observations showed that the wall of chitinoidellid lorica is composed of three zones. The two outer zones are formed by scalenohedral calcite crystallites perpendicular to the lorica wall, while the central dark zone consists of small rhombohedral transversely oriented calcite crystallites and also of remains of organic substance.

Chitinoidellids were formerly assigned to the single genus *Chitinoidella* Pop (1997, 1998a) made their taxonomic revision and regrouped them into several new genera. The author of this contribution has tried to revise previous knowledge on these microplanktonic organisms from the West Carpathian area and to correlate these results with those stated by Pop (1997, 1998a). She has tried to bring further lights to the taxonomy and phylogeny of the chitinoidellids.

Geological and lithological background

Jurassic and Lower Cretaceous formations form a considerable part of the Mesozoic sequences in both, the Outer and Central Western Carpathians (Fig. 1). Upper Jurassic–Lower Cretaceous carbonate microfacies and environmental models for the Western Carpathians and adjacent paleogeographic units were created in detail by Vašíček et al. (1994) and Reháková (1995a). Chitinoidellids are common elements of "Ammonitico Rosso" — type condensed deposits accumulated on the thresholds in a pelagic environments. The Czorsztyn Limestone Formation (locally Niedzica or Tegernsee Limestone Formations), the typical West Carpathian representatives of "Ammonitico Rosso" facies consists of Kimmeridgian and Tithonian reddish nodular or pseudonodular limestone. They are of biomicrite (packstone) and biomicrosparite (wackestone) character. Intraclasts occur frequently, some beds pass to limestone microbreccia. A rich association of microfossils allows us to distinguish several calpionellid and dinoflagellate zones in the framework of this limestone sequence: the Kimmeridgian Moluccana and Borzai Zones, Early Tithonian Pulla, Tithonica and Malmica Zones, Middle Tithonian Semiradiata, Tenuis and Chitinoidella Zones and Late Tithonian Fortis, Proxima, Praetintinnopsella and Crassicollaria Zones (Michalík et al. 1990; Reháková

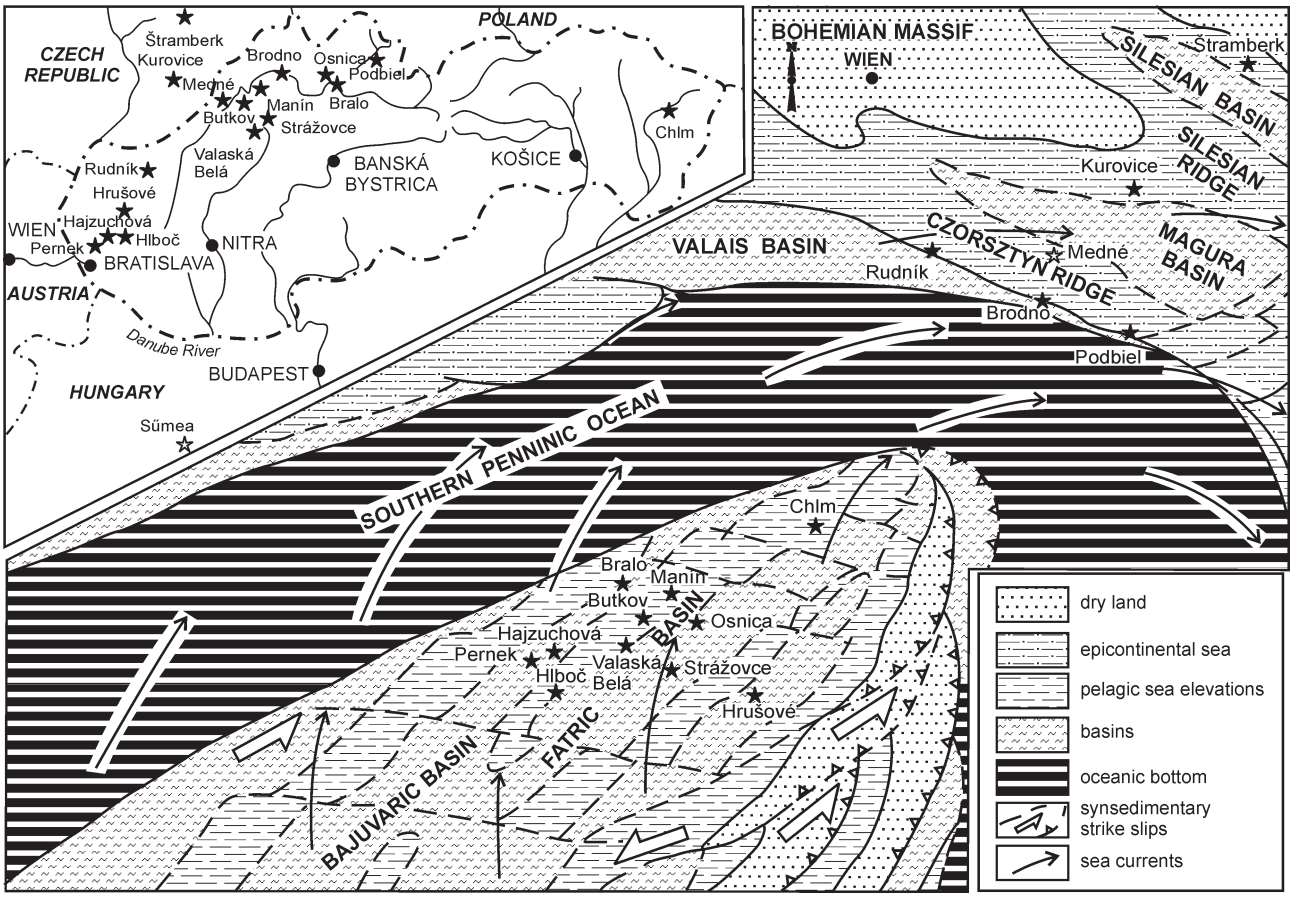

Fig. 1. Location of the section studied in the Upper Jurassic and Lower Cretaceous sequence of the Western Carpathians.

2000a,b). In both the Outer and Central Carpathians, condensed nodular limestone facies continued on "pelagic elevations" (Czorsztyn Limestone Formation, Horné Sŕnie Formation), or shallow marine ridges (Olivetská, Lysa, Spiš and Raptawicka Turnia Formations) up to the Late Berriasian (Reháková 1995a).

Systematics — chitinoidellid genera and species from the Western Carpathians

On the basis of chitinoidellid morphological features (lorica and collar construction) it was possible to recognize following chitinoidellid genera and species.

Family Chitinoidellidae Trejo, 1975

Genus *Chitinoidella* Doben, 1963
Chitinoidella boneti Doben, 1963
Fig. 2.1–4

1963 *Chitinoidella boneti* n.sp. — Doben, pl. 6, figs. 1–5
1965 *Tintinnopsella carpathica* (Murgeanu et Filipescu) — Furrazola-Bermudez, pl. 4, fig. 2
1965 *Chitinoidella boneti* Doben — Borza, pl. I, figs. 1–6; pl. II, figs. 1–4
1975 *Tintinnopsella carpathica* (Murgeanu et Filipescu) — Trejo, pl. XII, fig. 34
1993 *Chitinoidella boneti* Doben — Lakova, pl. I, figs. 7–8
1995 *Chitinoidella boneti* Doben — Reháková, pl. I, figs. 6–7
1995 *Chitinoidella boneti* Doben — Oloriz et al. pl. I, fig. 3
1998 *Chitinoidella boneti* Doben — Pop, pl. I, figs. 34–37, 39

Diagnosis: Microgranular calcitic, bell-shaped lorica, commonly with a slightly preoral constriction and a length/width ratio smaller than 1.5. Aboral pole of lorica ends by a short caudal appendage, its large oral opening bears a collar which outwardly deflected the lorica. Common dimensions are 55–83 μm in length and 40–50 μm in width. It resembles that of *Tintinnopsella carpathica* (Murgeanu et Filipescu) or *Praetintinnopsella andrusovi* Borza.

Occurrence: Boneti Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; South Carpathians, Western Balkanides, NW Anatolia, in the Spanish Betic Cordillera and in the Venetian Alps, Eastern Alps, Cuba, Mexico.

Chitinoidella elongata Pop, 1997
Fig. 2.5–8

1969 *Chitinoidella boneti* Doben — Borza, pl. LXVIII, fig. 8
1997 *Chitinoidella elongata* n.sp. — Pop, Fig. 2, photos 3, 4

Diagnosis: Cylindrical or cylindroid lorica with a conical aboral pole ended by caudal appendage and an out-

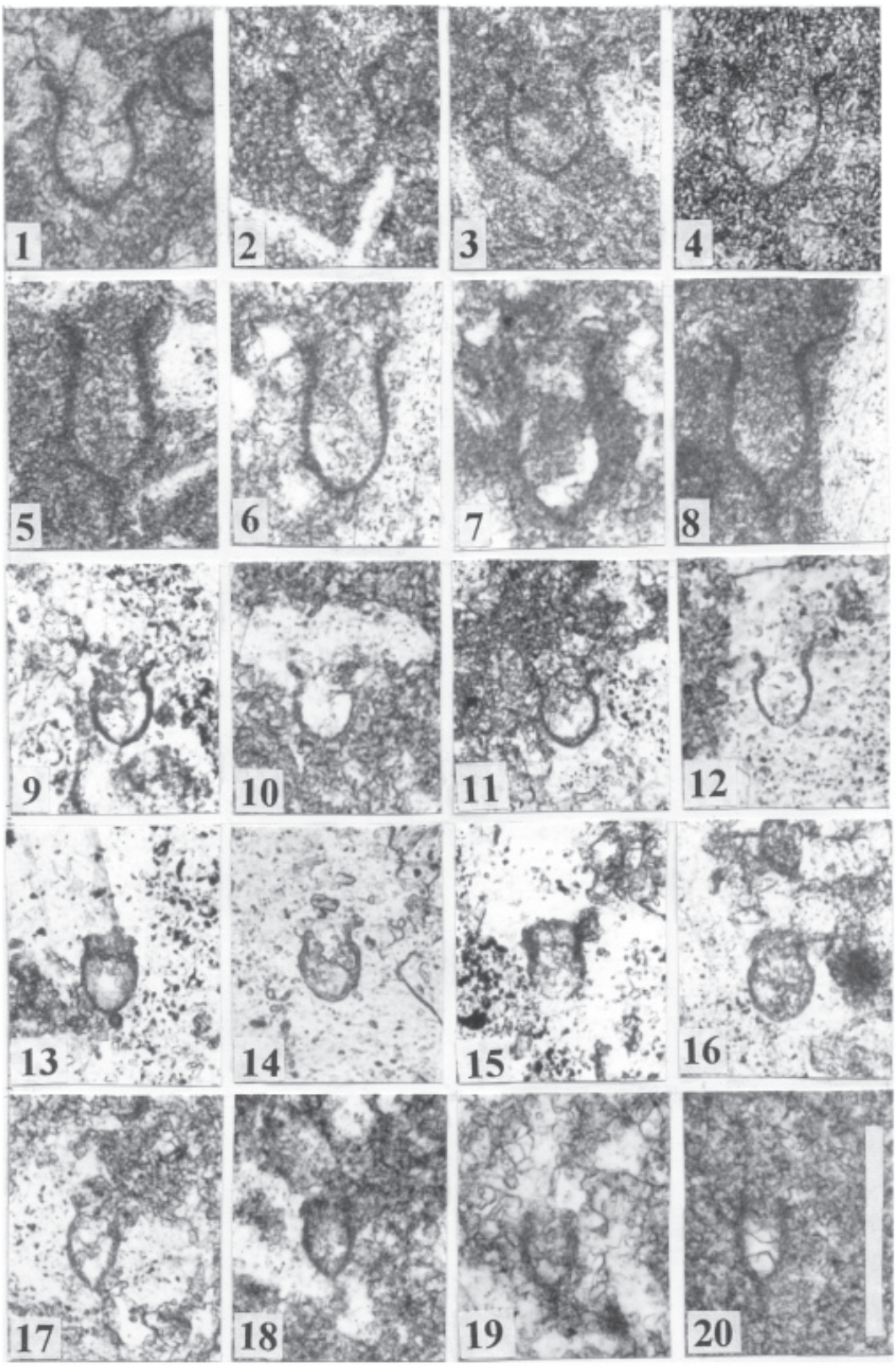

Fig. 2. 1–4. *Chitinoidella boneti* Doben. 1 — Manínska úžina, thin section 5472; 2 — Rudník, thin section 5029; 3 — Manínska úžina, thin section 5472; 4 — Butkov Gallery 13, thin section 8421. **5–8.** *Chitinoidella elongata* Pop. 5 — Manínska úžina, thin section 5472; 6 — Podbiel, thin section 4942; 7 — Podbiel, thin section 4941; 8 — Manínska úžina, thin section 5472. **9–12.** *Borziella slovenica* (Borza). 9 — Podbiel, thin section 4930; 10 — Podbiel, thin section 4928; 11 — Podbiel, thin section 4930; 12 — Podbiel, thin section 4928. **13–16.** *Carpathella rumanica* Pop. 13 — Podbiel, thin section 4930; 14 — Podbiel, thin section 4932; 15 — Podbiel, thin section 4930; 16 — Podbiel, thin section 4929. **17–20.** *Daciella danubica* Pop. 17 — Podbiel, thin section 4928; 18–19 — Brodno, thin section 5048; 20 — Brodno, thin section 5047. All figures are related to the bar in Fig. 20 = 100 μm.

wardly deflected collar. The lorica length is 84–105 μm, its width is 44–55 μm. Its shape resembles that of *Tintinnopsella longa* (Colom).

Occurrence: Boneti Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Southern Carpathians.

Genus *Borziella* Pop, 1997
Borziella slovenica (Borza, 1969)
Fig. 2.9–12

1969 *Chitinoidella slovenica* n.sp. — Borza, pl. LXVI, figs. 8–9
1993 *Chitinoidella slovenica* Borza — Lakova, pl. I, fig. 2
1995 *Chitinoidella slovenica* Borza — Reháková, pl. I, fig. 3
1997 *Borziella slovenica* (Borza) — Pop, Fig. 2, photos 14–15
1998 *Borziella slovenica* (Borza) — Pop, pl. I, figs. 16, 17

Diagnosis: Ovoidal to spaeroidal lorica with rounded aboral pole. The lorica length is 40–48 μm, its width is 28–32 μm. Its preoral part bears a small constriction following by a relatively short outwardly deflected collar similar to *Tintinnopsella remanei* Borza or *Lorenziella hungarica* Knauer type.

Occurrence: Dobeni Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Southern Carpathians, Western Balkanides, NW Anatolia, Eastern Alps.

Genus *Carpathella* Pop, 1998
Carpathella rumanica Pop, 1998
Fig. 2.13–16

1969 *Chitinoidella* sp. — Borza, pl. LXIX, fig. 3
1998 *Chitinoidella rumanica* n.sp. — Pop, Figure 2, photos 1–5

Diagnosis: Species with globular to ovoidal lorica. Its bowl is rounded, aboral pole and a slightly constricted preoral part forming a characteristic "shoulder". Oral opening continues by a short cylindrical collar the diameter of which is commonly smaller than the maximum width of the lorica. The lorica length is 38–42 μm, its width is 34–36 μm. This species strongly resembles *Calpionella alpina* Lorenz.

Occurrence: Dobeni Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Southern Carpathians.

Genus *Daciella* Pop, 1998
Daciella danubica Pop, 1998
Fig. 2.17–20

1969 *Chitinoidella* sp. — Borza, pl. LXIX, fig. 4
1998 *Daciella danubica* n.sp. — Pop, Figure 2, photos 14–18

Diagnosis: Conical and more or less elongated lorica, commonly with a sharp aboral pole ended by a caudal appendage and a large opening, preceded by a characteristic swelling, sometimes hardly perceptible; the oral end of the lorica shows occasionally a very slight constriction, being gradually followed by a short cylindrical collar. The lorica length is 44–58 μm, its width is 34–36 μm. This species strongly resembles *Crassicollaria parvula* Remane.

Occurrence: Dobeni Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Southern Carpathians.

Daciella svinitensis Pop, 1998
Fig. 3.1–3

1998 *Daciella svinitensis* n.sp. — Pop, Fig. 2, photos 19–20

Diagnosis: Lorica elongated or cylindrical its aboral part ended by a short caudal appendage. The lorica length is 52–67 μm, its width is 42–45 μm. The large oral opening is surrounded by a short cylindrical collar; the preoral part of the lorica displays a more or less pronounced swelling resembling the lorica of *Crassicollaria massutiniana* (Colom, 1948).

Occurrence: Upper part of Dobeni Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Southern Carpathians.

Genus *Dobeniella* Pop, 1997
Dobeniella cubensis (Furrazola-Bermudez, 1965)
Fig. 3.4–6

1965 *Tintinnopsella cubensis* n.sp. — Furrazola-Bermudez, pl. 1, figs. 1a–c; pl. 2, figs. 1–5; pl. 5, fig. 1
1966 *Chitinoidella cubensis* (Furrazola-Bermudez) — Borza, pl. X, Fig. 10
1995 *Chitinoidella cubensis* (Furrazola-Bermudez) — Reháková, pl. I, fig. 10
1998 *Dobeniella cubensis* (Furrazola-Bermudez) — Pop, pl. I, figs. 27–29

Diagnosis: Bell-shaped, elongated lorica, the oral part of which ends with a composite collar. The outer ring of collar is relatively short outwardly deflected, its margin is denticulate, the inner ring piece is two times stronger, it is rounded and more or less closes the lorica oral zone. Aboral pole pointed ended by a caudal appendage. The lorica length is 55–72 μm, its width is 45–52 μm.

Occurrence: Boneti Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Cuba, Mexico, Southern Carpathians.

Dobeniella bermudezi (Furrazola-Bermudez, 1965)
Fig. 3.7–9

1965 *Tintinnopsella bermudezi* n.sp. — Furrazola-Bermudez, pl. 1, figs. 2a–c; pl. 2, figs. 6, 8; pl. 3, fig. 1; pl. 5, fig. 2
1966 *Chitinoidella bermudezi* (Furrazola-Bermudez) — Borza, pl. X, Fig. 11
1995 *Chitinoidella bermudezi* (Furrazola-Bermudez) — Reháková, pl. I, fig. 9
1998 *Dobeniella bermudezi* (Furrazola-Bermudez) — Pop, pl. I, figs. 22–24

Diagnosis: The bell-shaped, elongated to subcylindrical lorica with an aboral pole ended by short pointed caudal appendage. Uppermost part of lorica body bears the shoulder following the coarse swelled collar. Sharp distinct steems are visible on the outer surface of the collar surrounding the middle part of the swell. The lorica length is 57–85 μm, its width is 42–57 μm.

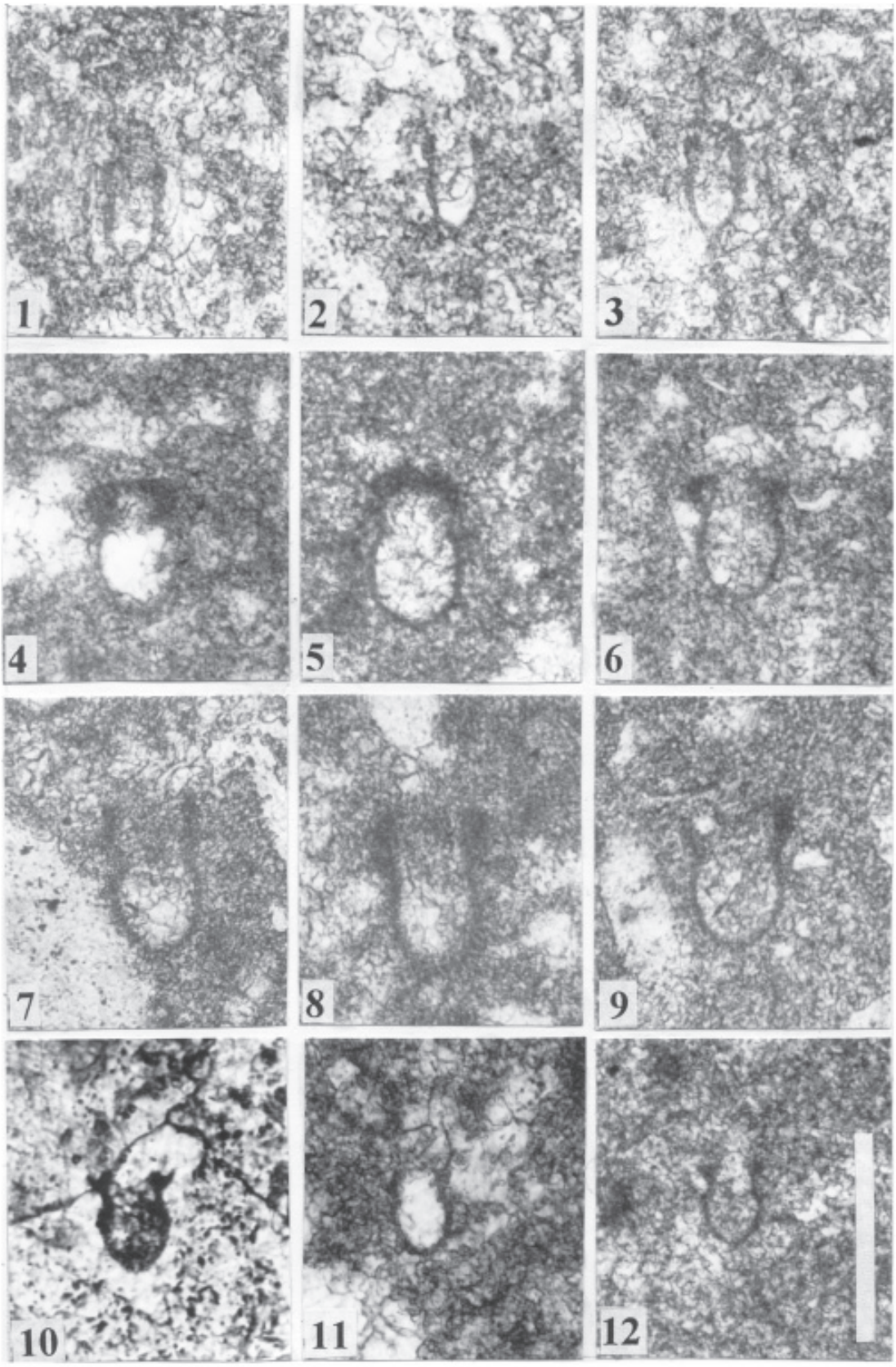

Fig. 3. 1–3. *Daciella svinitensis* Pop — all species derived from locality Podbiel, thin section 4913. **4–6.** *Dobeniella cubensis* (Furrazola-Bermudez). 4 — Brodno, thin section 5061; 5 — Rudník, thin section 5017; 6 — Brodno, thin section 5060. **7–9.** *Dobeniella bermudezi* (Furrazola-Bermudez). 7 — Manínska úžina, thin section 5471; 8 — Manínska úžina, thin section 5472; 9 — Manínska úžina, thin section 5472. **10–12.** *Dobeniella tithonica* (Borza). 10 — Rudník, thin section 2678; 11 — Brodno, thin section 5053; 12 — Brodno, thin section 5052. All figures are related to the bar in Fig. 12 = 100 μm.

Occurrence: Boneti Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Cuba, Mexico, Southern Carpathians.

Dobeniella tithonica (Borza, 1969)
Fig. 3.10–12

1969 *Chitinoidella tithonica* n.sp. — Borza, pl. LXVII, figs. 1–2
1993 *Chitinoidella tithonica* Borza — Lakova, pl. I, fig. 3
1995 *Chitinoidella tithonica* Borza — Reháková, pl. I, fig. 5
1998 *Dobeniella tithonica* (Borza) — Pop, pl. I, figs. 25–26

Diagnosis: Shortly elipsoid or bell-shaped lorica bowl. Its aboral part is pointed or ended by a caudal appendage. An acute constriction is visible in the preoral part of lorica. Oral zone of lorica is large. It bears the compose collar consisting of two rings. The outer, little bit longer ring is outwardly deflected in its distal part; the inner one is short and shows lens-like profile in the cross-section. The lorica length is 42–54 μm, its width is 34–38 μm.

Occurrence: Uppermost part of Dobeni Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Southern Carpathians, Western Balkanides.

Dobeniella colomi (Borza, 1966)
Fig. 4.1–3

1966 *Chitinoidella colomi* n.sp. — Borza, pl. X, figs. 4–7
1995 *Chitinoidella colomi* Borza — Reháková, pl. I, fig. 4
1997 *Dobeniella tithonica* (Borza) — Pop, Fig. 2, photo 9

Diagnosis: Bell-shaped lorica ended by a caudal appendage. Oral belt of lorica is wide, it is followed by distinctly developed outwardly deflected collar. The wall of the collar is progressively thickened towards its distal end. The length of lorica attains 43–60 μm, its width is 28–35 μm; the thickness of the lorica wall is 2–5 μm.

Species occurs in the uppermost part of the Dobeni Subzone of the Middle Tithonian Chitinoidella Zone.

Occurrence: Dobeni Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Southern Carpathians.

Genus *Longicolaria* Pop, 1997
Longicolaria dobeni (Borza, 1966)
Fig. 4.4–6

1966 *Chitinoidella dobeni* n.sp. — Borza, pl. IX, figs. 1, 2
1993 *Chitinoidella dobeni* Borza — Lakova, pl. I, figs. 5, 6
1995 *Chitinoidella dobeni* Borza — Reháková, pl. I, fig. 2
1997 *Longicolaria dobeni* (Borza) — Pop, Fig. 2, photos 12–13
1998 *Longicolaria dobeni* (Borza) — Pop, pl. I, figs. 1–4

Diagnosis: Cup-shaped or ovoid lorica with conical aboral pole ended by a caudal appendage. The preoral segment of lorica bears a slight constriction following to an elongated cylindrical or subcylindrical collar the wall of which is progressivelly thickened towards the distal end. Its length is comparable with that of the lorica. The lorica length is 48–65 μm, its width is 34–42 μm.

Occurrence: Boneti Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Southern Carpathians, Western Balkanides.

Longicolaria insueta (Řehánek, 1986)
Fig. 4.7–9

1986 *Chitinoidella insueta* n.sp. — Řehánek, pl. I, figs. 1–4
1993 *Chitinoidella insueta* Řehánek — Lakova, pl. I, figs. 1
1995 *Chitinoidella insueta* Řehánek — Reháková, pl. I, 8
1997 *Cylindrella insueta* (Řehánek) — Pop, Fig. 2, photos 16
1998 *Aninella insueta* (Řehánek) — Pop, pl. I, figs. 21

Diagnosis: Lorica bowl is elongated vase-like with a rounded aboral pole, the caudal appendage was not observed. The total lorica length is from 85 to 137 μm, its width varies between 58–68 μm. The preoral segment of lorica is without constriction, followed by elongated cylindrical or tabular collar with its wall progressively thickened towards the distal end. Compared with the lorica bowl, the length of the collar is two times longer. Lorica shape resembles the colomiellid forms.

Remarks: Pop (1997) introduced genus *Cylindrella* for ovoidal chitinoidellids showing a rounded aboral pole and long cylindrical collar. Author described *Chitinoidella insueta* Řehánek as its type species. Later Pop (1998b) mentioned, that the generic name *Cylindrella* is a homonym (*Cylindrella* Sharp, fide Slipinski, 1992) and the author replaced it with the new generic name *Aninella*. According to this investigation, the lorica and collar structure of this species have similar character to forms belonging to *Longicollaria*.

Occurrence: Boneti Subzone. Czorsztyn Limestone Formation of the Western Carpathians; Southern Carpathians, Western Balkanides.

Genus *Popiella* n.gen.

Lorica bowl is elongated with a rounded aboral pole; the caudal appendage was not observed. The total lorica length varies between 65 and 89 μm, its width between 31–38 μm. The preoral segment of lorica widely opened, sharply ended; collar was not observed. Lorica shape resembles the forms belonging to *Calpionellopsis*.

Genotype: *Popiella oblongata* n.gen. n.sp.
Popiella oblongata n.sp.
Fig. 4.10–12

1998 *Daciella svinitensis* — Pop, Figure 2, Photo 19.

Holotypus: Specimen on Fig. 4.10, deposited in the Geological Institute of Slovak Academy of Sciences. Locality Podbiel, thin section No. 4918.

Paratypes: Fig. 4.11–12. Locality Podbiel, thin section 4920, 4919.

Derivatio nominis: The generic name is devoted to memory of Grigore Pop, famous micropaleontologist, specialist in calpionellids. The name of the species is derived from the lorica shape.

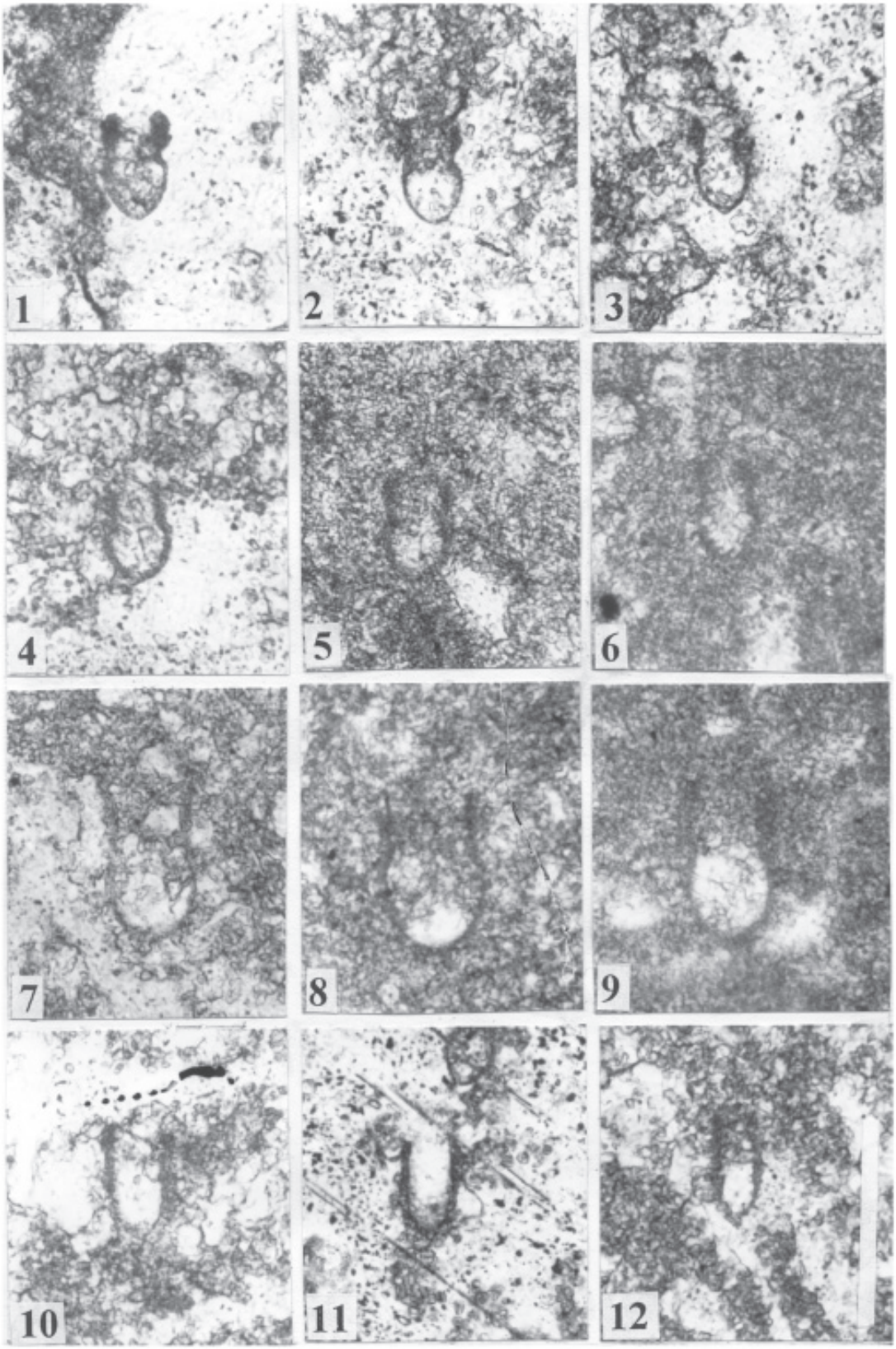

Fig. 4. 1–3. *Dobeniella colomi* (Borza). 1 — Podbiel, thin section 4929. **2–3.** Podbiel, thin section 4930. **4–6.** *Longicollaria dobeni* (Borza). 4 — Podbiel, thin section 4932; 5 — Butkov, Gallery 13, thin section 8423; 6 — Manínska úžina, thin section 5466. **7–9.** *Longicollaria insueta* (Řehánek). 7 — Podbiel, thin section 4941; 8 — Rudník, thin section 5016; 9 — Brodno, thin section 5061. **10.** *Popiella oblongata* n.sp. (holotype). Podbiel, thin section 4918. **11–12.** *Popiella oblongata* n.sp. (paratypes). 11 — Podbiel, thin section 4920; 12 — Podbiel, thin section 4919. All figures are related to the bar in Fig. 12 = 100 μm.

Stratum typicum: Middle Tithonian, biomicritic nodular, or pseudonodular limestone of the Chitinoidella Zone.

Locus typicus: Klippe Podbiel, Middle Tithonian part of the Czorsztyn Limestone Formation, Pieniny Klippen Belt.

Material: 5 specimens in thin sections No. 4918, 4919 and No. 4920 (Klippe Podbiel), 2 specimens in thin section No. 29 (Czorsztyn Limestone Formation of the the Hlboč section,Vysoká Unit of the Krížna Nappe, Central Western Carpathians).

Diagnosis: Lorica bowl is elongated with a rounded aboral pole; the caudal appendage was not observed. The total lorica length (H) varies between 65 and 89 μm, its width (W) between 31–38 μm. The width of the aperture (A) commonly attains the lorica maximum width, but sporadically it can be slightly closer. The wall thickness (Tw) varies between 5–6 μm. The preoral segment of lorica is widely opened and sharply ended; collar was not observed. Lorica shape resembles the forms belonging to Calpionelopsis.

Parameters of the holotype: H = 79 μm, W = 35 μm, A = 29 μm, Tw = 6 μm.

Associations: Chitinoidellids of the Boneti Subzone of the Chitinoidella Zone — *Longicolaria insueta* (Řehánek), *Chitinoidella boneti* Doben 1963, *Chitinoidella elongata* Pop in association with abundant *Saccocoma* Agassiz as well as *Globochaete alpina* Lombard, *Colomisphaera carpathica* Borza, *Schizosphaerella minutissima* (Colom), crinoids, bivalves, ostracods, aptychi fragments and juvenile ammonites.

Occurrence: Boneti Subzone. Czorsztyn and Tegernsee Limestone Formations of the Western Carpathians; Southern Carpathians.

Chitinoidellids — stratigraphic distribution and biozonation

Chitinoidellids attained a dominant position in the plankton during the Middle Tithonian. Chitinoidella Zone was introduced by Enay & Geyssant (1975) in Spanish Betic Cordillera and defined by Grandesso (1977) in the Venetian Alps. The Dobeni and Boneti Subzones (Borza 1984) were characterized by the total range of the index species. However, Reháková (1995b) pointed out that the Chitinoidella Zone and both its subzones are close to interval zones, their upper boundaries being defined by the first index occurrences of the overlying younger biostratigraphic unit. The Chitinoidella Zone was distinguished in the Eastern Alps (Reháková et al. 1996), in Western Carpathians (Borza 1984; Reháková 1995b), Southern Carpathians (Pop 1986, 1989, 1997, 1998a,b), Western Balkanides (Bakalova 1977; Lakova 1993) and in NW Anatolia (Altiner & Özkan 1991). This zone has not been recognized in the Hellenides (Skourtsis-Coroneou & Solakius 1999), Western Mediterranean and westernmost parts of the Tethyan region (Adatte et al. 1992; Remane et al. 1986). Another subdivision of this zone was given by Řehánek (1990).

Consequently, Chitinoidella Zone is defined by the first occurrence (FO) of microgranular chitinoidellids. FO of *Longicollaria dobeni* (Borza) represents the beginning of the Dobeni Subzone (the zonal species is accompanied by *Longicollaria insueta* (Řehánek), *Borziella slovenica* (Borza), *Carpathella rumanica* Pop, *Daciella danubica* Pop, *Daciella svinitensis* Pop higher also *Dobeniella tithonica* (Borza)). *Daciella banatica* Pop, *Daciella almajica* Pop and *Almajella cristobalensis* (Furrazola-Bermudez) were not recognized in the Western Carpathians section studied.

The FO of *Chitinoidella boneti* Doben is typical of the Boneti Subzone. Besides the zonal species, chitinoidellid association consists of *Chitinoidella elongata* Pop, *Longicollaria insueta* (Řehánek), *Dobeniella bermudezi* (Furrazola-Bermudez), *Dobeniella cubensis* (Furrazola-Bermudez), *Popiella oblongata* n.sp. as well as some forms persisting from the preceding interval the Dobeni Subzone.

Chitinoidellid phylogeny

Paleozoic and Triassic microfossils attributed to ancestors of the calpionellids have been described by Colom (1988); Visscher (1970, 1971) and Eshet (1990). However, true calpionellid ancestors still remain uncertain. The start of the phylogenetic history of calpionellids was connected with rapid radiation of microgranular forms at the beginning of the Middle Tithonian (Reháková & Michalík 1997; Pop 1997, 1998a). The evolution of the small chitinoidellids of the Dobeni Subzone followed by the radiation of more advanced and diversified forms in the Boneti Subzone was finished by chitinoidellid exctinction and their substitution by hyaline forms of the Praetintinnopsella Zone having an inner hyaline and an outer microgranular wall layer. The appearence of hyaline calpionellids coincides with the rapid evolution of nannoplankton associations (Reháková 2002).

Reháková & Michalík (1997) pointed out, that calcite composition of calpionellid loricas changed several times during their evolution. At the beginning of the Middle Aptian new forms of microgranular praecolomiellids appeared. The vertical span of these specified forms is short and microgranular loricas are less frequent. On the other hand, they are twice or several times larger than those of Middle Tithonian chitinoidellids. It seems, that the nomismogenesis of planktonic foraminifers lowered the selectional stress among praecolomiellids and such competitive environment led to a growth expansion of their loricas. During the Early Albian, the praecolomiellids were replaced by a new group of hyaline colomiellids. The change of lorica composition was synchroneous with the early Albian peak in nannoconid abundance, as during previously described Late Tithonian change of a chitinoidellid microgranular structure. On the basis of the first study of lorica structure in cathodoluminiscence microscope (Reháková 2000b) considered that during the periods of nannoconid blooming tintinnids started to agglutinate their loricas. Tightly packed coccoliths could have been diagenetically replaced by blocky calcite crystals building fossil hyaline species. The revival of microgranular calpionellids also allows us

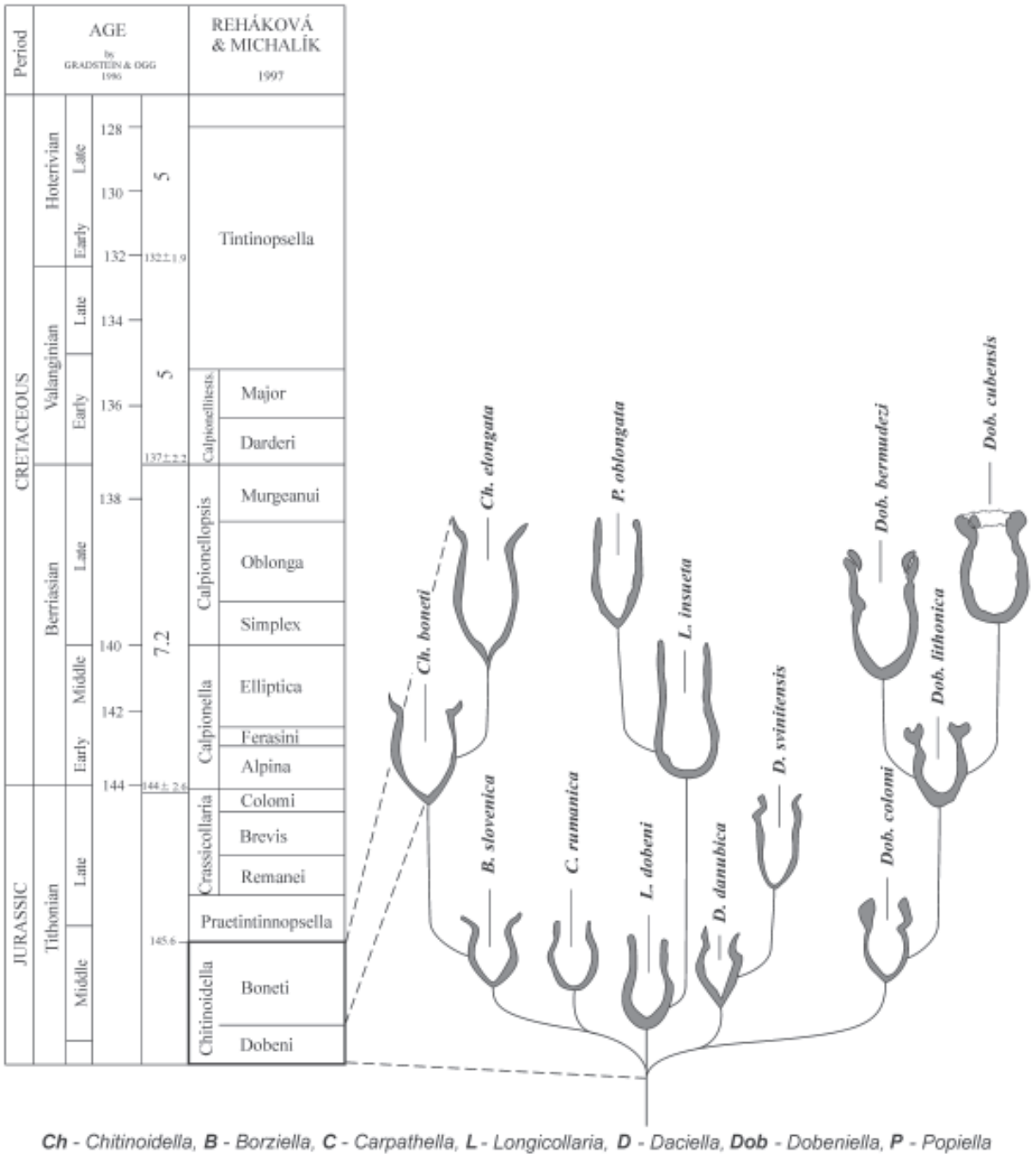

Fig. 5. Stratigraphic distribution and possible lineages in the evolution of chitinoidellids. Geochronological data according to Gradstein & Ogg (1996), actual calpionellid zonation for the Western Carpathians according to Reháková & Michalík (1997).

to speculate about similar climatic and paleoceanographic conditions during both time intervals.

Pop (1998a) discussed in detail the phylogeny of chitinoidellids. He found out, that practically all newly defined species (Pop 1997) are morphologically very comparable with some calpionellids of the Crassicollaria and Calpionella Zones. Among the chitinoidellid associations Pop (1998b) identified several logical parallel phylogenetic lineages proving the phylogenetic relationship between chitinoidellids and calpionellids: *Borziella slovenica* → *Tintinnopsella remanei* or *Lorenziella hungarica*; *Carpathella rumanica* → *Calpionella alpina*; *Daciella danubica* → *Crassicollaria parvula*; *Daciella svinitensis* → *Crassicollaria massutiniana*; *Chitinoidella boneti* → *Praetintinnopsella andrusovi* → *Tintinnopsella carpathica*. All these stocks confirm the phylogenetic concept introduced by Reháková & Michalík (1997).

In contrast to Pop results, this paper (Fig. 5) considers that *Longicollaria dobeni* gave rise to stock represented by two lineages passing through larger *Dobeniella* species and terminated by *Crassicollaria* loricas with more-or-less pronounced swellings below the base of their collars: *Dobeniella colomi* → *Crassicollaria intermedia*.

The species *Dobeniella tithonica* could have been the ancestor of the calpionellids with collars composed of one or several plicae: *Dobeniella tithonica* → *Remaniella ferasini*. The newly described *Popiella oblongata* could have been the ancestor of the *Calpionellopsis* type forms: *Popiella oblongata* → *Calpionellopsis simplex* → *Calpionellopsis oblonga*.

Conclusions

Detailed investigations of chitinoidellid morphological features (lorica and collar construction) allowed us to distinguish several chitinoidellid genera and species among the Middle Tithonian chitinoidellids of the Chitinoidella Zone (the Dobeni and the Boneti Subzones) in pelagic "Ammonitico Rosso" type facies as followed:

Chitinoidella Doben, 1963 — *Chitinoidella boneti* Doben, *Chitinoidella elongata* Pop; *Borziella* Pop, 1997 — *Borziella slovenica* (Borza);

Carpathella Pop, 1998 — *Carpathella rumanica* Pop;

Longicollaria Pop, 1997 — *Longicolaria dobeni* (Borza), *Longicolaria insueta* (Řehánek);

Daciella Pop, 1998 — *Daciella danubica* Pop, *Daciella svinitensis* Pop;

Dobeniella Pop, 1997 — *Dobeniella tithonica* (Borza), *Dobeniella cubensis* (Furrazola-Bermudez), *Dobeniella bermudezi* (Furrazola-Bermudez) and

Popiella n.gen. — *Popiella oblongata* n.sp.

Further, three phylogenetic stocks were recognized in the framework of vertical chitinoidellid distribution (Fig. 5):

1) The first one is derived from *Longicollaria dobeni* which could have been the ancestor of larger crasicollarian loricas.

2) Lineage represented by *Dobeniella tithonica* gave rise to forms having composed collars

3) Newly described *Popiella oblongata* could have been the ancestor of *Calpionellopsis* and later *Calpionellopsella* type forms.

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References

Adatte T., Stinnesbeck W., Hubberten H. & Remane J. 1992: The Jurassic-Cretaceous boundary in NE and Central Mexico — a multistratigraphical approach. *Actas de III Congreso Geológico de Espana y VIII Congreso Latinoamericano de Geología* 4, 23–29.

Altiner D. & Özkan S. 1991: Calpionellid zonation in north-western Anatolia (Turkey) and calibration of the stratigraphic ranges of some benthic foraminifers at the Jurassic-Cretaceous boundary. *Geol. Romana* 27, 215–235.

Bakalova D. 1977: La succession a Calpionelles de la coupe pres du village de Ginci, Bulgarie du Nord-Ouest. *Compte Rendu, Académie Bulgare de Sciences* 30, 423–426.

Bonet F. 1956: Microfaunal zonation of the Cretaceous limestones of the Eastern Mexico. *Boletín de la Asociación Mexicana de Geólogos Petroléros* 8, 389–488 (in Spanish).

Borza K. 1965: Das Vorkommen der Gattung Chitinoidella Doben, 1962 im Oberjura der Westkarpaten. *Geologický Sborník Slovenskej Akademie Vied* 16, 3–5.

Borza K. 1966: Neue Arten der Gattung Chitinoidella Doben, 1962 in den Westkarpaten. *Geologický sborník Slovenskej akademie vied* 17, 259–265.

Borza K. 1969: Die Mikrofacies und Mikrofossilien des Oberjuras und der Unterkreide der Klippenzone der Westkarpaten. *Slovak Academy of Sciences Publishing House, Bratislava,* 302.

Borza K. 1984: The Upper Jurassic-Lower Cretaceous parabiostratigraphic scale on the basis of Tintinninae, Cadosinidae, Stomiosphaeridae, Calcisphaerulidae and other microfossils from the West Carpathians. *Geol. Zbor. Geol. Carpath.* 35, 5, 539–550.

Colom G. 1948: Fossil tintinnids: loricated Infusoria of the order of the Oligotricha. *J. Paleontology* 22, 233–263.

Colom G. 1988: Tintinnids revision (Infusoria, Oligotricha, Loricas). Species evolution in Paleozoic and Mesozoic marine conditions. *Rev. Españ. Paleontología* 3, 71–104 (in Spanish).

Doben K. 1962: Paläontologisch-stratigraphische und fazielle Untersuchungen an der Jura/Kreide-Grenze in den bayrischen Kalkalpen zwischen Inn und salzach. *Univ. München.* Diss. 1–97.

Doben K. 1963: Ueber Calpionelliden an der Jura/Kreide — Grenze. *Mitt. Bayer. Staatsam. Paläontol. Hist. Geol.* 3, 35–50.

Enay R. & Geyssant J.R. 1975: Faunes tithoniques des chaines bétiques (Espagne méridionale). *Mém. B.R.G.M.* 86, 39–55.

Eshet Z. 1990: The palynostratigraphy of the Permian-Triassic boundary in Israel: two approaches to biostratigraphy. *Israel J. Earth Sci.* 39, 1–15.

Furrazola-Bermúdez G. 1965: New species of tintinnids from Upper Jurassic of Cuba. *Instituto Cubano de Recursos Minerales, Publ. Espec.* 2, 1–29 (in Spanish).

Grandesso P. 1977: Tithonian praecalpionellids derived from Ammonitico Rosso facies. *Mem. Sci. Geol.* 32, 1–14 (in Italian).

Lakova I. 1993: Middle Tithonian to Berriasian praecalpionellid and calpionellid zonation of the Western Balkanides, Bulgaria. *Geol. Balcanica* 23, 3–24.

Michalík J., Reháková D. & Halásová E. 1990: Stratigraphy of the Jurassic-Cretaceous boundary beds in the Hlboč Valley (Vysoká Unit of the Krížna Nappe, Malé Karpaty Mts). *Knih. ZPN* 9a, 183–204.

Murgeaunu G. & Filipescu M.G. 1933: Calpionella carpathica n.sp. dans les Carpathes roumaines. *Notationes Biologicae* 1, 63–64.

Olóriz F., Caracuel J.E., Marques B. & Rodríguez-Tovar F.J. 1995: Tintinnid associations from Ammonitico Rosso of the Sierra Norte (Mallorca). *Rev. Españ. Paleontol.* 77–93 (in Spanish).

Pop G. 1986. Calpionellids and correlation of Tithonian-Valanginian formations. *Acta Geol. Hung.* 29, 93–102.

Pop G. 1989: Age and facies of the calpionellid formations from the South Carpathians. In: Cretaceous of the Western Tethys. In: Wiedmann J. (Ed.): Cretaceous of the Western Tethys. *Proceedings of the 3rd International Cretaceous Symposium, Tübingen 1987*, 525– 542.

Pop G. 1997: Révision systématique des chitinoidelles tithoniennes des Carpathes méridionales (Roumanie). *C.R. Acad. Sci. Paris, Sci. de la Terre Planètes* 324, 931–938.

Pop G. 1998a: Nouvelles chitinoďdelles tithoniennes des Carpathes méridionales (Roumanie). *C.R.Acad.Sci. Paris, Sci. de la Terre et Plan.* 326, 817–822.

Pop G. 1998b: Stratigraphic distribution and biozonation of Tithonian Praecalpionellids and calpionellids from the South Carpathians. *Rom. J. Stratigraphy* 77, 4, 3–25.

Reháková D. 1995a: Upper Jurassic–Lower Cretaceous carbonate microfacies and environmental models for the Western Carpathians and adjacent palaeogeographic units. *Cretaceous Research* 16, 283–297.

Reháková D. 1995b: Calpionellid distribution in Upper Jurassic and Lower Cretaceous sequences of the Western Carpathians. *Miner. Slovaca* 27, 308–318.

Reháková D. & Michalík J. 1992: Notes to ultrastructure study of Upper Jurassic–Lower Cretaceous calpionellid tests. *Acta Univ. Carolinae Geol.* 1–2, 107–110.

Reháková D. & Michalík J. 1993: Observation of ultrastructure of the Upper Jurassic and Lower Cretaceous calpionellid tests. *Geol. Carpathica* 44, 75–79.

Reháková D., Michalík J. & Ožvoldová L. 1996: New microbiostratigraphical data from several Lower Cretaceous pelagic sequences of Northern Calcareous Alps (preliminary results). *Mitt. Geol. Bergbaustud. Innsbruck* 4, 57–81.

Reháková D. & Michalík J. 1997: Evolution and distribution of calpionellids — the most characteristic constituent of Lower Cretaceous Tethyan microplankton. *Cretaceous Research* 18, 493–504.

Reháková D. 2000a: Evolution and distribution of the Late Jurassic and Early Cretaceous calcareous dinoflagellates recorded in the Western Carpathian pelagic carbonate facies. *Miner. Slovaca* 32, 79–88.

Reháková D. 2000b: Calcareous dinoflagellate and calpionellid bioevents versus sea-level fluctuations recorded in the West-Carpathian (Late Jurassic/Early Cretaceous) pelagic environments. *Geol. Carpathica* 51, 4, 229–243.

Reháková D. 2002: Upper Jurassic and Lower Cretaceous microgranular calpionellids — implication for palaeoecology and .palaeooceanography of the Western Carpathian pelagic environments. *ESSE WECA 2002, Abstract Book,* 31–33.

Řehánek J. 1986: Chitinoidella insueta n.sp. (Protozoa incertae sedis) from the Tithonian of southern Moravia. *Čas. Mineral. Geol.* 31, 3, 287–292.

Řehánek J. 1990: Calpionellids from the Jurassic and Cretaceous limestones on the SE slope of the Bohemian Massif. Biostratigraphical and sedimentological study from Mesozoicum of the Western Carpathian and Bohemian Massif. *Knih. ZPN* 9b, 185–208 (in Czech).

Remane J. 1969: Les possibilités actuelles pour une utilisation stratigraphique des calpionelles (Protozoa incertae sedis, Ciliata?). *Proceedings, Plankton Conference, Geneve 1967*, 2, 559–573.

Remane J., Bakalova-Ivanova D., Borza K., Knauer J., Nagy I., Pop G. & Tárdi-Filácz E. 1986: Agreement on the subdivision of the standard calpionellid zones defined at the IInd Planktonic Conference, Roma 1970. *Acta Geol. Hung*. 29, 5–14.

Skourtsis-Coroneou V. & Solakius N. 1999: Calpionellid zonation at the Jurassic/Cretaceous boundary within the Vigla Limestone Formation (Ionian Zone, western Greece) and carbon isotope analysis. *Cretaceous Research* 20, 583–595.

Slipinski S.A. 1992: Larinotinae — a new subfamily of Trogossitidae (Coleoptera), with notes on the construction of Trogossitidae and related families of Cleroidea. *Rév. Suisse Zool.* 99, 2, 439–493.

Trejo M. 1975a: Mesozoic tintinnids of Mexico. *Mém. Bureau Réch. Géol. Min.* 86, 95–104 (in Spanish).

Trejo M. 1975b: Mesozoic tintinnids of Mexico (taxonomy, age, paleobiology). *Bol. Asoc. Méxicane Geól. Petrol*. XXVII, 10–12, 329–449 (in Spanish).

Vašíček Z., Michalík J. & Reháková D. 1994: Early Cretaceous stratigraphy, paleogeography and life in Western Carpathians. *Beringeria* 10, 3–169.

Visscher H. 1970: On the occurrence of chitinoid loricas of Tintinnida in an Early Triassic palynological assemblage from Kingscourt, Ireland. *Geological Survey of Ireland, Bull.* 1, 61–64.

Visscher H. 1971: The Permian and Triassic of the Kingscourt outlier, Ireland — a palynological investigation related to regional stratigraphical problems in the Permian and Triassic of Western Europe. *Geological Survey of Ireland, Spec. Pap.* 1, 1–114.