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# Lower Triassic conodont fauna from Tržič (Karavanke Mts., Slovenia)

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*Key words:* Conodonts, taxonomy, biostratigraphy, Lower Triassic, Slovenia

## ABSTRACT

The results of micropaleontological examinations of Upper Permian and Lower Triassic beds in the Tržška Bistrice valley northeast of Tržič, Slovenia, are described. The rocks of the studied section form part of the Southern Karavanke nappe situated between the Košuta nappe and the Sava fault. The section starts with Gröden beds which pass upwards into the Upper Permian dolomite followed by the Lower Triassic variegated sequence which is overlain by the Anisian bedded dolomite. The Lower Triassic oolitic limestone contains the conodont elements: *Foliella gardenae* (STAESCHE), *Hadrodontina anceps* STAESCHE, *Pachycladina obliqua* STAESCHE and *Parachirognathus ethingtoni* CLARK which are of Smithian age.

## Introduction

The Permian-Triassic boundary sediments were subject of numerous studies. Facies, paleogeography and biostratigraphy of the marine Upper Permian and the Permian-Triassic boundary in the Southern Alps and the Karavanke Mountains were studied by Noé (1987). The Permian-Triassic beds of the Carnic Alps in Austria (Gartenkofel core) were cross-disciplinary investigated by a team of specialists (Holser & Schönlaub 1991).

Various studies have been dealing with the Permian and Triassic beds of the Southern Karavanke nappe. Teller (1903) first recorded the Scythian gastropod *Natiria costata* MÜNSTER. Buser (1980) described in the Guidebook to sheet Celovec (Klagenfurt) 1:100,000 several localities of Lower Triassic pelecypods and numerous other fossils including the foraminifer *Meandrosira pusilla* (HO). He mentioned also sampling for conodonts which did not give expected results. The Permian and Triassic beds of the Tržič environs and their fossil contents were further described in two popular papers by Ramovš (1958, 1980). Dolenec et al. (1981) investigated the microfacial, mineralogical and geochemical aspects of a continuous profile of Upper Permian and Scythian beds near Tržič, and interpreted the depositional environment as part of an extended shallow carbonate shelf.

The authors undertook this study in the same profile (Figs. 1, 2) which was investigated by Dolenec et al. (1981), partly in the frame of the investigations for oil and gas in western Slovenia, and partly in the frame of the Triassic conodont studies funded by the Slovenian Ministry of Science and Technology. Seventeen samples from the Upper Per-

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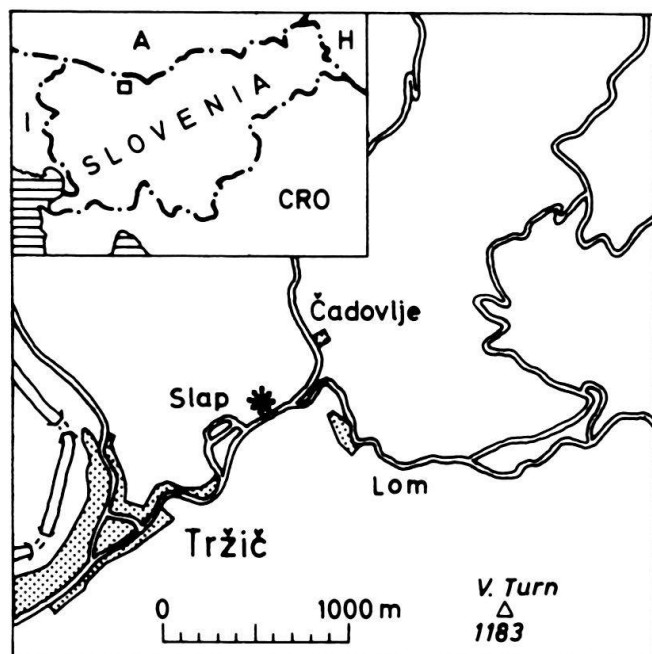


Fig. 1. Location map of the collected locality near Tržič.

mian, Scythian and Anisian bed sequences were collected in the course of this study. Samples of 1 to 1.5 kg were prepared according to the standard procedure for preparation of conodont samples. In seven samples a microfauna consisting of conodonts and ostracods were recovered. The photographs of microfauna were taken under the electron microscope EM JEOL by J. Rode, M.Sc., at the Department of Biology, University of Ljubljana.

### Stratigraphy

The Upper Permian beds overlie conformingly the clastic sediments of the Gröden Formation in the investigated profile (Fig. 2), as in the wider area of the Southern Karavanke nappe. They are dated northeast from the studied section by microfossils which include the algae *Velebitella*, *Mizzia* and *Gymnocodium* (Buser 1980), and may be subdivided roughly into the basal sequence, the overlying dolomite-evaporite complex, and the upper dolomite complex (Buser 1980, Dolenec et al. 1981).

Typical for the basal part is the interbedding of thin red and grey-green shale and silt layers with yellow-red sandy, microsparitic dolomite. Above follow a few meters of cellular dolomite, and then dark grey microsparitic dolomite with 5–10 cm thick layers. Dolomite is somewhat recrystallized, and owing to the organic admixture it has a bituminous smell.

In the dolomite-evaporite complex occurs dolomitic breccia with intercalated beds of porous dolomite. Fragments in the breccia are angular and up to 5 cm in size; at least two dolomite varieties occur. The breccia cement is harder than the rock fragments that usually are leached out leaving cellular rock of the 'rauhwacke' type. Microscopic examinations of the cellular dolomite indicate a high degree of calcitization, and in part silicification. The thickness of the evaporitic complex is about 35 m.

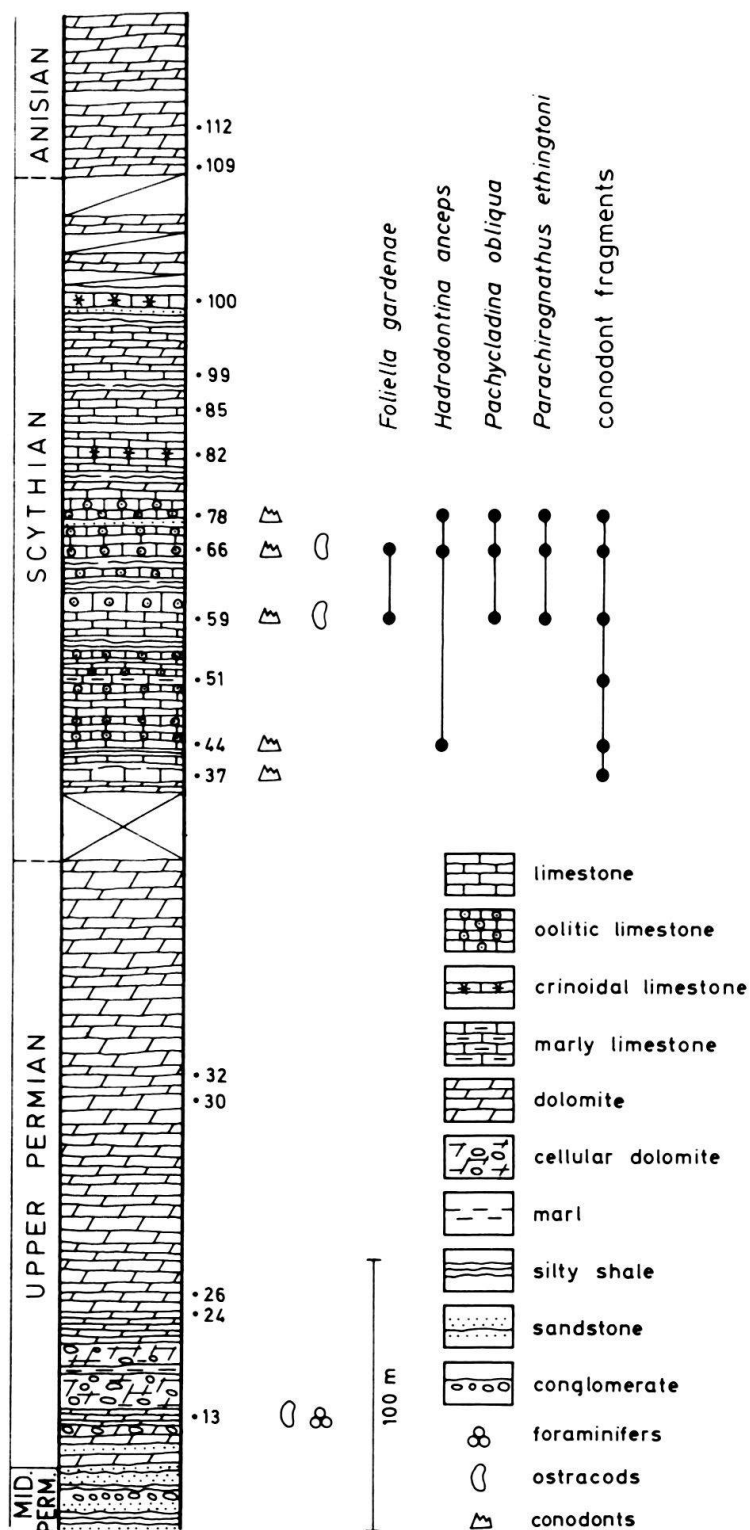


Fig. 2. Stratigraphic section of the studied sequence near Tržič.

The upper dolomitic complex consists of monotonous dolomite that becomes upward more and more thickly bedded (beds up to 50 cm). It is fine grained, with recrystallized and in part washed out micritic matrix. Biomicritic and intrabiomicritic types of dolomite predominate over the pelmicritic and micritic types. The most frequent fossils are non-skeletal algae, foraminifers, recrystallized skeletal algae, ostracods of the genus *Hollinella* (Pl. 1, Figs. 2, 4, 6, 8, 10), microgastropods, and less common pelecypods and echinoid remains. Locally, desiccation cracks, stromatolitic structures and bioturbation may be observed. The thickness of the upper dolomitic complex is about 200 m, which is an approximate estimate, because a part of the profile is covered.

The Lower Triassic beds of Karavanke conformingly overlie the Upper Permian dolomite. They can be subdivided roughly into two approximately equally thick complexes. The lower complex starts with yellow-grey platy micritic dolomite that is interbedded with sheets of shaly dolomitic marl. About 15 m of brownish grey biomicritic limestone and silty dolomite follow upwards. Oolitic limestone of the lower complex appears in 20 to 80 cm layers and lenses. It contains the often tiny gastropods *Holopella gracilior* SCHAUROTH, and *Natica* sp. The rock was affected by late diagenetic dolomitization. Layers of grey or olive grey medium bedded, locally laminated limestone with a micritic, pelmicritic or biosparitic texture are occasionally interbedded. Next to pelecypod valves the limestone contains also gastropods and the conodonts *Foliella gardenae* (STAESCHE), *Hadrodontina anceps* STAESCHE, *Pachycladina obliqua* STAESCHE and *Parachirognathus ethingtoni* CLARK. In the upper part of the lower complex appear rare sheets and beds of reddish silty shale, silty sandstone and sandy dolomite. The thickness of the described sequence is estimated at 100 m.

In the upper complex of the Lower Triassic beds packets of dark grey limestone, sandy and clean dolomite and rare sheets of shale alternate. Limestone is grey and of micritic or biomicritic, more rarely pelmicritic and intramicritic texture. Fossils include echinoderm plates and pelecypod valves, and in the upper part the foraminifer *Glomospira sinensis* HO (Dolenec et al. 1981). The crinoid plates are in places so abundant that they form the skeleton of the rock (crinoidal limestone). The upper complex is terminated by dolomite, predominantly microsparitic. The thickness of the entire Lower Triassic sequence of beds is around 200 m.

The Lower Triassic beds near Tržič pass upwards into Anisian beds. In the area of the studied profile the Anisian stage is of dolomitic development. The dolomite is layered, stromatolitic in places, medium grey and biopelmicritic. The microfauna is dominated by *Meandrospira dinarica* KOCHANSKY DEVIDÉ & PANTIĆ (Dolenec et al. 1981). The Anisian dolomite of the wider area is up to 200 m thick. In the Tržič section about 70 m of the lower part of the Anisian sequence were studied.

### Sedimentary environment

After deposition of the Gröden clastics of fluvial-eolic origin a transgression followed that is reflected in the transitional beds, and in the basal Upper Permian sequence respectively. From that time on, during the entire period from the Upper Permian to the end of Anisian, deposition on a wide shallow shelf prevailed.

The dolomite-evaporite complex of the Upper Permian indicates an arid climate in a high salinity environment with lagoons and evaporitic basins in which cellular dolomite

was formed. The upper part of the Upper Permian dolomitic complex is interpreted to have formed on a shallow restricted shelf with periodic littoral and intertidal conditions.

The Scythian beds display a high diversity of textural types. Limestone was deposited on a very shallow and quiet shelf. Characteristic for the entire Scythian time is the supply of fine grained detritic material that is very variable, and possibly in part of wind-blown origin. In intertidal channels and deltas, where the energy of waves was sufficiently high, the oolitic limestone formed as a typical Lower Triassic deposit of the region.

In contrast to the Lower Triassic beds the Anisian dolomite is very pure, without clastic admixture. It was sedimented on a very shallow, quiet shelf, as indicated by low to very low energy index. Rare desiccation pores and stromatolitic texture indicate periodic littoral deposition.

### Systematic paleontology

Brief description and discussion of recovered conodont elements are given bellow. Multi-element conodont taxonomy is used herein. The classification follows Robinson (1981), except for genus *Foliella* whose position within the family Ellisoniidae is discussed.

Conodont elements have a high colour alteration index (CAI = 5) sensu Epstein and others (1977).

All studied and figured material is stored in the Ljubljana Geological Survey, under registration numbers GZL 2566, 2571, 2635, 2637, 2638, 2640 and 2644.

*Foliella* BUDUROV & PANTIĆ, 1973

*Foliella gardenae* (STAESCHE, 1964)

Pl. 2, Fig. 2–4.

1964 *Polygnathus gardenae* STAESCHE, p. 286–288, Abb. 4, 59, Pl. 30, Figs. 3, 4, 5, 6.

1973 *Foliella gardenae* (STAESCHE) – Budurov & Pantić, p. 52–53, Pl. 1, Figs. 19, 20.

### Description:

Apparatus unimembrate with arched carminiplanate Pa elements. Unit robust, thick, suboval in outline. Platform upper surface nodose. Nodes with more or less regular arrangement, tend to be aligned into radial rows. Nodes subequal in size. Carina composed of low and discrete nodes. Cusp in subcentral position, indistinct. Carina is slightly bent near the cusp. Lower surface is marked by small basal pit beneath cusp. Narrow groove-like extensions are present anterior and posterior of the basal pit. Attachment surface is distinguished by an extensive zone of recessive basal margin which occupies about half width of the lower surface.

### Remarks:

This species reveals great variety in size and ornamentation. The variation in degree of pronounced radial arrangement of rows of nodes has already been observed by Staesche (1964). The elements of *F. gardenae* may at first sight resemble the elements of *Platyllosus asperatus* CLARK, SINCAVAGE & STONE 1964, in their size and ornamentation due to great variability of both species. The Pa elements of *Foliella* can easily be distinguished

from the Pa elements of *Platyvillosus* by the presence of carina and keel. According to the proposed classification in the Treatise of Invertebrate Paleontology, Part W (Robinson 1981) both families, the Ellisoniidae and Xaniognathidae, comprise basically seximembrate apparatuses, but are reduced to unimembrate apparatuses in some species. The unimembrate apparatuses of Ellisoniidae have well developed anterior and posterior processes, whereas in unimembrate Xaniognathidae species the Pa elements lack a posterior process. The segminiplanate Pa elements of *Platyvillosus* and carminiplanate Pa elements of *Foliella* are therefore components of two different apparatuses. The carminiplanate Pa elements of *Foliella* show a closer relationship to the Ellisoniidae.

Material: 12 specimens.

Repository: GZL 2637, 2640 (59, 66).

*Hadrodontina* STAESCHE, 1964

*Hadrodontina anceps* STAESCHE, 1964

Pl. 1, Fig. 7.

1964 *Hadrodontina anceps* STAESCHE, p. 272–273, Figs. 9, 40, Pl. 28, Figs. 7, 8, Pl. 32, Fig. 5.

1981 *Hadrodontina anceps* STAESCHE – Sweet, p. 153, Fig. 101. Ellisoniidae, 1a–e.

1987 *Hadrodontina anceps* STAESCHE – Perri & Andraghetti, p. 306–308, Pl. 31, Figs. 1–6.

Remarks:

Skeletal apparatus of *Hadrodontina* is seximembrate (Sweet 1981). Some elements representing the Sb (digyrate), Sc (bipennate), M (digyrate), and ? Pa (angulate), and ? Sa (alate) positions can be distinguished. For detailed description and further synonymy see Perri & Andraghetti (1987).

Material: 12 specimens.

Repository: GZL 2571, 2637, 2635 (44, 66, 78).

*Pachycladina* STAESCHE, 1964

*Pachycladina obliqua* STAESCHE, 1964

Pl. 1, Fig. 1, 3, 5.

1964 *Pachycladina obliqua* STAESCHE, p. 279, Figs. 14, 21, 31, 46, 47, Pl. 29, Figs. 2–4 (M element).

1964 *Pachycladina symmetrica* STAESCHE, p. 280–281, Figs. 19, 20, 30, 35, 48–51, Pl. 29, Fig. 1, Pl. 31, Fig. 4, Pl. 32, Fig. 1 (Sa element).

1964 *Pachycladina tricuspidata* STAESCHE, p. 281–282, Figs. 16, 34, 52 (Sb element).

1964 *Pachycladina inclinata* STAESCHE, p. 282–283, Figs. 17, 23, 33, 53, 54, Pl. 29, Figs. 5, 6 (Pb element).

1964 *Pachycladina lata* STAESCHE, p. 284–285, Figs. 18, 55 (Pa element).

1964 *Pachycladina longispinosa* STAESCHE, p. 285, Figs. 15, 22, 32, 56–58, Pl. 30, Fig. 2, Pl. 31, Fig. 2 (Sc element).

1981 *Pachycladina obliqua* STAESCHE – Sweet, p. 154, Fig. 102. Ellisoniidae, 4a–e.

1987 *Pachycladina obliqua* STAESCHE – Perri & Andraghetti, p. 312–314, Pl. 34, Figs. 1–7.



**Remarks:**

Apparatus is seximembrate composed of Pa (carminate to planate), Pb (digyrate), M (digyrate), Sa (alate), Sb (digyrate) and Sc (bipennate) elements (Sweet 1981). The elements of *Pachycladina obliqua* STAESCHE can be easily distinguished from other ramiform elements by the presence of the midlateral rib and fine longitudinal striations of the denticles. For complete discussion of the skeletal apparatus *P. obliqua* refer to Perri & Andraghetti (1987).

Material: 20 specimens.

Repository: GZL 2640, 2637, 2635 (59, 66, 78)

*Parachirognathus* CLARK, 1959

*Parachirognathus ethingtoni* CLARK, 1959

Pl. 1, Fig. 9.

1959 *Parachirognathus ethingtoni* CLARK, p. 311–312, Pl. 45, Figs. 3, 5, 7.

1959 *Parachirognathus geiseri* CLARK, p. 312, Pl. 45, Figs. 4, 8, 10, 11.

1981 *Parachirognathus ethingtoni* CLARK – Sweet, p. 154, Fig. 103. Ellisoniidae, 2.

**Remarks:**

According to Sweet (1981), the apparatus is bi- or trimembrate. In collected material some asymmetrical and bladelike elements representing the ?Sb positions are present.

Material: 12 specimens.

Repository: GZL 2640, 2637, 2635 (59, 66, 78).

**Discussion and conclusion**

The Permian part of the studied section near Tržič is characterized by the presence of the ostracod genus *Hollinella*. Several species of *Hollinella* have been described from Upper Permian and Lower Triassic strata worldwide.

The sampled Lower Triassic oolitic lithofacies yields ostracod and conodont faunas. It contains the following conodonts: *Foliella gardenae* (STAESCHE), *Hadrodontina anceps* STAESCHE, *Pachycladina obliqua* STAESCHE, and *Parachirognathus ethingtoni* CLARK. There are also many fragmentary unidentified ramiform elements which may belong to other conodont genera (i.e. *Ellisonia*). The recovered conodont fauna is marked by the shallow-water elements and they confirm a Scythian age, the Smithian stage. This fauna can be correlated to the faunas of Zone 7B and Zone 8 proposed by Solien (1979). Identified conodont elements have wide geographic distribution and are therefore significant for international correlation.

Sweet (1988) claims that in the Lower Triassic (Scythian) genus *Ellisonia* was joined or replaced in shallow-water environments by species of *Furnishius*, *Hadrodontina* and *Pachycladina*. According to Sweet and Bergström (1981) "... the second gondolellacean stock, represented basically by seximembrate *Ellisonia*, probably includes the ancestors



of *Furnishius* and *Hadrodontina*, which are stratigraphically useful genera in shallow-water Smithian rocks ...“ An important stratigraphic use for *Pachycladina obliqua* was emphasized by Perri and Andraghetti (1987). *F. gardenae* has been described from the uppermost part of the Campil beds in South Tyrol, Italy (Staesche 1964). It has been also reported from the Campil beds of Brassina in western Serbia (Budurov & Pantić 1973). Multielement species *H. anceps* has been recovered from the Werfen Formation (Griesbachian–Spathian) (Perri & Andraghetti 1987). *P. obliqua* is widely distributed in Asia, N. America and in Europe; in Southern Alps, Italy, it has been recovered from the Werfen Formation (upper Nammalian–Spathian) (Perri & Andraghetti 1987). Based on data obtained from Thaynes Formation in Utah, Solien (1979) concluded that *Pachycladina* and *Hadrodontina* characterize the Smithian. The Scythian species *P. ethingtoni* has wide geographic distribution (Europe, Asia, N. America). The *Parachirognathus* – *Furnishius* fauna is placed into Zone 7 (Lower Smithian) according to Sweet and others (1971); both forms are present throughout the zone, however *Furnishius* is the dominant element in the lower part of this zone, and *Parachirognathus* becomes dominant in its higher part. Environmental control for *Parachirognathus* and *Furnishius* has been studied by Clark and Rosser (1976). The Smithian Range Zones were later redefined by Solien (1979) and in the recognized conodont zonation of Thaynes Formation, Utah the genus *Parachirognathus* is present in the Zone 7B (a mixed *Parachirognathus*/*Furnishius* Zone) and Zone 8 (a *Parachirognathus* Zone exclusive of *Furnishius* and associated with elements of *Neospathodus bicuspidatus* (MÜLLER).

Lower Triassic conodonts have been previously reported from Vrležca in western Slovenia (Kolar-Jurkovšek 1990), representing the following elements: *Furnishius triseratus* CLARK, *Hadrodontina* sp., *P. obliqua* (Pa, M, Sa and Sc elements) and *P. ethingtoni*. The conodont fauna corresponds to the Smithian *Parachirognathus*/*Furnishius* assemblage Zone (Zone 7) of Sweet and others (1971).

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We wish to thank Dr. H. Kozur (Budapest), Dr. L. Krystyn (Vienna) and Dr. M. Orchard (Vancouver) for critically reviewing the manuscript and for helpful suggestions. A grant of the Slovenian Ministry of Science and Technology to the Geological Survey Ljubljana (Institute of Geology, Geotechnics and Geophysics) is gratefully acknowledged.

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**Plate 1**

Fig. 1, 3, 5: *Pachycladina obliqua* STAESCHE, Tržič 66 (GZL 2637), Lower Triassic, Smithian stage;

Fig. 1: Sa element, posterior view, 70 x,

Fig. 3: M element, anterior view, 70 x,

Fig. 5: Sc element, lateral view, 56 x.

Fig. 2, 4, 6, 8, 10: *Hollinella* sp., Tržič 13 (GZL 2566), Upper Permian;

Fig. 2, 6: left valve, female, 42 x,

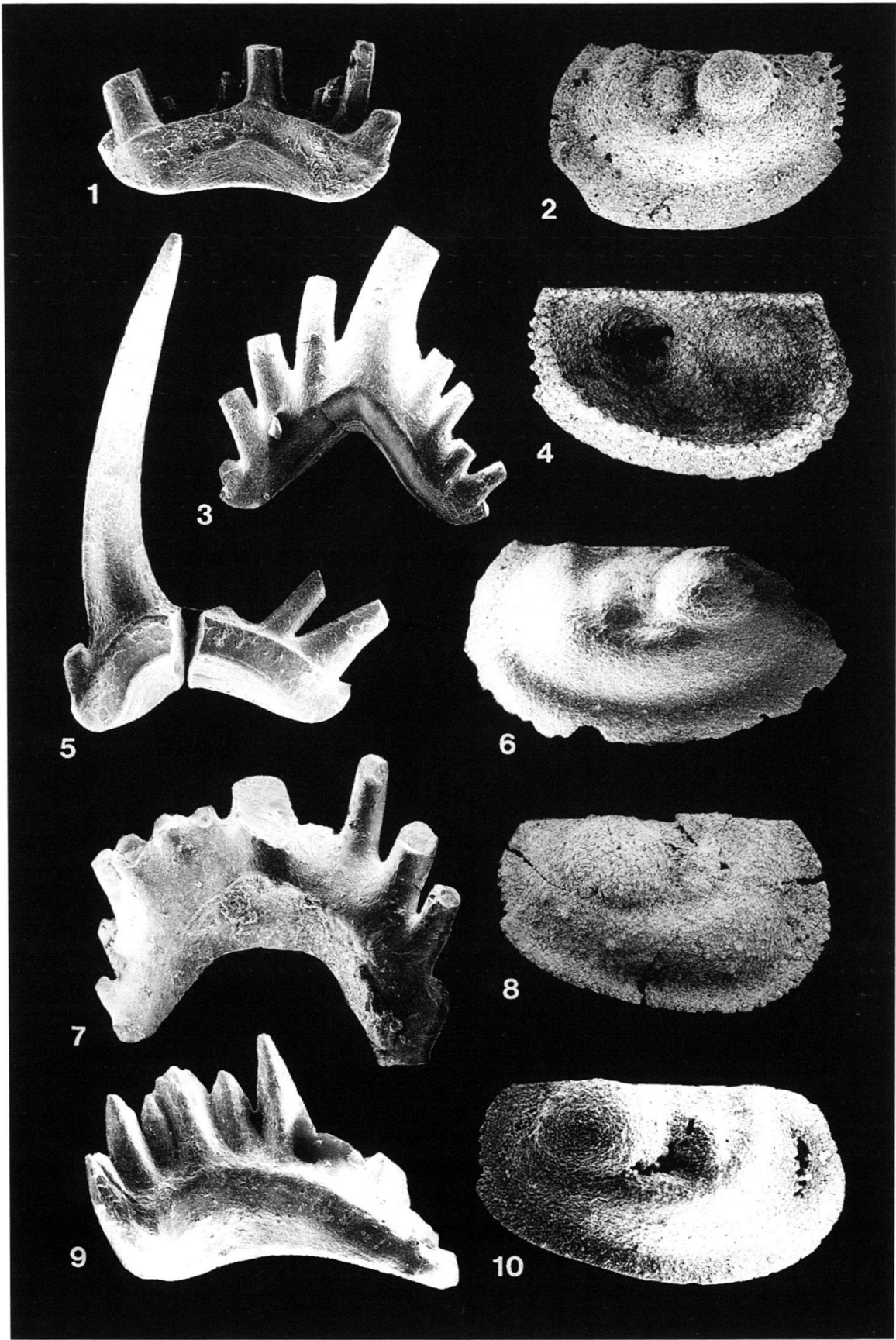
Fig. 4: left valve, male, 42 x,

Fig. 8: right valve, male, 42 x,

Fig. 10: right valve, ? male, 42 x.

Fig. 7: *Hadrodontina anceps* STAESCHE, Sb element, posterior view, Tržič 59 (GZL 2640), Lower Triassic, Smithian stage; 35 x.

Fig. 9: *Parachirognathus ethingtoni* CLARK, ? Sb element, posterior view, Tržič 78 (GZL 2635), Lower Triassic, Smithian stage; 35 x.



**Plate 2**

Fig. 1: *Foliella* sp., Pa element, juvenile specimen, Tržič 66 (GZL 2637), Lower Triassic. Smithian stage; 146 x.

Fig. 2a, b; 3a, b; 4a, b: *Foliella gardenae* (STAESCHE), Pa elements, Tržič 66 (GZL 2637), Lower Triassic, Smithian stage; Fig. 2a, b 65 x; Fig. 3a, b; 4a, b 70 x. a-oral view, b-aboral view.

