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**Harald Lobitzer & Pavol Grecula**

# Silurian and lowermost Devonian bivalves of Bohemian type from the Carnic Alps

Jiří Kříž

7 Text-Figures, 10 Plates

*Österreich*
*Karnische Alpen*
*Silur*
*Bivalven*
*Paläoökologie*
*Stratigraphie*
*Korrelation*

*Österreichische Karte 1:50.000*
*Blätter 197, 199*

## Contents


| | | |
|---|---|---|
| | Zusammenfassung | 261 |
| | Summary | 261 |
| 1. | Introduction | 261 |
| 2. | Geology, Stratigraphy, Localities and Preservation | 261 |
| 3. | Systematic Part | 264 |
| | Superfamily Ctendontacea Wöhrmann, 1893 | 264 |
| 3.1. | Family Ctenodontidae Wöhrmann, 1893 | 264 |
| 3.1.1. | Genus Ctenodonta Salter, 1852 | 264 |
| 3.1.1.1. | *"Ctenodonta" simplicitor* (Barrande, 1881) | 264 |
| | Superfamily Praecardiacea Hörnes, 1884 | 266 |
| 3.2. | Family Antipleuridae Neumayr, 1891 | 266 |
| 3.2.1. | Genus *Dualina* Barrande, 1881 | 266 |
| 3.2.1.1. | *Dualina comitans* Barrande, 1881 | 266 |
| 3.2.1.2. | *Dualina* aff. *comitans* Barrande, 1881 | 266 |
| 3.2.1.3. | *Dualina consors* Barrande, 1881 | 266 |
| 3.2.1.4. | *Dualina longiuscula* Barrande, 1881 | 266 |
| 3.2.1.5. | *Dualina socialis* Barrande, 1881 | 267 |
| 3.2.1.6. | *Dualina secunda* Barrande, 1881 | 267 |
| 3.2.1.7. | *Dualina nigra* Barrande, 1881 | 267 |
| 3.2.1.8. | *Dualina annulosa* Barrande, 1881 | 267 |
| 3.2.1.9. | *Dualina inexplicata* Barrande, 1881 | 268 |
| 3.2.1.10. | *Dualina? cocco* sp. n. | 268 |
| 3.2.2. | Genus *Antipleura* Barrande, 1881 | 270 |
| 3.2.2.1. | *Antipleura bohemica* Barrande, 1881 | 270 |
| 3.2.3. | Genus *Silurina* Barrande, 1881 | 270 |
| 3.2.3.1. | *Silurina percalva* Barrande, 1881 | 270 |
| 3.2.4. | Genus *Vlasta* Barrande, 1881 | 271 |
| 3.2.4.1. | *Vlasta bohemica* Barrande, 1881 | 271 |
| | Superfamily Cardiolacea Fischer, 1886 | 271 |
| 3.3. | Family Cardiolidae Fischer, 1886 | 271 |
| 3.3.1. | Genus *Cardiobeleba* Kříž, 1974 | 271 |
| 3.3.1.1. | *Cardiobeleba lavina* Kříž, 1979 | 271 |
| 3.3.1.2. | *Cardiobeleba obstetrix* Kříž, 1974 | 271 |
| 3.3.1.3. | *Cardiobeleba ava* Kříž, 1979 | 271 |
| 3.3.2. | Genus *Carnalpia* Kříž, 1974 | 274 |
| 3.3.2.1. | *Carnalpia rostrata* Kříž, 1974 | 274 |
| 3.3.2.2. | *Carnalpia nivosa* Kříž, 1979 | 274 |
| 3.3.3. | Genus *Cardiolopsis* Stache in Heritsch, 1929 | 274 |
| 3.3.3.1. | *Cardiolopsis alpina* Stache in Heritsch, 1929 | 274 |


(Author's address: RNDr. Jiří Kříž, PhD., Division of Regional Geology of Sedimentary Formations, Czech Geological Survey, P.O.B. 85, Praha 011, 118 21, Czech Republic)

3.3.4. Genus *Cominicula* KŘÍŽ, 1974 ... 274
3.3.4.1. *Cominicula kokiana* STACHE in HERITSCH, 1929 ... 275
3.3.5. Genus *Cardicarnia* KŘÍŽ, 1974 ... 275
3.3.5.1. *Cardicarnia monticola* KŘÍŽ, 1974 ... 275
3.3.5.2. *Cardicarnia barrandei* sp. n. ... 275
3.3.6. Genus *Cardiola* BRODERIP in MURCHISON, 1839 ... 278
3.3.6.1. *Cardiola bifasciata* (STACHE in HERITSCH, 1929) ... 278
3.3.6.2. *Cardiola stachei* sp. n. ... 278
3.3.6.3. *Cardiola tinda* sp. n. ... 278
3.3.6.4. *Cardiola* aff. *figusi* KŘÍŽ, 1993 ... 279
3.3.6.5. *Cardiola schoenlaubi* sp. n. ... 279
3.3.6.6. *Cardiola docens* BARRANDE, 1881 ... 282
3.3.6.7. *Cardiola spectabilis* BARRANDE, 1881 ... 282
3.3.6.8. *Cardiola consanguis* BARRANDE, 1881 ... 283
3.3.6.9. *Cardiola signata* BARRANDE, 1881 ... 283
3.3.6.10. *Cardiola conformis* BARRANDE, 1881 ... 283
3.3.6.11. *Cardiola cf. tix* KŘÍŽ, 1979 ... 286
3.3.6.12. *Cardiola eximia* BARRANDE, 1881 ... 286
3.3.6.13 *Cardiola pectinata* BARRANDE, 1881 ... 286
3.3.6.14. *Cardiola alata* BARRANDE, 1881 ... 286
3.3.7. Genus *Isiola* KŘÍŽ, 1974 ... 287
3.3.7.1. *Isiola zila* sp. n. ... 287
3.3.8. Genus *Cardiolinka* KŘÍŽ, 1981 ... 287
3.3.8.1. *Cardiolinka bohemica* (BARRANDE, 1881) ... 287
3.3.8.2. *Cardiolinka* cf. *irregularis* (BARRANDE, 1881) ... 290
3.3.8.3. *Cardiolinka* cf. *concubina* (KŘÍŽ, 1979) ... 290
3.3.9. Genus *Pygolfia* KŘÍŽ, 1974 ... 290
3.3.9.1. *Pygolfia* cf. *nina* (BARRANDE, 1881) ... 290

3.4. Family Slavidae KŘÍŽ, 1982 ... 290
3.4.1. 290Genus *Slava* BARRANDE, 1881 ... 290
3.4.1.1. *Slava 290 fibrosa* (SOWERBY in MURCHISON, 1839) ... 290
3.4.1.2. *Slava pelerina* KŘÍŽ, 1985 ... 290
3.4.1.3. *Slava* cf. *sathon* KŘÍŽ, 1985 ... 291
3.4.2. Genus *Slavinka* KŘÍŽ, 1982 ... 291
3.4.2.1. *Slavinka* aff. *damona* KŘÍŽ, 1985 ... 291
3.4.2.2. *Slavinka cubula* KŘÍŽ, 1985 ... 291
3.4.2.3. *Slavinka elevata* (BARRANDE, 1881) ... 291

Superfamily Ambonychiacea S. A. MILLER, 1887 ... 294
3.5. Family Ambonychiidae S. A. MILLER, 1877 ... 294
3.5.1. ?Ambonychiidae gen. et sp. indet. ... 294

3.6. Family Lunulacardiidae FISCHER, 1887 ... 294
3.6.1. Genus *Maminka* BARRANDE, 1881 ... 294
3.6.1.1. *Maminka comata* BARRANDE, 1881 ... 294
3.6.2. Genus *Mila* BARRANDE, 1881 ... 294
3.6.2.1. *Mila complexa* BARRANDE, 1881 ... 294
3.6.2.2. *Mila janina* sp. n. ... 295
3.6.3. Genus *Spanila* BARRANDE, 1881 ... 295
3.6.3.1. *Spanila aspirans* BARRANDE, 1881 ... 295
3.6.3.2. *Spanila gracilis* BARRANDE, 1881 ... 298
3.6.3.3. *Spanila celer* BARRANDE, 1881 ... 298
3.6.4. Genus *Tenka* BARRANDE, 1881 ... 298
3.6.4.1. *Tenka bohemica* BARRANDE, 1881 ... 298
3.6.5. Genus *Patrocardia* FISCHER, 1887 ... 298
3.6.5.1. *Patrocardia* aff. *novela* (BARRANDE, 1881) ... 298
3.6.5.2. *Patrocardia celloni* sp. n. ... 299
3.6.5.3. *Patrocardia simplex* (BARRANDE, 1881) ... 299
3.6.5.4. *Patrocardia* aff. *analoga* (BARRANDE, 1881) ... 299
3.6.5.5. *Patrocardia sulcifera* (BARRANDE, 1881) ... 299
3.6.5.6. *Patrocardia* aff. *sulcifera* (BARRANDE, 1881) ... 302
3.6.5.7. *Patrocardia* cf. *fraterna* (BARRANDE, 1881) ... 302
3.6.5.8. *Patrocardia* sp. A ... 302
3.6.5.9. *Patrocardia* sp. B ... 302
3.6.5.10. *Patrocardia* sp. C ... 302
3.6.5.11. *Patrocardia* sp. D ... 302
3.6.5.12. *Patrocardia evolvens evolvens* (BARRANDE, 1881) ... 303

Superfamily Pteriacea GRAY, 1847 ... 303
3.7. Family Pterineidae MILLER, 1877 ... 303
3.7.1. Genus *Leiopteria (Leiopteria)* HALL, 1883 ... 303
3.7.1.1. *Leiopteria (Leiopteria)* sp. ... 303

Superfamily Modiomorphacea MILLER, 1877 ... 303
3.8. Family Modiomorphidae MILLER, 1877 ... 303
3.8.1. Genus *Procarinaria* PERNER, 1911 ... 303
3.8.1.1. *Procarinaria zephyrina* (BARRANDE, 1881) ... 303

3.9. Family Butovicellidae KŘÍŽ, 1965 ... 303
3.9.1. Genus *Butovicella* KŘÍŽ, 1965 ... 303

3.9.1.1. *Butovicella migrans* (BARRANDE, 1881) ..... 303
3.9.1.2. *Butovicella medea* KŘÍŽ, 1969 ..... 304

4. Bivalve Dominated Communities ..... 304
4.1. *Cardiola* Community Group ..... 304
4.1.1. *Carnalpia nivosa* Community ..... 304
4.1.2. *Cardiola agna* Community – *Slava pelerina–Isiola zila* Subcommunity ..... 305
4.1.3. *Cardiola consanguis* Community ..... 306
4.1.4. *Cardiola docens* Community ..... 307
4.1.5. *Cardiola alata* Community – *Cardiola pectinata* Subcommunity ..... 307
4.1.6. *Cardiolinka bohemica* Community ..... 308

4.2. *Cheiopteria* Community Group ..... 309
4.3. *Snoopyia* Community Group ..... 309
4.4. *Patrocardia* Community Group ..... 309
4.4.1 *Patrocardia-Dualina* Community – *Dualina nigra-Patrocardia* Subcommunity ..... 309

4.5. *Antipleura-Hercynella* Community Group ..... 310
4.5.1. *Antipleura bohemica* Community ..... 310

5. Paleogeographic and Stratigraphic Conclusions ..... 311
5.1. Paleogeographic Position of the Carnic Alps Basin in the Silurian and Lowermost Devonian ..... 311
5.2. Correlation and Relationships of the Carnic Alps Basin with Other World Regions in the Silurian and Lowermost Devonian ..... 311
5.3. Chronostratigraphic Position of the Cardiola Formation ..... 314

6. Acknowledgments ..... 314
7. Abbreviations used in this work ..... 315
8. References ..... 315

## Bivalven von böhmischem Typ des Silurs und untersten Devons der Karnischen Alpen

### Zusammenfassung

In dieser Arbeit werden aus Ablagerungen des Silurs und frühen Unterdevons der Karnischen Alpen 73 Arten von Bivalven beschrieben. Mehrheitlich zeigen sich vor allem enge Beziehungen zu gleich alten Vorkommen von Perunica (Prager Becken, Böhmen), aber auch zu anderen Vorkommen am ehemaligen Nordrand von Gondwana wie Sardinien, Montagne Noire, dem Massiv von Mouthoumet und Armorica. Von allen hier beschriebenen Arten sind 25 Arten auf die Karnischen Alpen beschränkt, 7 werden hier erstmals beschrieben. Insgesamt ist die von Bivalven dominierte Faunengemeinschaft eng an die Cephalopoden-Kalkfazies und an mikritische Kalke gebunden. Die Faunenanalyse zeigt weiters, daß sich die gesamte Bivalvenassoziation am Nordrand von Gondwana durch weitgehende Übereinstimmung auszeichnet und sich damit auch sehr gut für die interregionale Korrelation der einzelnen Vorkommen eignet. Diese Gemeinsamkeiten in der von Bivalven dominierten Faunengemeinschaft führen zur Schlußfolgerung, daß zwischen den einzelnen Vorkommen am Nordrand von Gondwana einschließlich den Karnischen Alpen im Silur und Unterdevon eine wesentlich engere räumliche Nachbarschaft bestand als dies nach den bisher bekannten paläomagnetischen Messungen vermutet worden ist.

### Summary

73 species of bivalves are described from the Silurian and lowermost Devonian of the Carnic Alps. The majority of the species are closely related to the species described from Perunica (Prague Basin, Bohemia) and the Northern Gondwana marginal regions (Sardinia, Italy; the Montagne Noire, the Mouthoumet Massif and Massif Armoricain, France). 25 species (7 new) are characteristic to the Carnic Alps. The bivalve dominated communities, known also from Bohemia, France and Sardinia, are closely related to the cephalopod limestone biofacies and micritic limestone facies. In practice they may be used for correlation with Perunica and other Gondwanan European basins. Analysis of the Bivalve dominated communities shows that the development of the Carnic Alps Basin during the Silurian was very similar to other Northern Gondwana regions and that the distance between Perunica and Northern Gondwana was much smaller than has been interpreted on the basis of paleomagnetic measurements.

## 1. Introduction

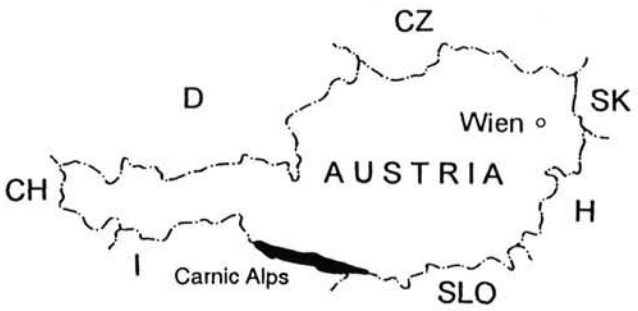
Silurian bivalves collected by the Author in the Carnic Alps during joint field trips with H. P. SCHÖNLAUB from the Geologische Bundesanstalt in Vienna in 1969, 1976, 1982, 1994, 1996, 1997 and 1998 and other bivalves collected there in the past, namely by G. STACHE, F. HERITSCH, H. R. von GAERTNER, H. JAEGER, O. H. WALLISER and H. P. SCHÖNLAUB, have been studied, described and analyzed in this paper. Most of the Silurian bivalves collected in the past are deposited in the Geologische Bundesanstalt, Vienna, Austria. A few specimens are deposited in the Museo Friulano di Storia Naturale, Udine, Italy.

It is the purpose of this study to contribute to a detailed correlation with other Gondwanan European regions, namely Sardinia (Italy), the Montagne Noire and the Mouthoumet Massif (France) and with Perunica, Prague Basin, Bohemia. In the past bivalves from the Carnic Alps were studied by M. GORTANI & P. VINASSA de REGNY (1909), G. STACHE (MS), F. HERITSCH (1929) and by J. KŘÍŽ (1979, 1985).

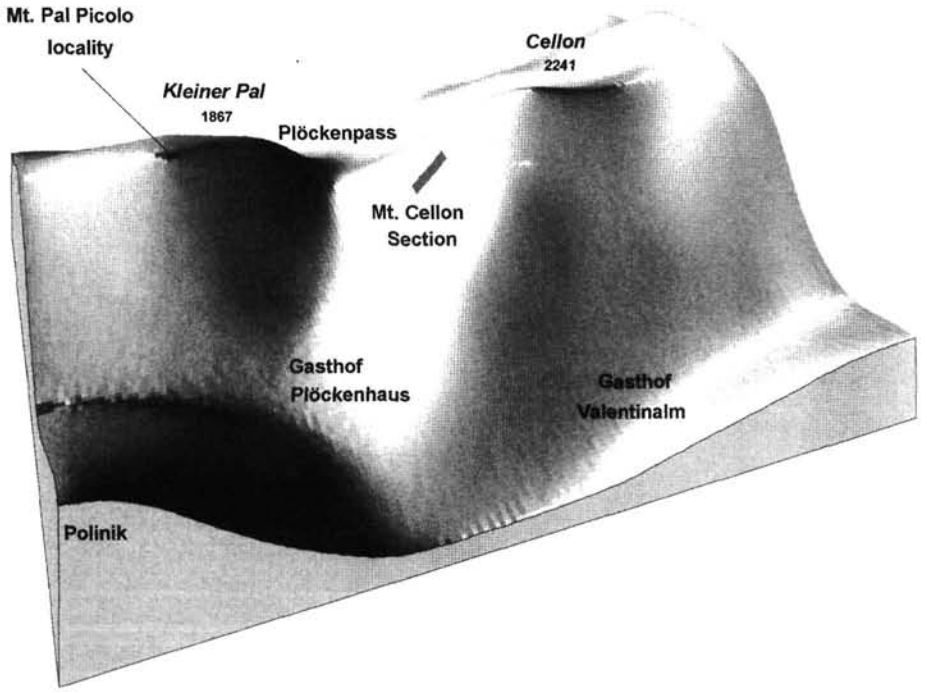
A systematic study of more than 600 determinable specimens resulted in the description of 73 species of bivalves from the Silurian and lowermost Devonian of the Carnic Alps. The majority of the species (43) are closely related to the species described from Perunica (Prague Basin, Bohemia) and Northern Gondwana marginal regions (Sardinia, Italy; the Montagne Noire, the Mouthoumet Massif and Massif Armoricain, France). 25 species (7 new) are characteristic to the Carnic Alps.

## 2. Geology, stratigraphy, localities and preservation

The Geology and Silurian Stratigraphy of the Carnic Alps (Text – Fig. 1) was studied namely by HERITSCH (1929), GAERTNER (1931), WALLISER (1964), JAEGER (1975), SCHÖNLAUB




Text–Fig. 1.
Paleozoic of the Carnic Alps.




Text–Fig. 2.
Mountain ridge of the Carnic Alps around the Plöckenpass region showing location of the Mt. Cellon Section and Mt. Pal Picolo localities. View from the north–east. South–west of Kötschach–Mauthen (Österreichische Karte 1 : 50 000, no. 197, Kötschach).

(1980, 1985, 1994, 1997, 1998), PRIEWALDER (1987, 1997), KREUTZER & SCHÖNLAUB (1997), SCHÖNLAUB & HEINISCH (1994) and FERRETTI & HISTON (1997). They also described all the principal sections and localities from which the author of this paper collected and studied Silurian and lowermost Devonian bivalves (Text – Figs. 2–5).

The Mt. Cellon Section (Text – Fig. 2) was first described by GAERTNER (1931), WALLISER (1964), JAEGER (1975), SCHÖNLAUB (1980, 1994, 1997), PRIEWALDER (1987, 1997), KREUTZER & SCHÖNLAUB (1997) and HISTON (1997, in press b). Bivalves have been found in the strata from the Sheinwoodian (Wenlock) to Přídolí.

The Base of the Seewarte Section (Text – Fig. 4), the lower part of the section was described by GAERTNER (1931), SCHÖNLAUB (1980, 1994). Bivalves were collected from the uppermost 30 cm of the Cardiola Formation, middle Ludfordian, Ludlow.

The Rauchkofel Boden Section (Text – Fig. 4), was described in detail by GAERTNER (1931), SCHÖNLAUB (1980, 1994), and SCHÖNLAUB and BOGOLEPOVA (1994), and FERRETTI & HISTON (1997) and HISTON (in press a). Bivalves have been collected from the Homerian to lowermost Lochkov (Lower Devonian).

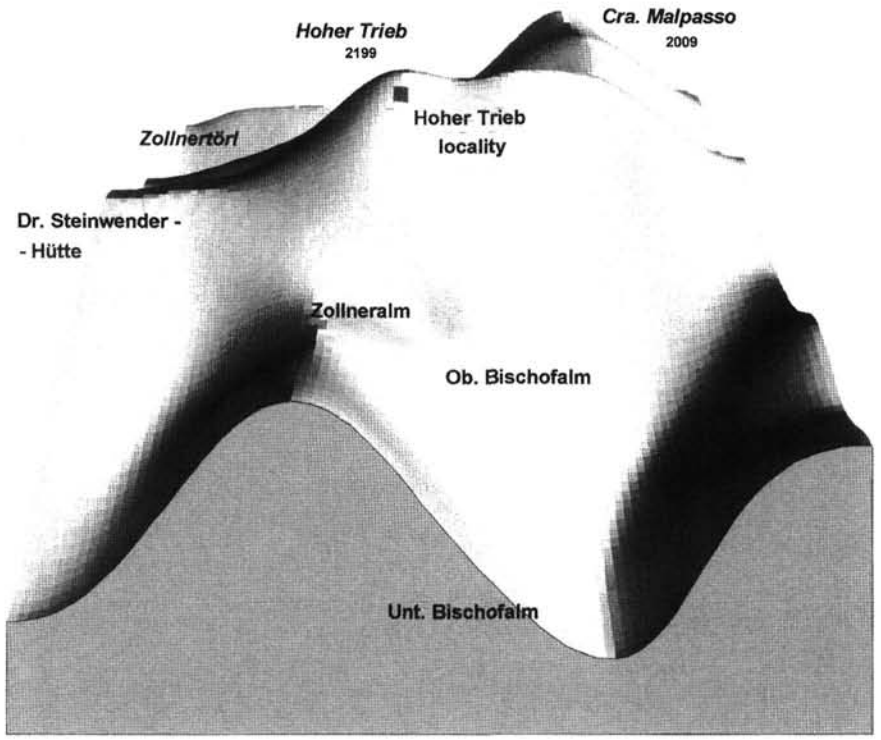
The Seekopf Sockel Section (Text – Fig. 4) was described by SCHÖNLAUB (1980, 1985). Bivalves were collected in the nodules within the shales below bed no. 358, lower Lochkovian, lowermost Devonian.

The Hoher Trieb Section (Text – Fig. 3); bivalves were collected together with H. P. SCHÖNLAUB in an undescribed section of the Cardiola Formation, Ludfordian, Ludlow, at the base of the northern rock slope of the peak.

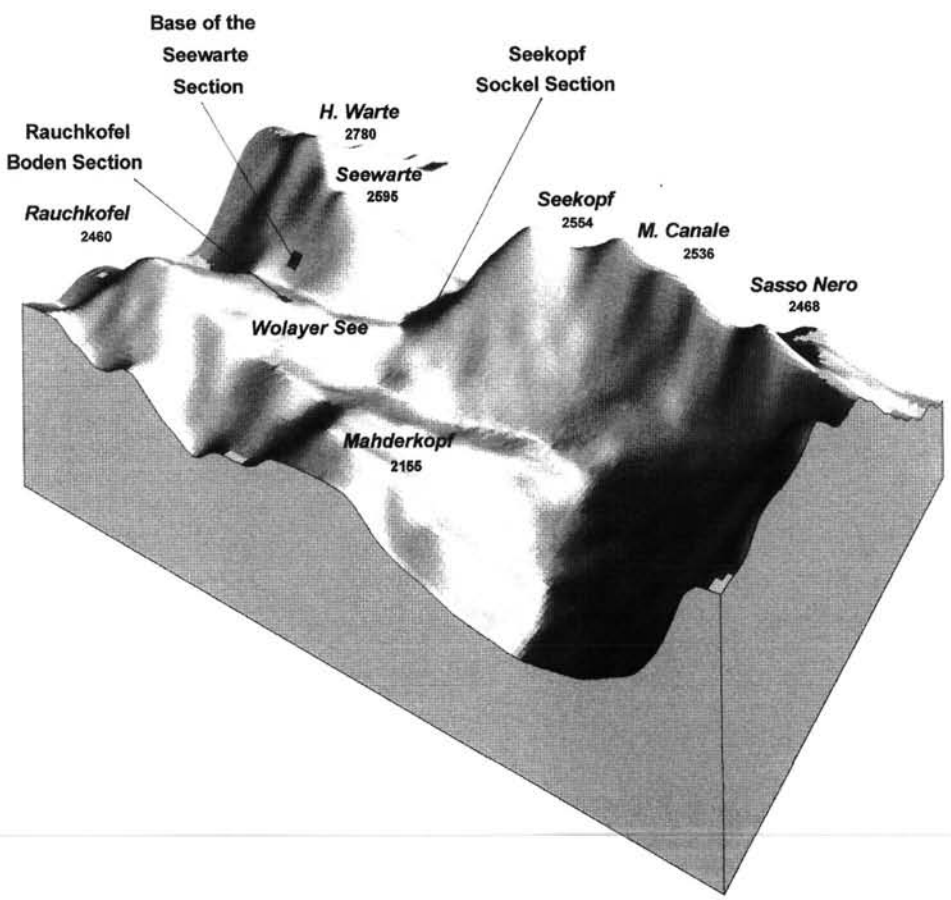
The Mt. Pal Picolo Section (Text – Fig. 2) was described by GORTANI & VINASSA de REGNY (1909). Bivalves were collected from the Wenlock to Ludlow rocks.

The Mt. Cocco Section (Text – Fig. 5) was described by HERITSCH (1929). Bivalves were recently collected in the debris from the old mine gallery on the top of the hill in the Ludlow rocks.

Preservation of bivalves is usually poor, since the rocks in general have been tectonically effected. Long time (29 years)




Text–Fig. 3.
Mountain ridge of the Carnic Alps around Mt. Hoher Trieb showing the location of the Mt. Hoher Trieb locality. View from the north. South east of Kötschach–Mauthen (Österreichische Karte 1 : 50 000, no. 197, Kötschach).




Text–Fig. 4.
Mountain ridge of the Carnic Alps around the Wolayer See region showing location of the Base of the Seawarte Section, Rauchkofel Boden Section and Seekopf Sockel Section localities. View from the north–west. South–west of Kötschach– Mauthen (Österreichische Karte 1 : 50 000, no. 197, Kötschach).

## Plate 1

Fig. 1: ***"Ctenodonta" simplicitor*** (BARRANDE).
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, right valve, GBA 1998/2/411, lateral view; x 8.75.
Fig. 2: ***Dualina comitans*** BARRANDE. Mt. Cocco, Cardiola Formation, Ludlow, right valve, GBA 4933, lateral view, x 3.55.
Fig. 3: ***Dualina aff. comitans*** BARRANDE.
Mt. Cellon, 0–20 cm above bed no. 35, Alticola Kalk Formation, Přídolí, right valve, GBA 1998/2/243, lateral view, x 3.75.
Figs. 4, 5, 6, 8, 14: ***Dualina consors*** BARRANDE.
Mt. Cellon, 20 cm above bed no. 35, Alticola Kalk Formation, Přídolí.
Fig. 4: Right valve, GBA 1998/2/244, lateral view, x 1.95.
Fig. 5: Left valve, GBA 1998/2/245, dorsal view, x 1.5.
Fig. 6: Left valve, GBA 1998/2/245, anterior view, x 1.85.
Fig. 8: Right valve, GBA 1998/2/244, dorsal view, x 1.65.
Fig. 14: Left valve, GBA 1998/2/245, lateral view, x 1.85.

Figs. 7, 10, 12, 13, 17: ***Dualina socialis*** BARRANDE.
Rauchkofel Boden Section, bed no. 331, latest Přídolí.
Fig. 7: Left valve, GBA 1998/2/337, lateral view, x 2.1.
Fig. 10: Left valve, GBA 1998/2/254, lateral view, x 1.8.
Fig. 12: Left valve, GBA 1998/2/337, anterior view, x 2.1.
Fig. 13: Right valve, GBA 1998/2/275, lateral view, x 1.95.
Fig. 17: Left valve, GBA 1998/2/250, lateral view, x 2.1.

Fig. 9: ***Dualina longiuscula*** BARRANDE.
Mt. Cellon, bed no. 22a, Cardiola Formation, Ludlow, right valve, GBA 1998/2/239, lateral view, x 3.7.

Fig. 11: ***Dualina longiuscula*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, right valve, GBA 1998/2/445, lateral view, x 2.9.

Figs. 15, 21, 23, 24, 25, 26, 27: ***Dualina nigra*** BARRANDE.
Rauchkofel Boden Section, bed no. 331, latest Přídolí
Fig. 15: Left valve, GBA 1998/2/283, lateral view, x 1.85.
Fig. 21: Left valve, GBA 1998/2/354, dorsal view, x 2.6.
Fig. 23: Left valve, GBA 1998/2/354, lateral view, x 2.1.
Fig. 24: Left valve, GBA 1998/2/354, ventral view, x 1.75.
Fig. 25: Left valve, GBA 1998/2/360, antero–ventral view, x 2.0.
Fig. 26: Left valve, GBA 1998/2/354, antero–ventral view, x 1.75.
Fig. 27: Left valve, GBA 1998/2/354, posterior view, x 1.7.

Fig. 16: ***Dualina secunda*** BARRANDE.
Mt. Cocco, Ludlow, left valve, GBA 4932, lateral view, x 1.65.

Figs. 18, 19, 22: ***Dualina annulosa*** BARRANDE.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian, left valve, GBA 1998/2/484a.
Fig. 18. Anterior view, x 8.25.
Fig. 19: Lateral view, x 8.0.
Fig. 22: Posterior view, x 7.0

Fig. 20: ***Dualina inexplicata*** BARRANDE.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian, right valve, GBA 1998/2/385, lateral view, x 3.2.

All photos by Jiří Kříž, Czech Geological Survey, Praha.

was necessary for making a reasonable collection for this study because of limited possibilities to visit Austria in the period 1969 - 1989 due to political reasons and as the time for each expedition to the Carnic Alps was always limited. In spite of these problems the Author is of the opinion that the collection of bivalves from the Carnic Alps is representative of the Silurian and lowermost Devonian strata and localities.

# 3. Systematic Part

## Bivalvia

### Superfamily Ctendontacea WÖHRMANN, 1893

### 3.1. Family Ctenodontidae WÖHRMANN, 1893

#### 3.1.1. Genus *Ctenodonta* SALTER, 1852

Type species – *Tellinomya nasuta* HALL, 1847

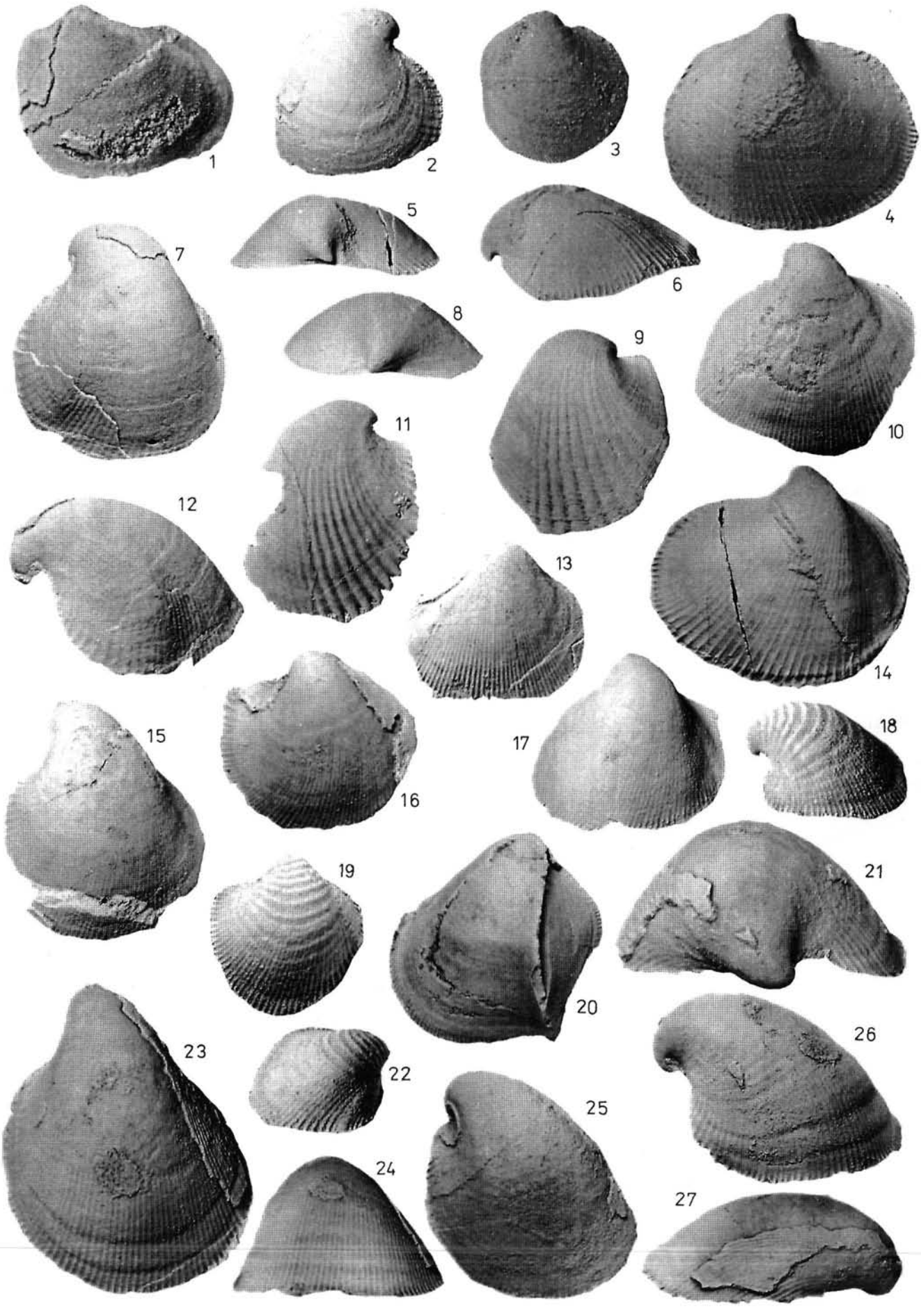
#### 3.1.1.1. *"Ctenodonta" simplicitor* (Barrande, 1881)

Pl. 1, Fig. 1

1881 *Nucula simplicitor* BARR. – BARRANDE, pl. 274, figs. IV/1-17.
Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

*The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.*

Type horizon and type locality: Silurian, upper Wenlock, *Motol Formation Bohemia, Prague Basin.*
Material: 1 shell with conjoined valves.
Remarks: Specimen from the Carnic Alps is conspecific with BARRANDE'S type material. The specimen is relatively smaller than upper Wenlock specimens from Bohemia.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Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/411 | 4.4 | 3.4 | 1.0 |

Occurrence: *"Ctenodonta" simplicitor* is a common upper Wenlockian representative of the Silurian Nuculoids in Bohemia, Prague Basin and occurs in the *Buceqia obolina* Community at the locality Lištice Section no. 759 near Beroun (KŘÍŽ, 1992, KŘÍŽ et al., 1993, MANDA, 1996), mostly preserved as conjoined shells. In the Carnic Alps *"Ctenodonta" simplicitor* occurs rarely at the Mt. Cellon locality in bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock.

**Superfamily Praecardiacea HÖRNES, 1884**

## 3.2. Family Antipleuridae NEUMAYR, 1891

### 3.2.1. Genus *Dualina* BARRANDE, 1881

Type species – *Dualina comitans* BARRANDE, 1881

#### 3.2.1.1. *Dualina comitans* BARRANDE, 1881

Pl. 1, Fig. 2

1881 *Dualina comitans* BARR. – BARRANDE, p. 77–80, pl. 19, figs. 21–24, pl. 22, figs. 1–35, pl. 79, figs. II/1–6.
1929 *Dualina comitans* BARR. – HERITSCH, p. 46, pl. 4, figs. 337, 338.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 1 right valve.

Remarks: Specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 4933 | 8.1 | – | 3.7 |

Occurrence: *Dualina comitans* is a common Ludlow representative of the Antipleuridae. The species is dominant in the Ludlow of the Prague Basin, Bohemia. In the Carnic Alps *Dualina comitans* occurs in the Ludlow, Cardiola Formation at Mt. Cocco, Italy.

#### 3.2.1.2. *Dualina* aff. *comitans* BARRANDE, 1881

Pl. 1, Fig. 3

Material: 1 right valve.

Remarks: Specimen is closely related to the specimen of *Dualina comitans* figured by BARRANDE (1881) on pl. 19, figs. 23–24 and to the specimen of *Dualina fidelis* figured by BARRANDE (1881) on pl. 19, figs. 8–11. From both BARRANDE'S types *Dualina* aff. *comitans* differs by smaller valves and by the not overhanging but wing like shape of the posterior margin.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/243 | 6.6 | 6.8 | 2.5 |

**Occurrence:** *Dualina* aff. *comitans* occurs 0–20 cm above bed no. 35, Alticola Kalk, Přídolí at the Mt. Cellon Section (WALLISER, 1964).

#### 3.2.1.3. *Dualina consors* BARRANDE, 1881

Pl. 1, Figs. 4–6, 8, 14

1881 *Dualina consors* BARR. – BARRANDE, pl. 20, figs. 1–36, pl. 85, figs. VIII/7–8.
1982 *Dualina consors* BARRANDE – KŘÍŽ & PARIS, p. 396, pl. 2, figs. 2a-d.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 1 left valve and 1 right valve.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/244 | 23.4 | 20.1 | 7.4 |
| GBA 1998/2/245 | 27.0 | 22.9 | 9.0 |

Occurrence: *Dualina consors* is a common Ludlow and Přídolí representative of the Antipleuridae. The species occurs in the Ludlow and Přídolí of the Prague Basin, Bohemia. In the Carnic Alps *Dualina consors* occurs 20 cm above bed no. 35, Alticola Limestone, Přídolí, Mt. Cellon Section (WALLISER, 1964).

#### 3.2.1.4. *Dualina longiuscula* BARRANDE, 1881

Pl. 1, Figs. 9, 11

1881 *Dualina longiuscula* BARR. – BARRANDE, p. 77, pl. 34, figs. II/8, pl. 35, figs. I/1–29, II/ 1–29.
1996 *Dualina longiuscula* BARRANDE – KŘÍŽ, p. 40, pl. 1, figs. 21, 23, 24, 27.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 2 left valves and 2 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/239 | 9.0 | 10.0 | 2.0 |
| GBA 1998/2/278a | 12.1 | 14.0 | 3.1 |

Occurrence: *Dualina longiuscula* is a common Ludlow representative of the Antipleuridae. The species occurs in the Ludfordian, Ludlow of Prague Basin, Bohemia (KŘÍŽ, 1998a; in press a). It was described by KŘÍŽ (1996) from the Ludlow of the Montagne Noire and from the Massif

Mouthoumet. In the Carnic Alps *Dualina longiuscula* occurs in bed no. 22a, Ludlow at the Mt. Cellon Section (WALLISER, 1964), in the Kok Formation at Mt. Cocco, Italy and in the bed between nos. 325–326, Cardiola Formation at the Rauchkofel Boden Section and in the *Cardiola pectinata* Subcommunity at the locality Base of Seewarte, (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian.

### 3.2.1.5. *Dualina socialis* BARRANDE, 1881

Pl. 1, Figs. 7, 10, 12, 13, 17

1881 *Dualina socialis* BARR. – BARRANDE, pl. 21, figs. 1–37.
1982 *Dualina socialis* BARRANDE – KŘÍŽ & PARIS, p. 397, pl. 1, figs. 1–3.
1993 *Dualina socialis* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, p. 311–312, pl. 4, Figs. 2, 6.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 6 left valves and 9 right valves. Another 4 left valves and 4 right valves are assigned as *Dualina* cf. *socialis* (1998/2/370, 313, 315, 361, 362, 365, 369, 371) because of their poor preservation.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/250 | 17.8 | 16.4 | 6.5 |
| GBA 1998/2/275 | 19.0 | 15.4 | 6.0 |
| GBA 1998/2/337 | 20.3 | 21.2 | 9.4 |
| GBA 1998/2/254 | 23.0 | 22.3 | 7.2 |

Occurrence: *Dualina socialis* occurs in the Přídolí of the Prague Basin, Bohemia (BARRANDE, 1881). In the Carnic Alps *Dualina socialis* occurs abundantly in bed no. 331, uppermost Přídolí, Rauchkofel Boden Section (SCHÖNLAUB, 1997).

### 3.2.1.6. *Dualina secunda* BARRANDE, 1881

Pl. 1, Fig. 16

1881 *Dualina secunda* BARR. – BARRANDE, pl. 24, figs. 1–39, pl. 25, figs. III/1–9, pl. 26, figs. IV/1–21, pl. 36, figs. V/1–6, pl. 73, figs. I/1–7, pl. 79, figs. III/1–9, pl. 98, figs. V/9–11.
1881 *Dualina sedens* BARR. – BARRANDE, pl. 25, figs. I/6–11.
1918 *Dualina comitans* BARRANDE – COUFFON, p. 215.
1929 *Dualina secunda* BARR. – HERITSCH, p. 46, pl. 4, fig. 336.
1966 *Dualina comitans* BARRANDE – BABIN, p. 131–132, pl. 4, fig. 15.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 1 left valve.

Remarks: Specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 4932 | 14.2 | 13.6 | 5.5 |

Occurrence: *Dualina secunda* is common Ludlow representative of the Antipleuridae. The species is common in the Ludfordian, Ludlow of Prague Basin, Bohemia. In the Carnic Alps *Dualina secunda* occurs in Ludlow at the Mt. Cocco, Italy.

### 3.2.1.7. *Dualina nigra* BARRANDE, 1881

Pl. 1, Figs. 15, 21, 23–27

1881 *Dualina nigra* BARR. – BARRANDE, pl. 31, figs. IV/1–5.
1881 *Dualina nigra*? BARR. – BARRANDE, pl. 30, figs. VII/1–2.

Holotype (designated herein) – Figured by BARRANDE (1881) on pl. 31, figs. IV/1–5 and deposited in the National Museum, Prague under no. L 14 628.

Material: 16 left valves and 16 right valves. Another 2 right valves are assigned as *Dualina* cf. *nigra* (1998/2/334, 366) because of their ill preservation.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/283 | 19.7 | 22.9 | 10.8 |
| GBA 1998/2/360 | – | 24.2 | 10.6 |
| GBA 1998/2/282 | – | 24.4 | 10.0 |
| GBA 1998/2/354 | 22.8 | 28.6 | 16.1 |

Occurrence: *Dualina nigra* rarely occurs in the Přídolí (Silurian) or in lowermost Lochkovian (Lower Devonian) in the Prague Basin, Bohemia (BARRANDE, 1881). In the Carnic Alps *Dualina nigra* occurs abundantly in bed no. 331, uppermost Přídolí, Rauchkofel Boden Section (SCHÖNLAUB, 1997).

### 3.2.1.8. *Dualina annulosa* BARRANDE, 1881

Pl. 1, Figs. 18. 19, 22

1881 *Dualina annulosa* BARR. – BARRANDE, pl. 23, figs. III/1–15.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 2 left valves

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material. Generally, the shells are smaller than those known from the Prague Basin, Bohemia.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/484a | 3.6 | 3.6 | 1.4 |

Occurrence: *Dualina annulosa* rarely occurs in the lower Lochkovian (Lower Devonian) in the Prague Basin,

## Plate 2

Fig. 1: ***Dualina inexplicata*** BARRANDE.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian, right valve, GBA 1998/2/385, ventro–lateral view, x 3.6.

Figs. 2, 5, 6: ***Dualina inexplicata*** BARRANDE.
Rauchkofel Boden Section, bed no. 331, latest Přídolí, left valve, GBA 1998/2/355.
Fig. 2: Ventral view, x 1.65.
Fig. 5: Lateral view, x 1.65.
Fig. 6: Antero–lateral view, x 1.9.

Figs. 3, 4, 7, 8, 9, 11: ***Dualina? cocco*** sp. n.
Mt. Cocco, Kok Formation?, Ludlow.
Fig. 3: Left valve, holotype, GBA 4946, lateral view, x 5.0.
Fig. 4: Left valve, holotype, GBA 4946, antero–lateral view, x 5.5.
Fig. 7: Left valve, paratype, GBA 4949, lateral view, x 6.25.
Fig. 8. Left valve, holotype, GBA 4946, dorso–lateral view, x 5.75.
Fig. 9. Left valve, holotype, GBA 4946, posterior view, x 6.0.
Fig. 11. Left valve, holotype, GBA 4946, detail of ventral sculpture, x 11.6.

Figs. 10, 12, 13,14, 15: ***Silurina percalva*** BARRANDE.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian.
Fig. 10: Right valve, GBA 1998/2/500, dorso–lateral view, x 1.75.
Fig. 12: Conjoined valves, GBA 1998/2/501a, left lateral view, x 1.3.
Fig. 13: Conjoined valves, GBA 1998/2/501a, dorsal view, x 2.5.
Fig. 14: Right valve, GBA 1998/2/500, lateral view, x 2.25.
Fig. 15: Conjoined valves, GBA 1998/2/501a, posterior view, x 2.5.

Figs. 16, 17, 20: ***Vlasta bohemica*** BARRANDE.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian.
Fig. 16: Right valve, GBA 1998/2/496, lateral view of the posterior, x 1.6.
Fig. 17: Left valve, GBA 1998/2/497, lateral view of the dorsal, x 2.5.
Fig. 20: Right valve, GBA 1998/2/488, lateral view of the posterior, x 1.6.

Figs. 18, 19: ***Antipleura bohemica*** BARRANDE.
Rauchkofel Boden Section, 40 cm above bed no. 331, earliest Lochkovian.
Fig. 18: Left valve, GBA 1998/2/332a, lateral view, x 1.7.
Fig. 19: Right valve, GBA 1998/2/331, lateral view, x 1.75.

All photos by Jiří KŘÍŽ, Czech Geological Survey, Praha.

Bohemia (BARRANDE, 1881). In the Carnic Alps *Dualina annulosa* occurs in the lenses of black micritic limestone within the level of shales below bed no. 358 at the locality Seekopf Sockel, lower Lochkovian (SCHÖNLAUB, 1980).

### 3.2.1.9. *Dualina inexplicata* BARRANDE, 1881

Pl. 1, Fig. 20, Pl. 2, Figs. 1, 2, 5, 6

1881 *Dualina inexplicata* BARR. – BARRANDE, pl. 32, figs. III/1–18, pl. 292, figs. 1–9.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 1 left valve and 1 right valve.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/385 | 11.9 | 13.7 | 7.8 |
| GBA 1998/2/355 | 24.0 | – | 10.3 |

Occurrence: *Dualina inexplicata* rarely occurs in the uppermost Přídolí (Silurian) and in lowermost Lochkovian (Lower Devonian) in the Prague Basin, Bohemia (BARRANDE, 1881). In the Carnic Alps *Dualina inexplicata* occurs rarely in the bed no. 331, uppermost Přídolí at the Rauchkofel Boden Section (SCHÖNLAUB, 1997), and in the lenses of black micritic limestone within the level of shales below bed no. 358 at the locality Seekopf Sockel, lower Lochkovian (SCHÖNLAUB, 1980).

### 3.2.1.10. *Dualina? cocco* sp. n.

Pl. 2, Figs. 3, 4, 7–9, 11

1929 *Lunulicardium longiusculum* BARR. – HERITSCH, p. 36, pl. 4, fig. 437.
1929 *Lunulicardium confertissimum* BARR. – HERITSCH, p. 37, pl. 4, fig. 415.
1929 *Dualina* aff. *cardiopsis* BARR. – HERITSCH, p. 46, pl. 4, figs. 339–340.

Holotype: Left valve figured herein on pl. 2, figs. 3, 4, 8, 9, 11, deposited in the Geologische Bundesanstalt, Vienna under no. 4946.

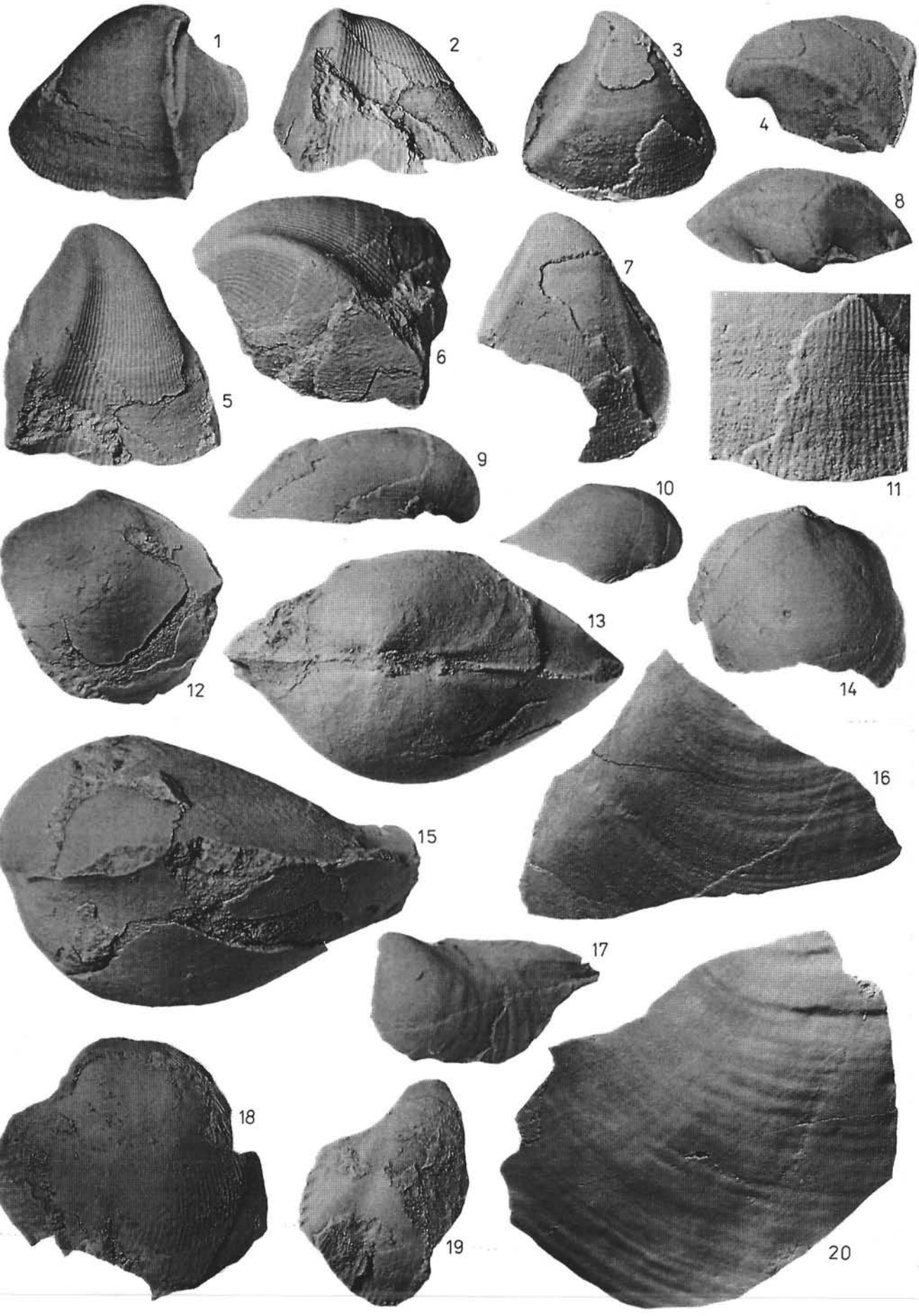
Paratypes: Other specimen figured herein on pl. 2, fig. 7, GBA 4949, and unfigured specimen [figured by HERITSCH (1929) on pl. 4, fig. 339–340, 437].

Derivation of name: The specific name is derived from the name of the type locality – Mt. Cocco.

Type horizon and type locality: Kok Formation?, Ludlow, Carnic Alps, Mt. Cocco, Italy.

Material: 2 left valves and 1 right valve.

Diagnosis: *Dualina? cocco* sp. n. differs from *Dualina? chaubetae* KŘÍŽ, 1996 and from *Dualina? triangulatum* (BAR-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RANDE, 1881) (*"Hemicardium" triangulatum*) mainly by opisthodetic shells. Stages II and III are less developed, but the change in commissural angle after the swollen band is prominent.

Description: Stage II (KŘÍŽ, 1979) – Shell broadly ovate in outline, moderately inflated, equivalve, inequilateral. Beaks prosogyrate. Outer surface sculpture formed by very fine radial ribs in combination with, wide, flat, regularly spaced growth bands separated by narrow, shallow, growth furrows. Inner surface on adult shells is smooth. Other features unknown.

Stage III: Continuous with stage II, wide, concentric. Shell broadly ovate, obese, opisthocline. Anterior slope of valve is much steeper than posterior slope. Anterior part of the valve is separated from the central part of the valve by a distinct curve developed during early growth of stage III. Outer surface sculpture consists of very fine, numerous radial ribs. Inner surface is smooth. Shell thickness is 0.07 mm. Other features unknown.

Stage IV: Shell subtriangular in outline, inequilateral, equivalve, opisthocline and obese. From ventral margin of the stage III a distinct curvature continues between the anterior part and central part of the valve. Anterior part is much steeper than posterior slope. The stage IV is separated from the stage III by a distinct change of commissural angle (KŘÍŽ, 1979). Outer surface sculpture consists of fine, numerous radial ribs in combination with very flat, irregularly spaced growth bands separated by deeper growth lines. Inner surface sculpture is smooth with very little visible irregularly spaced growth bands. Fine and numerous radial ribs are visible only close to ventral band. Shell thickness is 0.1–0.14 mm.

Remarks: *Dualina? cocco* sp. n. is the closest relative of *Dualina? chaubetae* KŘÍŽ, 1996 from the upper Wenlock of the Montagne Noire, France and to *Dualina? triangulatum* (BARRANDE, 1881) from the higher Ludfordian, Ludlow of the Prague Basin, Bohemia. *Dualina? cocco* sp. n. differs from both species mainly by an opisthodetic shell and by very fine and numerous radial ribs. Growth bands are almost not developed.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4946 | IV | 6.8 | 6.4 | 2.4 |

Occurrence: *Dualina? cocco* sp. n. is known only from the type locality.

### 3.2.2. Genus *Antipleura* BARRANDE, 1881

Type species – *Antipleura bohemica* BARRANDE, 1881

#### 3.2.2.1. *Antipleura bohemica* BARRANDE 1881

Pl. 2, Figs. 18, 19

1881 *Antipleura bohemica* BARR. – BARRANDE, pp. 18–19, pl. 15–18.
1966 *Antipleura bohemica* BARR. – BABIN, p. 137.
1977 *Antipleura bohemica* BARRANDE – HOLLARD, p. 174, 177, 183, 184.
1982 *Antipleura bohemica* BARRANDE – KŘÍŽ & PARIS, pp. 395–396, pl. 2, figs. 8, 9.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Material: 1 left valve and 1 right valve.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/332a | 35.3 | – | 10.3 |

Occurrence: *Antipleura bohemica* is a common lowermost Devonian representative of the Antipleuridae. The species is dominant in the *Antipleura bohemica* Community of the *Antipleura – Hercynella* Community Group (KŘÍŽ, in press a) and occurs at the base of the Devonian, Lochkovian in the Prague Basin, Bohemia (KŘÍŽ in press a), the Anti-Atlas (HOLLARD, 1977), and in the Armoricain Massif, France (KŘÍŽ & PARIS, 1982). In the Carnic Alps *Antipleura bohemica* occurs in the *Antipleura bohemica* Community at the locality Rauchkofel Boden Section, lowermost Lochkovian, 40 cm above bed no. 331 (SCHÖNLAUB, 1997).

### 3.2.3. Genus *Silurina* BARRANDE, 1881

Type species – *Silurina percalva* BARRANDE, 1881

#### 3.2.3.1. *Silurina percalva* BARRANDE, 1881

Pl. 2, Figs. 10, 12–15

1881 *Silurina percalva* BARR. – BARRANDE, p. 153–154, pl. 45, figs. 1–24, pl. 294, figs. 6 –16.
1881 *Silurina convergens* BARR. – BARRANDE, pl. 44, figs. 1–23.
1881 *Silurina complanata* Var. de *Silurina percalva* BARR. – BARRANDE, pl. 46, figs. 1–30.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimen from the Carnic Alps.

Material: 2 right valves and 1 shell with conjoined valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material. It is interesting that this is the first shell with conjoined valves ever found. It shows that also the genus Silurina shows development of the mirror-image morphology of shells (enantiomorphism), characteristic for the family Antipleuridae. BARRANDE (1881) described enantiomorphous shells as two separate species *Silurina percalva* and *Silurina convergens* (only having non conjoined left and right valves from both species at his disposal).

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/500 | 17.8 | – | 7.0 |
| GBA 1998/2/383 | – | 29.5 | 9.8 |
| GBA 1998/2/501a | 33.8 | 33.1 | 10.4 |

Occurrence: *Silurina percalva* is a lowermost Devonian representative of the Antipleuridae. The species is locally common in the *Antipleura bohemica* Community of the *Antipleura – Hercynella* Community Group (KŘÍŽ, in press a) and occurs in the lowermost Lochkovian, Prague Basin, Bohemia (KŘÍŽ, 1998b). In the Carnic Alps *Silurina percalva* occurs in the lenses of black micritic limestone within the

level of shales below bed no. 358 at the locality Seekopf Sockel, lower Lochkovian (SCHÖNLAUB, 1980).

### 3.2.4. Genus *Vlasta* BARRANDE, 1881

Type species – *Vlasta bohemica* BARRANDE, 1881

#### 3.2.4.1. *Vlasta bohemica* BARRANDE, 1881

Pl. 2, Figs. 16, 17, 20, Pl. 3, Fig. 25

1881 *Vlasta Bohemica* BARR. – BARRANDE, p. 167–171, pl. 1, figs. 1–11, Pl. 2, figs. 1–5, Pl. 3, figs. 1–14, Pl. 4, figs. 1–11, Pl. 11, figs. 12–14.

1998 *Vlasta bohemica* BARRANDE – KŘÍŽ, p. 461–464, figs. 3–12 (for other previous synonymy see this paper).

Lectotype (designated by RŮŽIČKA and PRANTL, 1960) – Internal mould of a left valve, figured by BARRANDE (1881) on pl. 2, figs. 1–5, and deposited in the National Museum in Pra-gue under no. L 26 288.

Material: 1 right and 1 left valve, fragments of 8 right valves and 1 left valve.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

| Dimensions (in mm) | | | |
|---|---|---|---|
| specimen | length | height | width/2 |
| GBA 1998/2/497a | 48.6 | 43.8 | 12.0 |

Occurrence: Vlasta bohemica is lowermost Devonian representative of the Antipleuridae. The species is locally common in the *Antipleura bohemica* Community of the *Antipleura – Hercynella* Community Group (KŘÍŽ, in press a) and occurs in the lowermost Lochkovian, Prague Basin, Bohemia (KŘÍŽ, 1998b). In the Carnic Alps *Vlasta bohemica* occurs in the lenses of black micritic limestone within the level of shales below bed no. 358 at the locality Seekopf Sockel, lowermost Lochkovian (SCHÖNLAUB, 1980).

## Superfamily Cardiolacea FISCHER, 1886

## 3.3. Family Cardiolidae FISCHER, 1886

### 3.3.1. Genus *Cardiobeleba* KŘÍŽ, 1974

Type species – *Cardiobeleba obstetrix* KŘÍŽ, 1974

Remarks: Most of the representatives of this genus (*Cardiobeleba lavina* KŘÍŽ, 1979, *Cardiobeleba obstetrix* KŘÍŽ, 1974, *Cardiobeleba ava* KŘÍŽ, 1979 and *Cardiobeleba thorali* KŘÍŽ, 1996) are known from the Northern Gondwana region – Sheinwoodian (Wenlock), the Carnic Alps, Italy and Austria and from the Homerian (Wenlock), the Massif Mouthoumet, France. From the Prague Basin, Perunica (HAVLÍČEK et al., 1994) is known only *Cardiobeleba domestica* KŘÍŽ, 1979 from the Sheinwoodian (Wenlock), *Cyrtograptus murchisoni* Zone. *Cardiobeleba lavina* KŘÍŽ, 1979 is also known from the Trewern Brook Mudstone Formation, *Cyrtograptus centrifugus – Cyrtograptus murchisoni* Zone, the Welsh Borderland, Great Britain.

#### 3.3.1.1. *Cardiobeleba lavina* KŘÍŽ, 1979

Pl. 3, Figs. 1–3

1929 *Cardiola faba* BARR. – HERITSCH, p. 42, pl. 4, figs. 395–400.

1979 *Cardiobeleba lavina* sp. n. – KŘÍŽ, p. 44, pl. 1, figs. 1–8.

Holotype (designated by KŘÍŽ, 1979): Internal mould of a right valve with fragments of recrystallized shell wall figured by KŘÍŽ (1979) on pl. 1, figs. 1, 4–8; re-figured herein on pl. 3, figs. 1–3, deposited in the Geologische Bundesanstalt, Vienna under no. 4941.

Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: Known only from the holotype.

Remarks: *Cardiobeleba lavina* differs from other species of *Cardiobeleba* in being opisthocline in growth stages III and IV (KŘÍŽ, 1979) and by lack of distinction between stages III and IV. The species *Cardiobeleba thorali* KŘÍŽ, 1996 described from the Wenlock of the Massif Mouthoumet, France differs by distinct opisthocline shells in stages II-IV, *prosogyrate umbones and more prominent radial ribbing in* stages II and III.

| Dimensions (in mm) | | | | |
|---|---|---|---|---|
| specimen | stage | length | height | width/2 |
| GBA 4941 | IV | 7.6 | 9.0 | 3.8 |

Occurrence: *Cardiobeleba lavina* is a rare Sheinwoodian (Wenlockian) representative of the Cardiolidae. The species occurs also in the Trewern Brook Mudstone Formation, *Cyrtograptus centrifugus – Cyrtograptus murchisoni* Zone, the Welsh Borderland, Great Britain. In the Carnic Alps *Cardiobeleba lavina* occurs at the type locality only.

#### 3.3.1.2. *Cardiobeleba obstetrix* KŘÍŽ, 1974

Pl. 3, Figs. 4, 5, 7

1929 *Cardiola persignata* BARR. – HERITSCH, p. 39, 40, pl. 3, figs. 267, 269, 270.

1974a *Cardiobeleba obstetrix* sp. n. – KŘÍŽ, p. 171,172, pl. 1, figs. 1–3, 7, 9; text-figs. 2a, 4,

1979 *Cardiobeleba obstetrix* KŘÍŽ – KŘÍŽ, p. 44–46, pl. 2, figs. 1, 3, 5, 7; text-figs. 19, 20.

Holotype (designated by KŘÍŽ, 1974a): Internal mold of a left valve with fragments of recrystallized shell wall figured by KŘÍŽ (1974a) on pl. 1, figs. 1–3, 7, 9; re-figured herein on pl. 3, figs. 4, 5, 7, deposited in the Geologische Bundesanstalt, Vienna under no. 4930.

Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: Known only from the holotype.

Remarks: *Cardiobeleba obstetrix* differs from other species of *Cardiobeleba* in having prominent sharp radial ribs in stage IV. The species *Cardiobeleba thorali* KŘÍŽ, 1996 described from the Wenlock of the Massif Mouthoumet, France differs by distinct opisthocline shells in stages II-IV, prosogyrate umbones and more prominent radial ribbing in stages II and III.

| Dimensions (in mm) | | | | |
|---|---|---|---|---|
| specimen | stage | length | height | width/2 |
| GBA 4930 | IV | 8.7 | 9.5 | 3.4 |

Occurrence: *Cardiobeleba obstetrix* is a rare Sheinwoodian (Wenlockian) representative of the Cardiolidae known from the type locality only.

#### 3.3.1.3. *Cardiobeleba ava* KŘÍŽ, 1979

Pl. 3, Figs. 8, 9

## Plate 3

Figs. 1, 2, 3: ***Cardiobeleba lavina*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, holotype, GBA 4941.
Fig. 1: Lateral view, x 4.55.
Fig. 2: Posterior view, x 5.9.
Fig. 3: Antero-lateral view, x 3.8.

Figs. 4, 5, 7: ***Cardiobeleba obstetrix*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 4930.
Fig. 4: Lateral view, x 4.9.
Fig. 5: Lateral view of the stage II (later stages blocked out), x 5.4.
Fig. 7: Postero-lateral view, x 4.25.

Figs. 6, 11, 20: ***Cardiolopsis alpina*** Stache in Heritsch.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, lectotype, GBA 4958.
Fig. 6: Lateral view of the stage II (later stages blocked out), x 5.0.
Fig. 11: Postero-lateral view, x 4.35.
Fig. 20: Lateral view, x 4.25.

Figs. 8, 9: ***Cardiobeleba ava*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, holotype, GBA 4943.
Fig. 8: Lateral view, x 5.25.
Fig. 9: Postero-lateral view, x 4.2.

Figs. 10, 13, 16: ***Carnalpia rostrata*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, holotype, GBA 4925/1.
Fig. 10: Posterior view, x 4.6.
Fig. 13: Lateral view of the stage III (later stages blocked out), x 4.7.
Fig. 16: Lateral view, x 3.8.

Fig. 12. ***Carnalpia rostrata*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, paralectotype, GBA 4925/3, lateral view, x 3.5.

Figs. 14. 15, 17: ***Carnalpia nivosa*** Kříž.
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, ČGU JK 1122.
Fig. 14: Lateral view of the stage III (later stages blocked out), x 4.5.
Fig. 15: Lateral view, x 3.2
Fig. 17: Posterior view, x 3.5.

Figs. 18, 19, 21, 22: ***Cardiolopsis alpina*** Stache in Heritsch.
Mt. Cellon, bed no. 12b, Cyrtograptus rigidus Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, GBA 1998/2/30a.
Fig. 18: Dorso-lateral view, x 3.55.
Fig. 19: Lateral view, x 3.9.
Fig. 21: Antero-lateral view, x 4.5.
Fig. 22: Ventro-lateral view, x 3.65.

Figs. 23, 27: ***Cardicarnia monticola*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 4954.
Fig. 23: Lateral view of the stage II (later stages blocked out), x 3.75.
Fig. 27: Posterior view, x 2.1. (For lateral view see Pl. 4, Fig. 7).

Figs. 24, 26, 28: ***Cominicula kokiana*** (Stache in Heritsch).
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, right valve, holotype, GBA 4938.
Fig. 24: Dorsal view, x 1.9.
Fig. 26: Antero-lateral view, x 1.75.
Fig. 28: Lateral view, x 2.0.

Fig. 25: ***Vlasta bohemica*** Barrande.
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian, left valve, GBA 1998/2/497a, lateral view, x 1.3.

All photos by Jiří Kříž, Czech Geologica Survey, Praha.

1929 *Cardiola signata* Barr. – Heritsch, p. 38, 39, pl. 4, figs. 403–406.
1929 *Cardiola* aff. *contrastans* Barr. – Heritsch, p. 42, 43, pl. 4, figs. 407–409.
1979 *Cardiobeleba ava* sp. n. – Kříž, p. 47, pl. 2, figs. 2, 6.

Holotype (designated by Kříž, 1979): Incomplete right valve figured by Kříž (1979) on pl. 2 as fig. 2; refigured herein on pl. 3, figs. 8, 9, deposited in the Geologische Bundesanstalt, Vienna under no. 4943.

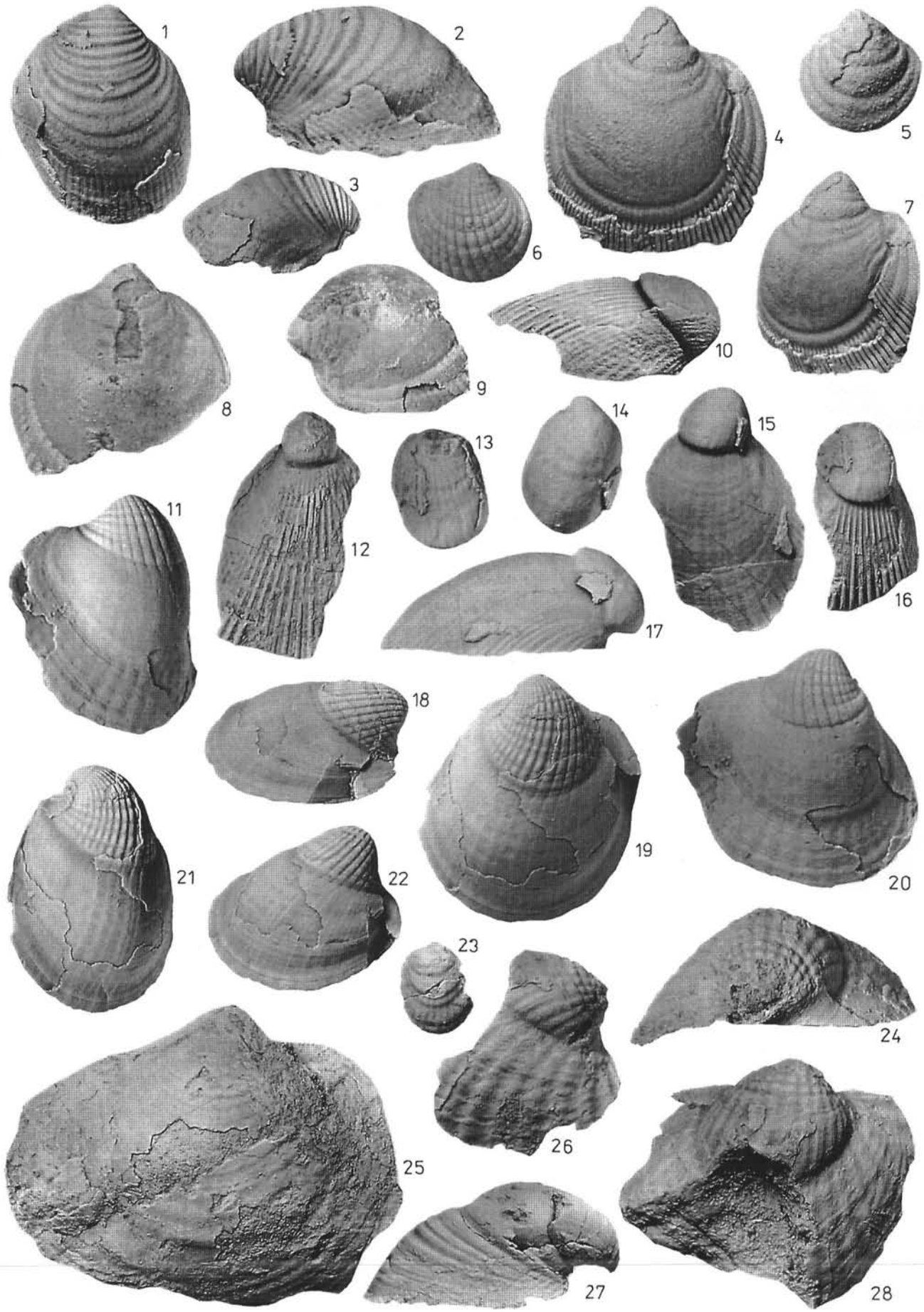
Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 2 left valves and 1 right valve.

Remarks: *Cardiobeleba ava* differs from other species of *Cardiobeleba* in reduced number of radial ribs in stage IV. The species *Cardiobeleba thorali* Kříž, 1996 described from the Wenlock of the Massif Mouthoumet, France differs by distinct opisthocline shells in stages II-IV, prosogyrate umbones and more prominent radial ribbing in stages II and III.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4943 | IV | 8.5 | 8.9 | 4.0 |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Occurrence: *Cardiobeleba ava* is a rare Sheinwoodian (Wenlockian) representative of the Cardiolidae known from the type locality only.

### 3.3.2. Genus *Carnalpia* Kříž, 1974

Type species – *Carnalpia rostrata* Kříž, 1974

Remarks: Both known representatives of this genus (*Carnalpia rostrata* Kříž, 1974 and *Carnalpia nivosa* Kříž, 1979) are known only from the Carnic Alps, Italy and Austria, the Sheinwoodian (Wenlock).

#### 3.3.2.1. *Carnalpia rostrata* Kříž, 1974

Pl. 3, Figs. 10, 12, 13, 16

1929 *Cardiola gibbosa* Barr. – Heritsch, p. 41, pl. 3, figs. 234, 237.
1929 *Cardiola* cf. *gibbosa* Barr. – Heritsch, p. 41, pl. 3, figs. 238–241.
1929 *Cardiola cometa* Barr. – Heritsch, p. 43, pl. 4, fig. 383.
1974a *Carnalpia rostrata* sp. n. – Kříž, p. 172, pl. 1, figs. 4–6, 8, 10, text-figs. 2a, 5.
1979 *Carnalpia rostrata* Kříž – Kříž, p. 48–50, pl. 3, figs. 1–8, text-figs. 21, 22.

Holotype (designated by Kříž, 1974a): Incomplete internal mould of a right valve with fragments of recrystallized shell wall figured by Kříž (1974a) on pl. 1, figs. 6–8; re-figured herein on pl. 3, figs. 10, 13, 16, deposited in the Geologische Bundesanstalt, Vienna under no. 4925/1.

Type horizon and type locality – Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 3 left and 8 right valves.

Remarks: *Carnalpia rostrata* differs from other species of *Carnalpia* by prominent radial ribs in growth stage IV (Kříž, 1979).

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4925/1 | III | 3.7 | 4.6 | 1.8 |
| GBA 4925 | IV | 8.7 | 13.1 | 4.5 |

Occurrence: *Carnalpia rostrata* is a quite common Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality only.

#### 3.3.2.2. *Carnalpia nivosa* Kříž, 1979

Pl. 3, Figs. 14, 15, 17

1979 *Carnalpia nivosa* sp. n. – Kříž, p. 50–51, pl. 4, figs. 1–9.

Holotype (designated by Kříž, 1979): Incomplete internal mould of a left valve with fragments of recrystallized shell wall figured by Kříž (1979) on pl. 4, figs. 3, 6, 7, 9, refigured herein on pl. 3, figs. 14, 15, 17, deposited in the Czech Geological Survey, Prague under no. JK 1122.

Type horizon and type locality: Bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cellon, Austria.

Material: 16 left and 9 right valves, 7 fragments and counterparts.

Remarks: Species was described by Kříž (1979). *Carnalpia nivosa* differs from other species of *Carnalpia* in having less prominent radial ribs and wider radial gutters in growth stage IV (Kříž, 1979).

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| CGS JK 1123 | II | 3.8 | 3.8 | 1.2 |
| | III | 3.8 | 5.3 | 2.5 |
| | IV | 6.8 | 8.4 | 4.1 |
| CGS JK 1121 | IV | 9.3 | 12.8 | 5.3 |

Occurrence: *Carnalpia nivosa* is a quite common Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality only.

### 3.3.3. Genus *Cardiolopsis* Stache in Heritsch, 1929

Type species – *Cardiolopsis alpina* Stache in Heritsch, 1929.

Remarks: The only representative of the genus is known only from the Carnic Alps, Italy and Austria, the Sheinwoodian (Wenlock).

#### 3.3.3.1. *Cardiolopsis alpina* Stache in Heritsch, 1929

Pl. 3, Figs. 6, 11, 18–22

1929 *Cardiolopsis alpina* Stache – Heritsch, p. 47, pl. 4, figs. 357–359, 363–373. Non: pl. 4, figs. 360–362 [= *Cardiola bifasciata* (Stache in Heritsch, 1929)].
1979 *Cardiolopsis alpina* Stache in Heritsch – Kříž, p. 52–54, pl. 5, figs. 1–9; text-figs. 23–25 (for other previous synonymy see this paper).

Lectotype (designated by Kříž, 1979): Right valve figured by Heritsch (1929) on. pl. 4, figs 357, 358, 370–373, re- figured herein on pl. 3, figs. 6, 11, 20, deposited in the Geologische Bundesanstalt, Vienna under no. 4958.

Type horizon and type locality: *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 15 right valves and 8 left valves.

Remarks: Species was in detail described by Kříž (1979).

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4958 | II | 4.8 | 4.5 | 2.1 |
| | III | 7.0 | 7.7 | 3.0 |
| | IV | 10.7 | 10.2 | 4.0 |
| 1998/2/30a | II | 5.1 | 5.1 | 2.1 |
| | IV | 9.0 | 10.0 | 3.5 |
| CGS JK 1003 | II | 5.9 | 5.8 | 2.7 |
| | IV | 9.4 | 10.2 | 4.2 |
| GBA 4951 | III | 7.6 | 7.7 | 1.9 |
| | IV | 11.9 | 12.5 | 3.6 |
| GBA 4958/1 | IV | 14.8 | 13.9 | 3.9 |

Occurrence: *Cardiolopsis alpina* is a common Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs in the Kok Formation at the locality Mt. Cocco, Italy and in bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Mt. Cellon, Austria.

### 3.3.4. Genus *Cominicula* Kříž, 1974

Type species – *Cardiola kokiana* Stache in Heritsch, 1929

Remarks: The only known representative of this genus is a rare species known from the Carnic Alps, Italy, the Wenlock only.

### 3.3.4.1. *Cominicula kokiana* (Stache in Heritsch, 1929)

Pl. 3, Figs. 24, 26, 28

1929 *Cardiola kokiana* Stache – Heritsch, p. 40, pl. 4, figs. 385–390.

1979 *Cominicula kokiana* (Stache in Heritsch) – Kříž, p. 55–56, pl. 6, figs. 1, 2, 4, 5, 9; text-figs. 26, 27 (for other previous synonymy see this paper).

Holotype (designated by Kříž, 1974a): Internal mould of right valve figured by Heritsch (1929) on. pl. 4, figs. 385-390, re- figured herein on pl. 3, figs. 24, 26, 28, deposited in the Geologische Bundesanstalt, Vienna under no. 4938.

Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 2 right valves and 1 left valve.

Remarks: Species was described in detail by Kříž (1974a, 1979).

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4938 | II | 10.9 | 9.4 | 3.6 |
| | III | 14.3 | 13.2 | 5.8 |
| | IV | 28.5 | 24.4 | 11.3 |
| GBA 4931 | II | 8.7 | 9.3 | 2.8 |

Occurrence: *Cominicula kokiana* is a rare Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality only.

### 3.3.5. Genus *Cardicarnia* Kříž, 1974

Type species – *Cardicarnia monticola* Kříž, 1974

Remarks: Representatives of this genus are known from the Carnic Alps, Italy, the Wenlock, Sheinwoodian only. The representatives of the genus show an adaptation to the semi-infaunal mode of life with commisural plane subvertical similar to the Ludlovian genus *Slavinka* Kříž, 1982. The general shape and outline is similar, but the ontogeny differs and is similar to the genus *Carnalpia*.

### 3.3.5.1. *Cardicarnia monticola* Kříž, 1974

Pl. 3, Figs. 23, 27, pl. 4, fig. 7

1929 *Gloria (Slava) fibrosa* Barr. – Heritsch, p. 45, pl. 3, figs. 277–281.

1974a *Cardicarnia monticola* sp. n. – Kříž, p. 176, pl. 2, figs. 3, 6–8; text-fig. 6.

1979 *Cardicarnia monticola* Kříž – Kříž, p. 57–58, pl. 6, figs. 3, 6–8; text-fig. 28.

Holotype (designated by Kříž, 1974a): Fragment of a left valve figured by Kříž (1974a) on. pl. 2, figs. 3, 6–8, refigured herein on pl. 3, figs. 23, 27, pl. 4, fig. 7, deposited in the Geologische Bundesanstalt, Vienna under no. 4954.

Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 1 left valve.

Remarks: *Cardicarnia monticola* is closely related to probably contemporaneous *Cardicarnia barrandei* sp. n.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 4954 | II | 3.7 | 4.9 | 2.2 |
| | III | 9.5 | 12.0 | 4.5 |
| | IV | – | 24.3 | 8.0 |

Occurrence: *Cardicarnia monticola* is a rare Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality only.

### 3.3.5.2. *Cardicarnia barrandei* sp. n.

Pl. 4, Figs. 1–6, 8–11, 13, 14, 19

1929 *Slava decurtata* Barr. – Heritsch, p. 44, pl. 3, figs. 286–291.

Holotype: Left valve figured herein on pl. 4, figs. 1–6, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/333.

Paratypes: Other specimens figured herein on pl. 4, figs. 8 - 14, 19, and unfigured specimens deposited in the Geologische Bundesanstalt, Vienna under nos. GBA 4957, 1998/2/ /135, 236, 291–292.

Derivation of name: The specific name is given in honour of Joachim Barrande on occasion of the 200 years anniversary of his birth and for his second to none work which laid the foundations for further study of the Lower Paleozoic Bivalvia and other fossils.

Type horizon and type locality: Bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cellon, Austria.

Material: 6 left valves.

Diagnosis: *Cardicarnia barrandei* sp. n. differs from *Cardicarnia monticola* by a generally smaller and subcircular stage II in outline, by smaller stage III, by distinctly developed anterior sulcus and by generally smaller adult shells.

Description: Stage II (Kříž, 1979) – Valve subcircular or broadly elliptic in outline, prosocline and obese. Anterior slope of the valve steeper than posterior slope. Umbones prominent, in anterior to central position, beaks prosogyrate. Cardiolid sculpture of inner surface sculpture consists of wide, distinct, convex and regularly spaced growth bands combined with less distinct relatively wide radial ribs. The width of radial ribs equals approximately 1/2 the width of the growth bands. Other features unknown. Shell thickness is 0.07–0.08 mm.

Stage III: Continuous with stage II, elliptical to broadly elliptical in outline, distinctly opisthocline, dorsoventrally elongated obese; the width equals 92–123 % the height of the shell. Swollen band distinct, wide, variable in outline, asymmetrical. Anterior slope of the valve is very steep and steeper than the posterior slope. Anterior margin usually straight. Umbones formed by the stage II are prosogyrate. Outer and inner surface almost smooth with poorly visible, very indistinct radial ribs of the same width as in stage II. Between anterior and central part of the valve a distinct curve is developed. Shell thickness is 0.07–0.1 mm. Other features unknown.

Stage IV: Shell opisthocline, inequivalve, inequilateral, valves broadly ovate to ovate, obese; the width equals 58–69 % the height of the shell. Commissure not planar, where the wide sulcus on the left valve reaches the commissire, it is folded to the right. Posterior slope steeper than anterior slope of the shell. Anterior margin of stage III continues to stage IV as a distinct curve. In front of it a relatively deep radial sulcus is developed, widening ventrally. In the anterior part a lunule is developed separated from the sinus by a distinct curve. Inner surface sculpture consists of wide and more distinct regularly spaced growth bands in

## Plate 4

Figs. 1–6: ***Cardicarnia barrandei* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 1998/2/333.
Fig. 1: Lateral view, x 4.5.
Fig. 2: Antero-lateral view, x 4.1.
Fig. 3: Posterior view, x 3.45.
Fig. 4: Lateral view of the stage III (later stages blocked out), x 3.45.
Fig. 5: Antero-dorsal view, x 3.9.
Fig. 6: Dorsal view, x 5.8.

Fig. 7: ***Cardicarnia monticola*** Kříž.
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 4954, lateral view, x 2.45. (For lateral view of the stage II and posterior view see Pl. 3, Figs. 23, 27).

Figs. 8, 9, 12: ***Cardicarnia barrandei* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, paratype, GBA 1998/2/292.
Fig. 8: Lateral view, x 3.45.
Fig. 9: Antero-lateral view, x 3.25.
Fig. 12: Ventro-lateral view, x 3.7.

Figs. 10, 13, 14, 19: ***Cardicarnia barrandei* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, paratype, GBA 1998/2/291.
Fig. 10: Dorsal view, x 3.2.
Fig. 13: Lateral view, x 2.25.
Fig. 14: Antero-lateral view, x 2.55.
Fig. 19: Posterior view, x 2.7.

Fig. 11: ***Cardicarnia barrandei* sp. n.**
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, left valve, paratype, GBA 4957, lateral view, x 2.35.

Figs. 15, 16: ***Cardiola bifasciata*** (Stache in Heritsch).
Mt. Cocco, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 9040.
Fig. 15: Lateral view of the stage II (later stages blocked out), x 2.7.
Fig. 16: Lateral view, x 3.85.

Figs. 17, 18: ***Cardiola stachei* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 1998/2/29a.
Fig. 17: Lateral view, x 3.9.
Fig. 18: Lateral view of the stage II (later stages blocked out), x 3.9.

Figs. 20, 21, 27: ***Cardiola bifasciata*** (Stache in Heritsch).
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, conjoined valves, GBA 1998/2/1.
Fig. 20: Posterior view, x 2.8.
Fig. 21: Left lateral view, x 2.1.
Fig. 27: Detail of ventral sculpture, x 7.1.

Figs. 22, 24, 25, 28, 29: ***Cardiola tinda* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, holotype, GBA 1998/2/35.
Fig. 22: Lateral view of stage III (later stages blocked out), x 4.2.
Fig. 24: Dorsal view, x 3.4.
Fig. 25: Postero-lateral view, x 3.0.
Fig. 28: Lateral view, x 3.7.
Fig. 29: Antero-lateral view, x 3.5.

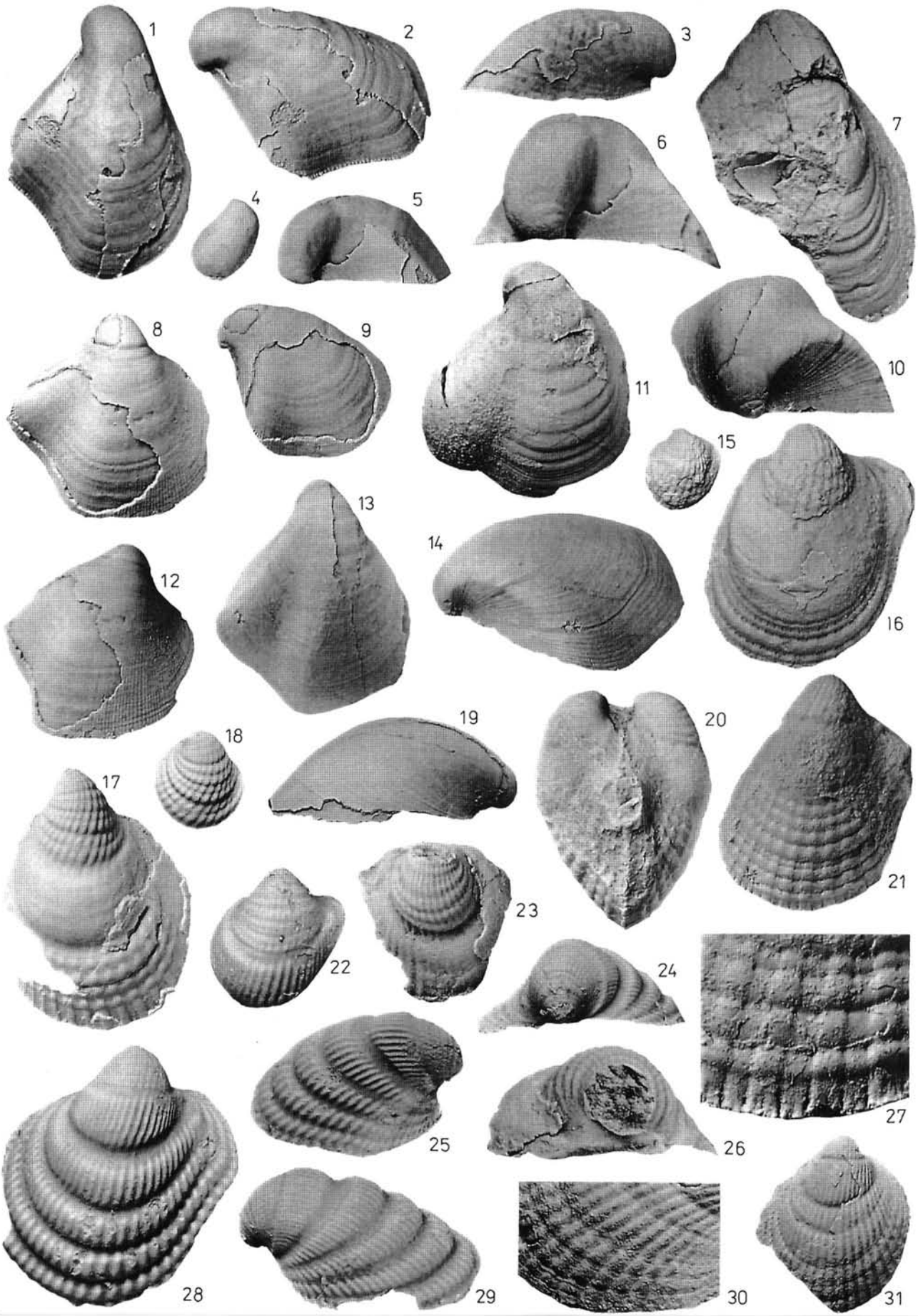
Figs. 23, 26: ***Cardiola tinda* sp. n.**
Mt. Cellon, bed no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, right valve, paratype, GBA 1998/2/233.
Fig. 23: Lateral view, x 3.15.
Fig. 26: Dorsal view, x 5.1.

Figs. 30, 31: ***Cardiola* aff. *figusi*** Kříž.
Rauchkofel Boden Section, 0–30 cm above base of the Kok Formation, lower Homerian, Wenlock, left valve, GBA 1998/2/20a.
Fig. 30: Detail of posterior sculpture, x 4.
Fig. 31: Lateral view, x 2.4.

All photos by Jiří Kříž, Czech Geological Survey, Praha.

the early part of the shell and narrow, less distinct and less regularly spaced growth bands in the later part of the shell. Growth sculpture is combined with fine numerous radial ribs and narrow radial gutters, more distinct in outer surface sculpture. Lunule is sculptured by distinct, fine radial ribs and gutters in combination with narrow and more or less regular growth bands. Shell thickness is 0.1–0.17 mm. Other features unknown.

Remarks: *Cardicarnia barrandei* sp. n. is the closest relative of contemporaneous *Cardicarnia monticola*. It differs mainly by a smaller stage III, by a distinctly developed anterior sulcus and by generally smaller adult shells.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Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/333 | III | 3.4 | 4.1 | 1.9 |
| | IV | 8.1 | 11.9 | 3.7 |
| GBA 1998/2/292 | IV | 10.2 | 10.7 | 3.7 |
| GBA 4957 | III | 3.6 | 5.2 | 2.1 |
| | IV | 12.0 | 14.5 | 4.2 |

Occurrence: *Cardicarnia barrandei* sp. n. is a common Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality and most probably in the same horizon in the Kok Formation, Sheinwoodian, Wenlock at the locality Mt. Cocco, Italy.

### 3.3.6. Genus *Cardiola* Broderip in Murchison, 1839

Type species – *Cardiola interrupta* Sowerby and Murchison, 1839

Remarks: The genus *Cardiola* is a characteristic cosmopolitan Silurian genus which is known from the Sheinwoodian, Wenlock and occurs up to the lowermost Přídolí.

#### 3.3.6.1. *Cardiola bifasciata* (Stache in Heritsch, 1929)

Pl. 4, Figs. 15, 16, 20, 21, 27

1929 *Cardiolopsis alpina* var. *bifasciata* Stache – Heritsch, p. 47, pl. 4, figs 360–362.

1979 *Cardiola bifasciata* (Stache in Heritsch) – Kříž, p. 64–65, pl. 8, figs. 8, 9.

Holotype (designated by Kříž, 1979): Internal mould of a left valve figured by Heritsch on pl. 4, figs. 360–362; re-figured herein on pl. 4, figs. 15, 16, deposited in the Geologische Bundesanstalt, Vienna under no. 9040.

Type horizon and type locality: Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cocco, Italy.

Material: 1 left valve, 1 right valve, 1 conjoined shell.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/1 | II | 4.7 | 4.7 | 2.4 |
| | III | 6.3 | 8.5 | 3.4 |
| | IV | 12.2 | 14.8 | 5.7 |
| GBA 9040 | II | 5.1 | 5.2 | 2.4 |
| | III | 8.1 | 10.2 | 3.4 |
| | IV | 10.7 | 12.3 | 4.4 |

Occurrence: *Cardiola bifasciata* is a relatively rare Sheinwoodian (Wenlockian) representative of the Cardiolidae. In the Carnic Alps it occurs at the type locality and in bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Mt. Cellon, Austria.

#### 3.3.6.2. *Cardiola stachei* sp. n.

Pl. 4, Figs. 17, 18

Holotype: Internal mold of left valve with fragment of recrystallized shell wall (mostly preserved in the counterpart of the specimen), figured herein on pl. 4, figs. 17, 18, deposited in the Geologische Bundesanstalt, Vienna under no. *1998/2/29* a, b.

Derivation of name: The specific name is given in honour of Guido Karl Heinrich Hector Stache for his excellent but unpublished pioneer research of the Silurian Bivalvia from the Carnic Alps.

Type horizon and type locality: Bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cellon, Austria.

Material: Known only from the holotype.

Diagnosis: *Cardiola stachei* sp. n. differs from its closest relative *Cardiola contrastans* Barrande, 1881 by a prosocline shell, higher stage II with no prominent median ribs developed and with deeper growth furrows than radial gutters, more flat and asymmetrical, relatively smooth stage III, distinctly narrower radial ribs than gutters in stage IV and V and by a generally less inflated shell.

Description: Stage II (Kříž, 1979) – Valve ovate in outline, obese; the width equals 108 % the height of the shell. Anterior slope of the valve steeper than posterior slope. Umbones prominent, in central position, beaks distinctly prosogyrate. Cardiolid sculpture of inner surface sculpture consists of distinct, convex and irregularly spaced growth bands combined with less prominent wide radial ribs (16 in number). The width of growth bands equals or exceeds the width of the radial ribs. The width of radial ribs equals the width of radial gutters. Growth furrows deeper than radial gutters. Other features unknown.

Stage III: Distinct, wide swollen band asymmetrical, posterior part larger than anterior part and anterior slope of the valve steeper than posterior slope, shell prosocline, dorsoventrally elongated obese; the width equals 56 % the height of the shell. Umbones formed by stage II are prosogyrate. Outer and inner surface almost smooth with very flat radial ribs of the same width as in stage II and more visible in posterior part. Radial gutters broaden ventrally more than radial ribs. Shell thickness is 0.14–0.15 mm. Other features unknown.

Stage IV: Valve prosocline, broadly ovate to ovate, obese; the width equals 50 % the height of the shell. Anterior slope steeper than posterior slope of the valve. Posterior margin larger with wing like shape. Umbones formed by stage II are prominent, beaks prosogyrate. Radial ribs convex, narrow, posteriorly curved. Radial gutters broaden ventrally, although the radial ribs retain almost the same width. Growth bands narrow, regularly spaced. Other features unknown.

Stage V: Ventral band well developed, narrow. Shell outline the same as that in stage IV. Radial ribs convex, narrow. Radial gutters wider than radial ribs. Crenulation riblets not developed. Shell thickness is 0.1 mm. Other features unknown.

Remarks: *Cardiola stachei* sp. n. most probably represents the ancestral form to the species *Cardiola contrastans* known from the Prague Basin, Bohemia. While *Cardiola stachei* sp. n. was probably adapted to the semiinfaunal mode of life in the facies of micritic limestones, *Cardiola contrastans* was most probably adapted to the epibyssate mode of life.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/29a | II | 4.2 | 4.8 | 2.6 |
| | III | 6.4 | 8.5 | 2.4 |
| | IV | – | 12.8 | 3.2 |

Occurrence: *Cardiola stachei* sp. n. is known from the type locality only.

#### 3.3.6.3. *Cardiola tinda* sp. n.

Pl. 4, Figs. 22–26, 28, 29

Holotype: Internal mould of left valve, figured herein on pl. 4, figs. 22, 24, 25, 28, 29, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/35.

Paratypes: Specimen figured herein on pl. 4, figs. 23, 26, and unfigured specimen deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/229.
Derivation of name: The specific name is derived from the Czech name Tinda which I call my grandson Kristian.
Type horizon and type locality: Layer no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cellon, Austria.
Material: 2 left valves and 1 right valve.
Diagnosis: *Cardiola tinda* sp. n. differs from all species of the genus *Cardiola* by a distinctly developed posterior wing in stage IV.
Description: Stage II (KŘÍŽ, 1979) – Valve broadly ovate in outline, opisthocline, obese; the width equals 86–97 % the height of the shell. Posterior slope of the valve steeper than anterior slope. Umbones prominent, in central position, beaks distinctly prosogyrate. Cardiolid sculpture of inner surface sculpture consists of distinct, convex and irregularly spaced growth bands combined with less prominent wide radial ribs (more than 23 in number).The width of growth bands equals or exceeds the width of the radial ribs. The width of radial ribs equals approximately the width of radial gutters. Growth furrows deeper than radial gutters. Outer surface sculpture coarser. Triangular ligament area well developed, the height of ligament area equals 1/3 the length of ligament area. Inner surface sculpture of ligament area is smooth. Shell thickness is 0.1–0.17 mm. Other features unknown.
Stage III: Distinct swollen band asymmetrical, anterior part larger than posterior part and anterior slope of the valve steeper than posterior slope, shell opisthocline, broadly ovate to elliptical, obese; the width equals 94 % the height of the shell. Umbones formed by the stage II are prosogyrate. Outer and inner surface with distinct, convex radial ribs (more than 30 in number) of the same width like radial gutters. Shell thickness is 0.07 mm. Other features unknown.
Stage IV: Valve opisthocline, broadly ovate, obese. Anterior slope steeper than posterior slope of the valve. In the posterior a distinct wing is developed starting with the first growth band. Umbones formed by stage II are prominent, beaks prosogyrate. Radial ribs prominent (more than 48 in number) of the same width as radial gutters. Both the radial ribs and radial gutters broaden ventrally. Growth bands wide, almost regularly spaced. Other features unknown.
Remarks: The Sheinwoodian *Cardiola tinda* sp. n. represents most probably the ancestral form to the Homerian closely related species *Cardiola agna, Cardiola figusi* and *Cardiola schoenlaubi* sp. n. known from the Prague Basin (Bohemia), Sardinia (Italy), Montagne Noire (France) and the Carnic Alps. While *Cardiola tinda* sp. n. was probably adapted to the semi-infaunal mode of life in the facies of micritic limestones, the Homerian species were most probably adapted to the epibyssate mode of life.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/35 | II | 4.2 | 4.4 | 1.9 |
| | III | 5.9 | 5.9 | 2.8 |
| | IV | 12.7 | 12.5 | 4.9 |
| GBA 1998/2/229 | II | 4.3 | 3.9 | 1.9 |

Occurrence: *Cardiola tinda* sp. n. is known from the type locality only.

### 3.3.6.4. *Cardiola* aff. *figusi* KŘÍŽ, 1993

Pl. 4, Figs. 30, 31

Material: 1 left valve, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/20 a, b.
Remarks: The specimen shows distinctly wide growth bands, dorsoventrally elongated shells and generally a similar type of outer and inner surface sculpture in stage IV as in *Cardiola figusi* (*Cardiola agna figusi* KŘÍŽ, 1993) known from Sardinia and the Montagne Noire (KŘÍŽ & SERPAGLI, 1993 and KŘÍŽ, 1996). The specimen is most probably conspecific with *Cardiola figusi* but a lack of material makes it impossible to prove this statement.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/20a | III | 6.1 | 6.3 | 2.5 |
| | IV | 10.6 | 11.6 | 2.8 |

Occurrence: The Rauchkofel Boden Section, 0–30 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Homerian, Wenlock, Silurian.

### 3.3.6.5. *Cardiola schoenlaubi* sp. n.

Pl. 5, Figs. 1–3, 6–8, 11, 13, 14

Holotype: Internal mold of left valve figured herein on pl. 5, figs. 1, 2, 6, 7, 13, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/19 a, b.
Paratypes: Other specimens figured herein on pl. 5, figs. 3, 8, 11, 14, and unfigured specimens deposited in the Geologische Bundesanstalt, Vienna under nos. 1998/2/18, 21, 22, 24, 33, 34, 77.
Derivation of name: The specific name is given in honour of Hans-Peter Schönlaub for his research of the Paleozoic in the Carnic Alps and for his help, cooperation and hospitality during the last thirty years of field work there.
Type horizon and type locality – 65–105 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Homerian, Wenlock, Silurian, Rauchkofel Boden Section, Carnic Alps, Austria.
Material: 4 left valves, 3 right valves.
Diagnosis: *Cardiola schoenlaubi* sp. n. differs from most closely related species *Cardiola agna* KŘÍŽ, 1979 and *Cardiola figusi* KŘÍŽ, 1993 (*Cardiola agna figusi*) generally by a less distinct outer and inner surface sculpture and by narrow growth bands in stage IV.
Description: Stage II (KŘÍŽ, 1979) – Valve subcircular or broadly elliptical in outline, opisthocline and obese; the width equals 85 % the height of the shell. Posterior slope of the valve steeper than anterior slope. Umbones prominent, in almost central position, beaks prosogyrate. Cardiolid sculpture of inner surface sculpture consists of relatively narrow irregularly spaced growth bands combined with more distinct relatively wide radial ribs (more than 20 in number) and narrow radial gutters. Radial ribs broaden ventrally. Radial gutters are deeper than growth furrows. Outer surface sculpture generally coarser than inner surface sculpture. Shell thickness is 0.07–0.14 mm. Other features unknown.
Stage III: Well developed swollen band, slightly asymmetrical; the shell growth anteroventrally. Valve opisthocline, obese. Radial ribs convex, more prominent in posterior of swollen band. Outer surface sculpture coarser. Width equals 65–79 % the height of the shell. Posterior slope of valve steeper than anterior slope. Shell thickness is 0.1–0.17 mm. Other features unknown.
Stage IV: Shell opisthocline, broadly elliptical to ovate, obese; the width equals 70 % the height of the shell. Anterior

## Plate 5

Figs. 1, 2, 6, 7, 13: ***Cardiola schoenlaubi* sp. n.**
Rauchkofel Boden Section, 65–105 cm above base of the Kok Formation, lower Homerian, Wenlock, left valve, holotype, GBA 1998/2/19a.
Fig. 1: Lateral view of the stage II (later stages blocked out), x 5.0.
Fig. 2: Lateral view of the stage III (later stages blocked out), x 3.5.
Fig. 6: Lateral view, x 4.5.
Fig. 7: Ventro-lateral view, x 3.6.
Fig. 13: Postero-lateral view, x 4.2.

Figs. 3, 8, 14: ***Cardiola schoenlaubi* sp. n.**
Rauchkofel Boden Section, 0–30 cm above base of the Kok Formation, lower Homerian, Wenlock, left valve, paratype, GBA 1998/2/22.
Fig. 3: Postero-lateral view, x 3.25.
Fig. 8: Lateral view of the stage II (later stages blocked out), x 6.25.
Fig. 14: Lateral view, x 3.8.

Figs. 4, 9, 10: ***Cardiola docens*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, right valve, GBA 1998/2/6.
Fig. 4: Dorso-lateral view, x 1.55.
Fig. 9: Lateral view, x 1.35.
Fig. 10: Dorsal view, x 1.85.

Figs. 5, 29, 31, 34: ***Cardiola consanguis*** BARRANDE.
Hoher Trieb, Cardiola Formation, Ludlow, left valve, GBA 1998/2/8.
Fig. 5: Lateral view of the stage III (later stages blocked out), x 3.0.
Fig. 29: Dorso-lateral view, x 1.95.
Fig. 31: Lateral view, x 2.4.
Fig. 34: Antero-lateral view, x 3.1.

Fig. 11. ***Cardiola schoenlaubi* sp. n.**
Rauchkofel Boden Section, 0–30 cm above base of the Kok Formation, lower Homerian, Wenlock, left valve, paratype, GBA 1998/2/21, postero-lateral view, x 3.3.

Figs. 12, 30: ***Cardiola consanguis*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, right valve, GBA 1998/2/11.
Fig. 12: Lateral view of the stage III (later stages blocked out), x 3.1.
Fig. 30: Lateral view, x 2.3.

Figs. 15, 16: ***Cardiola spectabilis*** BARRANDE.
Mt. Cocco, Kok Formation, Ludlow, right valve, GBA 4922.
Fig. 15: Dorso-lateral view, x 1.8.
Fig. 16: Lateral view, x 1.85.

Fig. 17: ***Cardiola docens*** BARRANDE.
Mt. Cellon, bed no. 20, Cardiola Formation, Ludlow, left valve, GBA 1998/2/7, lateral view, x 2.3.

Fig. 18: ***Cardiola docens*** BARRANDE.
Hoher Trieb, Cardiola Formation, Ludlow, left valve, GBA 1998/2/24, lateral view, x 2.0.

Figs. 19, 22: ***Cardiola docens*** BARRANDE.
Mt. Cellon, bed no. 20, Cardiola Formation, Ludlow, right valve, GBA 1998/2/31.
Fig. 19: Postero-lateral view, x 1.6.
Fig. 22: Lateral view, x 1.6.

Figs. 20, 24: ***Cardiola consanguis*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, left valve, GBA 1998/2/10.
Fig. 20: Antero-lateral view, x 2.25.
Fig. 24: Lateral view, x 2.95.

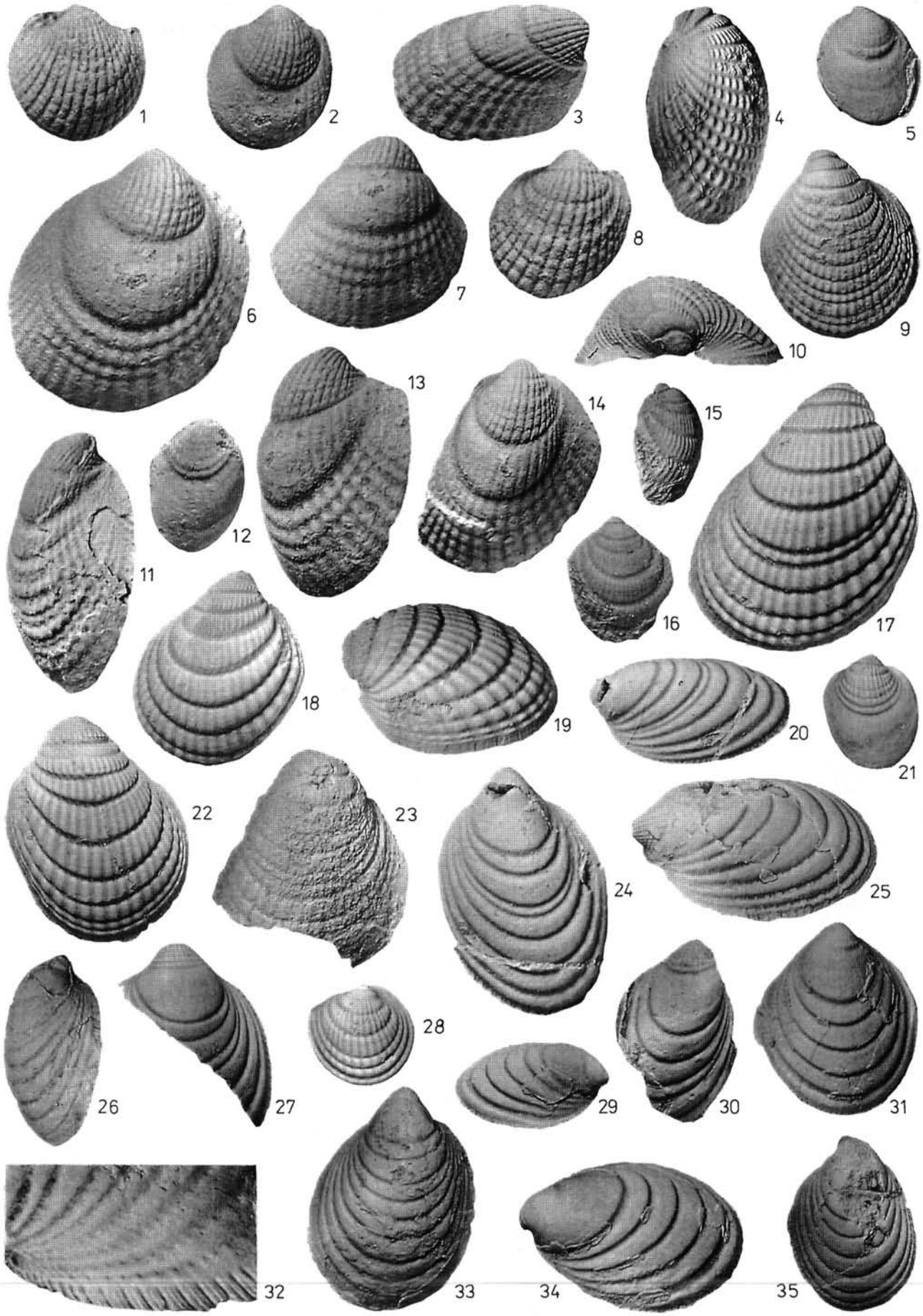
Figs. 21, 27, 28: ***Cardiola signata*** BARRANDE.
Hoher Trieb, Cardiola Formation, Ludlow, right valve, GBA 1998/2/9.
Fig. 21: Lateral view of the stage III (later stages blocked out), x 2.10.
Fig. 27: Lateral view, x 1.85.
Fig. 28: Lateral view of the stage II (later stages blocked out), x 3.4.

Fig. 23. ***Cardiola spectabilis*** BARRANDE.
Rauchkofel Boden Section, 260 cm above the Silurian base, Kok Formation, Ludlow, right valve, GBA 1998/2/159, lateral view, x 1.75.

Figs. 25, 35: ***Cardiola consanguis*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, right valve, GBA 1998/2/12a.
Fig. 25: Postero-lateral view, x 2.3.
Fig. 35: Lateral view, x 1.6.

Figs. 26, 32, 33: ***Cardiola consanguis*** BARRANDE.
Rauchkofel Boden Section, 260 cm above the Silurian base, Kok Formation, Ludlow, left valve, GBA 1998/2/14.
Fig. 26: Postero-lateral view, x 1.35.
Fig. 32: Deatail of anterior sculpture, x 3.55.
Fig. 33: Lateral view, x 1.6.

All photos by Jiří Kříž, Czech Geological Survey, Praha.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slope steeper than posterior slope. Umbones formed by stage II prominent, beaks prosogyrate. Radial ribs (more than 33 in number) convex, radial gutters wider than in stage III. Both the radial ribs and radial gutters broaden ventrally. Growth bands relatively narrow, mostly regularly spaced. Inner surface sculpture coarser, crenulation tubercles not visible. Shell thickness is 0.1–0.19 mm. Other features unknown.

Stage V: Ventral band well developed, narrow. Growth bands and furrows narrow and regularly spaced. Radial ribs flat, narrow. Well developed radial crenulation riblets. Shell thickness is 0.1–0.14 mm. Other features unknown.

Remarks: *Cardiola schoenlaubi* sp. n. is most closely related to the species *Cardiola agna* KŘÍŽ, 1979 known from the Prague Basin, Bohemia and *Cardiola figusi* KŘÍŽ, 1993 (*Cardiola agna figusi*) known from Sardinia and from the Montagne Noire, France. All are characteristic Homerian species and are probably descendants of *Cardiola tinda* sp. n. from the Sheinwoodian. *Cardiola tinda* sp. n. was probably adapted to the semi-infaunal mode of life in the facies of micritic limestones, the Homerian species were most probably adapted to the epibyssate mode of life. *Cardiola schoenlaubi* sp. n. is more closely related to *Cardiola figusi* which has a generally smoother surface sculpture than *Cardiola agna*.

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/21 | II | 1.5 | 3.5 | 1.5 |
| | III | 4.7 | 6.1 | 2.0 |
| GBA 1998/2/22 | II | 4.1 | 4.2 | 1.8 |
| | III | 5.5 | 6.6 | 2.3 |
| GBA 1998/2/19a | II | 4.4 | 4.5 | 1.9 |
| | III | 6.6 | 7.3 | 2.9 |
| | IV | 10.4 | 11.1 | 3.9 |

Occurrence: *Cardiola schoenlaubi* sp. n. is a common Homerian (Wenlock) representative of the Cardiolidae in the Carnic Alps. It occurs at the type locality only.

### 3.3.6.6. *Cardiola docens* BARRANDE, 1881

Pl. 5, Figs. 4, 9, 10, 17–19, 22

1881 *Cardiola docens* BARR. – BARRANDE, pl. 189, figs. 13–16.
1909 *Cardiola interrupta* SOWERBY in MURCHISON – GORTANI et VINASSA DE REGNY, p. 15–16, pl. 1, figs. 14–15.
1929 *Cardiola interrupta* SOW. – HERITSCH, p. 40–41, pl. 3, figs. 195–201.
1937 *Cardiola interrupta* SOWERBY – CHAUBET, p. 167, pl. VI, figs. 4, 8.
1979 *Cardiola docens* BARRANDE – KŘÍŽ, p. 74–76, Pl. XIV, figs. 1–12, text fig. 36 (for other previous synonymy see this paper).
1993 *Cardiola docens* BARRANDE – KŘÍŽ in KŘÍŽ et SERPAGLI, p. 317, pl. 5, figs. 1, 8, 9, 14–25.
1996 *Cardiola docens* BARRANDE – KŘÍŽ, p. 45, pl. 3, figs. 7, 8, 10, 11, 14, 15, 18, 19, 21, 22.

Holotype (by monotypy, designated by KŘÍŽ, 1979): Internal mould of a right valve figured by BARRANDE (1881) on pl. 189, figs. 13–16, re-figured by KŘÍŽ (1979) on pl. 14, fig. 8; deposited in the National Museum, Prague under no. L 6531.

Type horizon and type locality: Horizon with *Cromus beaumonti* (*S. linearis* Biozone), Ludlow, Bohemia, Prague Basin, Praha – Lochkov.

Material: 76 left and 73 right valves. Another 3 left and 2 right valves are assigned as *Cardiola* cf. *docens* (1998/2/74, 86, 156, 157, 160) because of their poor preservation.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/23 | II | 2.6 | 2.6 | 1.1 |
| | III | 4.2 | 3.7 | 1.7 |
| | IV | 15.3 | 17.3 | 6.4 |
| GBA 1998/2/24 | IV | 16.0 | 17.5 | 6.5 |
| GBA 1998/2/7 | IV | 19.4 | 21.8 | 9.8 |
| GBA 1998/2/31 | V | 21.6 | 23.3 | 11.7 |

Occurrence: *Cardiola docens* is the most common Silurian representative of the Cardiolidae. For occurrences other than Bohemia see KŘÍŽ (1979, 1996; KŘÍŽ & SERPAGLI, 1993). The species is dominant in the *Cardiola docens* Community of the *Cardiola* Community Group (KŘÍŽ, 1998) which occurs in Bohemia in the uppermost *Saetograptus chimaera* Zone and in the *S. linearis* Zone. In the Carnic Alps *Cardiola docens* occurs first in the *Cardiola consanguis* Community at the Rauchkofel Boden Section, 195–260 cm above the base of the "Orthoceras" limestone (Kok Formation, Ludlow) and is dominant in the *Cardiola docens* Community which occurs in the Cardiola Formation at the localities Mt. Cocco, Italy, Mt. Cellon (beds no. 20, 21, 22 c), Mt. Hoher Trieb and Rauchkofel Boden Section (bed between nos. 325–326).

### 3.3.6.7. *Cardiola spectabilis* BARRANDE, 1881

Pl. 5, Figs. 15, 16, 23

1881 *Cardiola spectabilis* BARR. – BARRANDE, pl. 286, figs. III/9–12.
1881 *Cardiola opulens* BARR. – BARRANDE, pl. 162, figs. IV/1–7.
1929 *Cardiola fluctuans* BARR. – HERITSCH, p. 42, pl. 3, figs. 177–180.
1979 *Cardiola spectabilis* BARRANDE – KŘÍŽ, p. 78–79, pl. 16, figs. 1–9.
1996 *Cardiola spectabilis* BARRANDE – KŘÍŽ, p. 46, pl. 3, fig. 25.

Holotype (designated by KŘÍŽ, 1979): Internal mould of a right valve figured by Barrande (1881) on pl. 286, figs. III/9–12, re-figured by KŘÍŽ (1979) on pl. 16, figs. 3, 7, 8; deposited in the National Museum, Prague under no. L 7251.

Type horizon and type locality: Silurian, Ludlow, Kopanina Formation, horizon with *Cromus beaumonti, Saetograpfus chimaera* Zone, Bohemia, Prague Basin, Koledník near Beroun.

Material: 2 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBW 4922 | II | 2.2 | 2.2 | 0.9 |
| | III | 3.6 | 3.8 | 1.4 |
| | IV | 8.5 | 9.0 | 3.4 |

Occurrence: *Cardiola spectabilis* is a quite common Silurian representative of the Cardiolidae. The species occurs in the *Cardiola consanguis* Community of the *Cardiola* Community Group (KŘÍŽ, in press a) and occurs in the Carnic

Alps at the Rauchkofel Boden Section, 260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow and at the Mt. Cocco, Italy.

### 3.3.6.8. *Cardiola consanguis* Barrande, 1881

Pl. 5, Figs. 5, 12, 20, 24–26, 29–35

1881 *Cardiola consanguis* Barr. – Barrande, pl. 165, figs. IV/9–20.
1979 *Cardiola consanguis* Barrande – Kříž, p. 82–84, pl. 19, figs. 1, 4–9 (for other previous synonymy see this paper).
1993 *Cardiola consanguis* Barrande – Kříž in Kříž & Serpagli, p. 318, pl. 16, 20, 22.

Lectotype (designated by Kříž, 1979): Internal mould of a left valve figured by Barrande (1881) on pl. 165, figs. IV/16–20, re-figured by Kříž (1979) on pl. 19, figs. 6,7; deposited in the National Museum, Prague under no. L 6962.

Type horizon and type locality: Silurian, Ludlow, Kopanina Formation, horizon with *Cromus beaumonti*, upper *Saetograptus chimaera* Zone, Bohemia, Prague Basin, Zadní Kopanina.

Material: 5 left and 6 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with Barrande's type material.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/10 | II | 2.9 | 3.2 | 1.1 |
| | III | 5.1 | 6.7 | 1.9 |
| | IV | 11.4 | 16.1 | 5.6 |
| GBA 1998/2/8 | II | 3.5 | 3.5 | 1.4 |
| | III | 5.8 | 7.1 | 2.1 |
| | IV | 12.7 | 15.2 | 4.7 |
| GBA 1998/2/11 | II | 3.7 | 3.8 | 1.4 |
| | III | 5.8 | 9.5 | 2.2 |
| GBA 1998/2/14 | III | 7.6 | 9.8 | 3.4 |
| | IV | 18.4 | 24.8 | 9.8 |
| | V | 20.6 | 25.8 | 11.0 |

Occurrence: *Cardiola consanguis* is a common Silurian representative of the Cardiolidae. The species is dominant in the *Cardiola consanguis* Community of the *Cardiola* Community Group (Kříž, in press a) which occurs in the Carnic Alps at the Rauchkofel Boden Section, 195–260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow, at the locality Valentintörl (Oberes Valentinthal – Frech, 1888), Austria and at Mt. Cocco, Italy. *Cardiola consanguis* occurs also in the *Cardiola docens* Community in the Cardiola Formation at the Rauchkofel Boden Section in the bed between nos. 325 and 326 (Schönlaub, 1980, 1997), at Mt. Cellon (bed no. 20) and at Mt. Hoher Trieb. The species occurs also at numerous Ludlovian localities in the Prague Basin, Bohemia (Kříž, 1979) and in the Montagne Noire, France (Kříž, 1996). A very similar *Cardiola* aff. *consanguis* occurs in the *Cardiola signata* Community described by Kříž & Bogolepova (1995) from the lower Ludlow, uppermost parts of the *Saetograptus chimaera* Zone,Tajmyr, Russia.

### 3.3.6.9. *Cardiola signata* Barrande, 1881

Pl. 5, Figs. 21, 27, 28, Pl. 6, Figs. 1–3

1881 *Cardiola signata* Barr. – Barrande, pl. 167, figs. V/9–23, 32–34, 37–42.
1937 *Cardiola signata* Barrande – Chaubet, p. 167.
1979 *Cardiola signata* Barrande – Kříž, p. 86–87, pl. 19, figs. 2,3, pl. 39, fig. 4 (for other previous synonymy see this paper).
1993 *Cardiola signata* Barrande – Kříž in Kříž & Serpagli, p. 318, pl. 6, fig. 21.
1995 *Cardiola signata* Barrande – Kříž & Bogolepova, p. 577–578, pl. 70, figs. 6, 8, 10, 13, 16.
1996 *Cardiola signata* Barrande – Kříž, p. 46, pl. 3, figs. 9, 12, 13, 17.

Lectotype (designated by Kříž, 1979): Left valve figured by Barrande (1881) on pl. 167, figs. V/39–42, re-figured by Kříž (1979) on pl. 19, figs. 2, 3, deposited in the National Museum, Prague under no. L 7249.

Type horizon and type locality: Horizon with *Cromus beaumonti*, Ludlow, Kopanina Formation, Bohemia, Prague Basin, Konžprusy near Beroun.

Material: 8 left and 7 right valves. Another 1 left valve and 1 fragment are assigned as *Cardiola* cf. *signata* because of their poor preservation.

Remarks: Specimens from the Carnic Alps are conspecific with Barrande's type material.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/16 | II | 5.3 | 5.3 | 1.9 |
| | III | 9.0 | 10.2 | 2.9 |
| | IV | 11.7 | 13.5 | 4.2 |
| GBA 1998/2/9 | II | 5.9 | 5.6 | 2.2 |
| | III | 8.5 | 11.9 | 3.6 |

Occurrence: *Cardiola signata* is a quite common Silurian representative of the Cardiolidae. The species is dominant in the *Cardiola signata* Community of the *Cardiola* Community Group (Kříž, in press a) which occurs in the Prague Basin, Bohemia and in Tajmyr, Russia (Kříž & Bogolepova, 1995), uppermost *Saetograptus chimaera* and *Saetograptus linearis* zones. *Cardiola signata* occurs commonly also in higher *Cardiola docens* Community in the Prague Basin, Bohemia (Kříž, 1979), in the Montagne Noire, France (Kříž, 1996) and in Sardinia (Kříž & Serpagli, 1993). In the Carnic Alps *Cardiola signata* is abundant in the *Cardiola consanguis* Community at the locality Rauchkofel Boden Section, 195–260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow. It also occurs in the higher *Cardiola docens* Community in the Cardiola Formation at the localities Mt. Cellon (beds no. 20 and 21), Rauchkofel Boden Section , Mt. Hoher Trieb and in the Kok Formation at Mt. Cocco, Italy.

### 3.3.6.10. *Cardiola conformis* Barrande, 1881

Pl. 6, Figs. 4–6

1881 *Cardiola conformis* Barr. – Barrande, pl. 179, figs. 1–23, 27–51.
1979 *Cardiola conformis* Barrande – Kříž, p. 79–80, pl. 17, figs. 1–10 (for other previous synonymy see this paper).

Lectotype (designated by Kříž, 1979): Internal mould of a right valve with fragments of recrystallized shell wall, figured by Barrande (1881) on pl. 179, figs. 44–47, re-figured by Kříž (1979) on pl. 17, figs. 9,10; deposited in the National Museum, Prague under no. L 6953.

Type horizon and type locality: Silurian, Uppermost Ludlow, Kopanina Formation, Bohemia, Prague Basin, Praha – Lochkov.

Material: 1 left and 2 right valves.

## Plate 6

Fig. 1, 2: ***Cardiola signata*** BARRANDE.
Rauchkofel Boden Section, 260 cm above the Silurian base, Kok Formation, Ludlow.
Fig. 1: Right valve, GBA 1998/2/16, lateral view, x 2.9.
Fig. 2: Right valve, GBA 1998/2/223, lateral view, x 3.8.

Fig. 3: ***Cardiola signata*** BARRANDE.
Mt. Cellon, bed no. 21, Cardiola Formation, Ludlow, right valve, stage III, GBA 1998/2/228a, lateral view, x 5.5.

Fig. 4, 6: ***Cardiola conformis*** BARRANDE.
Mt. Cellon, bed no 30, base of crispa Zone, Alticola Kalk Formation, late Ludlow.
Fig. 4: Left valve, GBA 1998/2/180, lateral view, x 3.5.
Fig. 6: Left valve, GBA 1998/2/179, lateral view, x 3.7.

Figs. 5, 7, 8: ***Cardiola* cf. *tix*** KŘÍŽ.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, right valve, GBA 1998/2/455.
Fig. 5: Lateral view of the stage III (later stages blocked out), x 3.4.
Fig. 7: Lateral view, x 2.4.
Fig. 8: Postero-lateral view, x 2.95.

Figs. 9, 10: ***Cardiola eximia*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, left valve, GBA 1998/2/456.
Fig. 9: Lateral view, x 2.0.
Fig. 10: Detail of ventral sculpture, x 3.6.

Figs. 11–17: ***Cardiola pectinata*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 11: Left valve, GBA 1998/2/2a, lateral view of the stage III (later stages blocked out), x 3.5.
Fig. 12: Left valve, GBA 1998/2/2a, antero-lateral view, x 2.8.
Fig. 13: Left valve, GBA 1998/2/2a, postero-lateral view, x 3.0.
Fig. 14: Left valve, GBA 1998/2/2a, lateral view, x 3.05.
Fig. 15: Left valve, GBA 1998/2/470, lateral view, x 3.25.
Fig. 16: Right valve, GBA 1998/2/26, lateral view, x 2.15.
Fig. 17: Right valve, GBA 1998/2/26, antero-lateral view, x 2.7.

Figs. 18, 19: ***Cardiola alata*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 18: Right valve, GBA 1998/2/459, lateral view, x 3.5.
Fig. 19: Right valve, GBA 1998/2/460a, lateral view, x 3.0.

Figs. 20, 25: ***Isiola zila* sp. n.**
Rauchkofel Boden Section, 25–65 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, holotype, GBA 1998/2/4.
Fig. 20: Antero-lateral view, x 2.1.
Fig. 25: Lateral view, x 1.45.

Figs. 21, 23: ***Isiola zila* sp. n.**
Rauchkofel Boden Section, 0 - 30 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, paratype, GBA 1998/2/3.
Fig. 21: Lateral view of stage III (later stages blocked out), x 3.4.
Fig. 23: Lateral view, x 2.45.

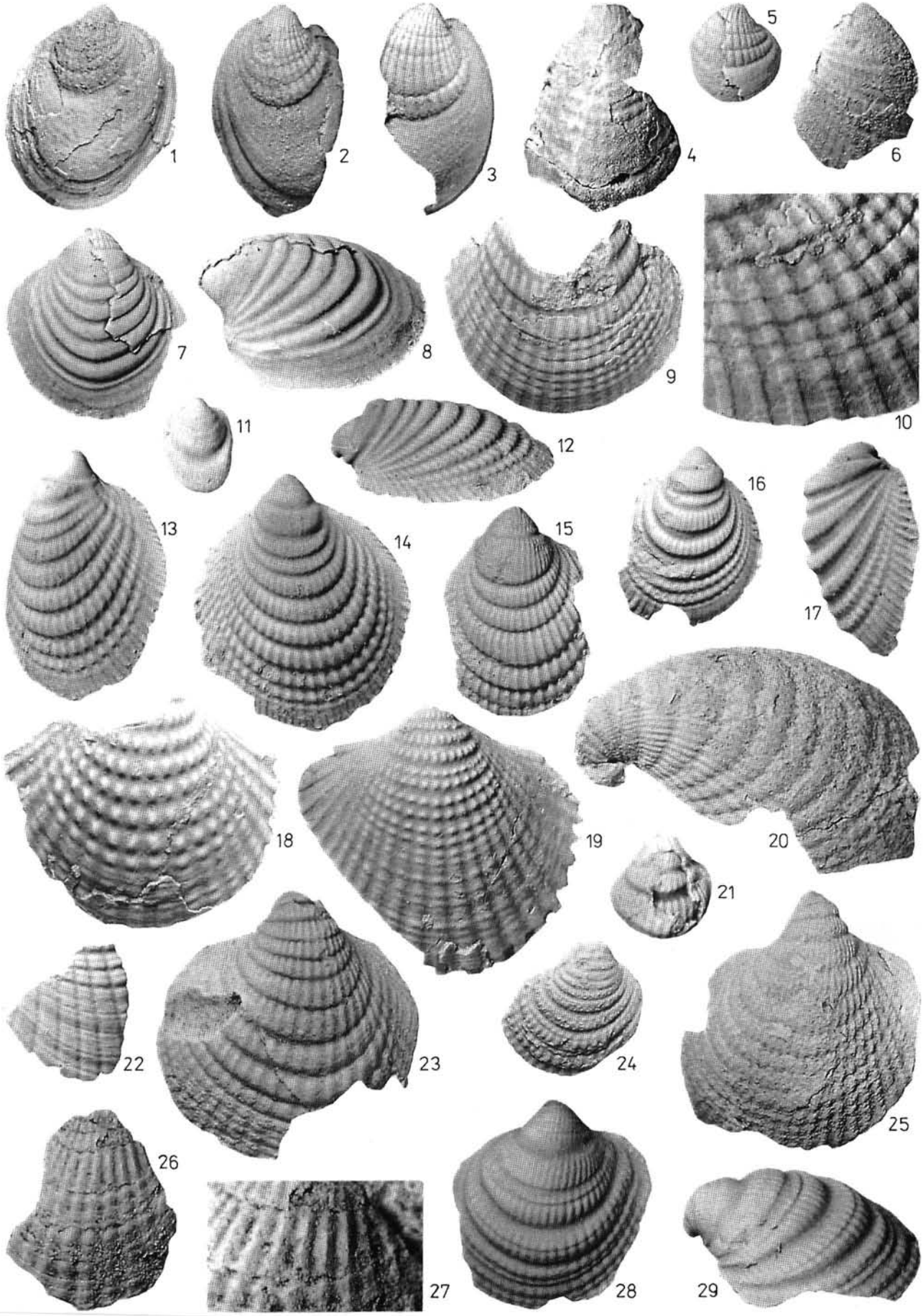
Fig. 22: ***Cardiolinka* cf. *irregularis*** (BARRANDE).
Mt. Cellon, bed no. 33, Alticola Kalk Formation, early Přídolí, right valve – fragment, GBA 1998/2/178, lateral view, x 4.15.

Fig. 24: ***Cardiolinka* cf. *concubina*** (KŘÍŽ).
Rauchkofel Boden Section, bed no. 331, latest Přídolí, left valve, GBA 1998/2/288, lateral view, x 2.7.

Figs. 26, 27: ***Pygolfia* cf. *nina*** (BARRANDE).
Rauchkofel Boden Section, bed no. 331, latest Přídolí, left valve, GBA 1998/2/25.
Fig. 26: Lateral view, x 5.4.
Fig. 27: Detail of radial sculpture, x 9.3.

Figs. 28, 29: ***Cardiolinka bohemica*** (BARRANDE).
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, left valve, GBA 1998/2/27.
Fig. 28: Lateral view, x 3.5.
Fig. 29: Antero-lateral view, x 4.0.

All photos by Jiří Kříž, Czech Geological Survey, Praha.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Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Occurrence: *Cardiola conformis* is a common Silurian representative of the Cardiolidae. The species is dominant in the *Cardiola conformis* Community of the *Cardiola* Community Group (KŘÍŽ, 1998) and occurs in Bohemia in the uppermost Ludlow and in the lowermost Přídolí. In the Carnic Alps *Cardiola conformis* occurs in bed no. 30 (WALLISER, 1964), at the base of the *crispa* Zone, in the Alticola Kalk Formation, upper Ludlow, at the locality Mt. Cellon.

### 3.3.6.11. *Cardiola* cf. *tix* KŘÍŽ, 1979

Pl. 6, Figs. 5, 7, 8

Material: 1 right valve, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/455.

Remarks: The specimen is closely related to *Cardiola tix* KŘÍŽ, 1979 known from the middle Ludlow of Prague Basin, Bohemia. It shows distinctly wide growth bands, generally long shells and a similar type of outer and inner surface sculpture. The specimen is most probably conspecific with *Cardiola tix* but a lack of material makes it impossible to prove this statement.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/455 | II | 4.2 | 3.7 | 1.8 |
| | III | 5.4 | 6.0 | 2.5 |
| | IV | 10.3 | 11.7 | 4.7 |
| | V | 12.4 | 14.0 | 5.2 |

Occurrence: In the Carnic Alps *Cardiola* cf. *tix* occurs in the *Cardiola alata* Community – *Cardiola pectinata* Subcommunity at the locality Base of Seewarte Section (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian.

### 3.3.6.12. *Cardiola eximia* BARRANDE, 1881

Pl. 6, Figs. 9, 10

1881 *Cardiola eximia* BARR. – BARRANDE, pl. 162, figs. V/13–20, pl. 181, figs. X/1–3.
1881 *Cardiola Bohemica* BARR. – BARRANDE, pl. 168, figs. VII/1–3.
1881 *Cardiola plicatissima* BARR. – BARRANDE, pl. 180, figs. IX/1–4.
1979 *Cardiola eximia* BARRANDE – KŘÍŽ, p. 91–92, pl. 27, figs. 2, 3, 5–8.

Lectotype (designated by KŘÍŽ, 1979): Internal mould of a right valve, figured by BARRANDE (1881) on pl. 162, figs. V/13–16, re-figured by KŘÍŽ (1979) on pl. 27, figs. 2, 3, 5–8; deposited in the National Museum, Prague under no. L 7005.

Type horizon and type locality: Silurian, Kopanina Formation, higher levels of the horizon with *Cromus beaumonti,* Ludlow, Bohemia, Prague Basin, Praha – Kosoř.

Material: 1 left valve.

Remarks: Specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

Occurrence: *Cardiola eximia* is a quite rare Silurian representative of the Cardiolidae. The species occurs in the *Cardiola docens* Community and in the *Cardiola alata* Community of the *Cardiola* Community Group (KŘÍŽ, in press a) in the Ludlow, Prague Basin, Bohemia. In the Carnic Alps *Cardiola eximia* occurs in the *Cardiola alata* Community – *Cardiola pectinata* Subcommunity at the locality Base of Seewarte Section (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian.

### 3.3.6.13. *Cardiola pectinata* BARRANDE, 1881

Pl. 6, Figs. 11–17

1881 *Cardiola pectinata* BARR. – BARRANDE, pl. 163, figs. VI/1–12.
1929 *Cardiola carnica* STACHE – HERITSCH, p. 43–44, pl. 4, figs. 392–394.
1979 *Cardiola pectinata* BARRANDE – KŘÍŽ, p. 94–95, pl. 23, figs. 1–9.

Lectotype (designated by KŘÍŽ, 1979): Internal mould of a right valve, figured by Barrande (1881) on pl. 163, figs. VI/1,2, re-figured by KŘÍŽ (1979) on pl. 23, figs. 5–7; deposited in the National Museum, Prague under no. L 7179.

Type horizon and type locality: Silurian, Kopanina Formation, uppermost levels of the horizon with *Cromus beaumonti,* Ludlow, Bohemia, Prague Basin, Praha – Lochkov.

Material: 11 left and 14 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/470 | II | 2.9 | 2.7 | 1.4 |
| | III | 4.4 | 5.1 | 2.0 |
| | IV | 5.8 | 7.1 | 2.6 |
| GBA 1998/2/2a | II | 3.0 | 3.0 | 1.4 |
| | III | 4.1 | 5.1 | 1.8 |
| | IV | 11.5 | 13.8 | 4.5 |
| | V | 13.3 | 14.7 | 4.8 |
| GBA 1998/2/26 | II | 3.2 | 3.2 | 1.5 |
| | III | 4.5 | 5.3 | 1.9 |
| | V | 11.9 | 14.3 | 5.5 |

Occurrence: *Cardiola pectinata* is a quite common Silurian representative of the Cardiolidae. The species is dominant or subdominant in the *Cardiola alata* Community of the *Cardiola* Community Group (KŘÍŽ, 1998a) and occurs in Bohemia most commonly in the upper parts of the upper parts of the horizon with *Cromus beaumonti* (*Neocucullograptus kozlowskii* Zone), higher Ludfordian, Ludlow. In the Carnic Alps *Cardiola pectinata* is dominant in the *Cardiola alata* Community – *Cardiola pectinata* Subcommunity at the locality Base of Seewarte Section (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, and at the locality Mt. Cocco, Italy.

### 3.3.6.14. *Cardiola alata* BARRANDE, 1881

Pl. 6, Figs. 18, 19

1881 *Cardiola alata* BARR. – BARRANDE, pl. 161, figs. III/1–23, pl. 204, figs. II/1–4.
1937 *Cardiola alata* BARRANDE – CHAUBET, p. 169.
1975 *Cardiola alata* BARRANDE – KŘÍŽ & VESELINOVIĆ, p. 368, pl. 1, figs. 3, 5, 9.
1979 *Cardiola alata* BARRANDE – KŘÍŽ, p. 95–97, pl. 24, figs. 1–11, pl. 25, figs. 1–8, pl. XL, fig. 6, text fig. 39.
1993 *Cardiola alata* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, p. 319, pl. 5, fig. 3.
1996 *Cardiola alata* BARRANDE – KŘÍŽ, p. 47, pl. 3, figs. 16, 20.

Lectotype (designated by Kříž, 1979): Internal mould of a right valve, figured by Barrande (1881) on pl. 161, figs. III/19–22, re-figured by Kříž (1979) on pl. 24, figs. 2, 7, 8, 10, 11; deposited in the National Museum, Prague under no. L 6508.

Type horizon and type locality: Silurian, Kopanina Formation, uppermost levels of the horizon with *Cromus beaumonti*, Ludlow, Bohemia, Prague Basin, Praha – Lochkov.

Material: 2 left and 2 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with Barrande's type material.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/460 | III | 3.1 | – | – |
| | IV | 9.6 | 8.8 | 3.1 |
| | V | – | 17.5 | 4.9 |

Occurrence: *Cardiola alata* is a quite common Silurian representative of the Cardiolidae. The species is dominant in the *Cardiola alata* Community of the *Cardiola* Community Group (Kříž, 1998) and occurs in Bohemia most commonly in the upper parts of the horizon with *Cromus beaumonti* (*Neocucullograptus kozlowskii* Zone), higher Ludfordian, Ludlow (Kříž, 1998a). It occurs also in the Montagne Noire, France (Kříž, 1996) and in Sardinia (Kříž & Serpagli, 1993). In the Carnic Alps *Cardiola alata* is subdominant in the *Cardiola alata* Community – *Cardiola pectinata* Subcommunity at the locality Base of Seewarte Section (Schönlaub, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian.

### 3.3.7. Genus *Isiola* Kříž, 1976

Type species – *Isiola lyra* Kříž, 1976

#### 3.3.7.1. *Isiola zila* sp. n.

Pl. 6, Figs. 20, 21, 23, 25

Holotype: Internal mold of left valve, figured herein on pl. 6, figs. 20, 25, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/4.

Paratypes: Other specimens figured herein on pl. 6, figs. 21, 23, and unfigured specimens deposited in the Geologische Bundesanstalt, Vienna under nos. 1998/2/3, 64, 65 a, b, 68 a, b, 69 - 71, 73, 76, 205.

Derivation of name: The specific name is derived from the former Slavic name Zila of the Gail River below the Carnic Alps.

Type horizon and type locality: 0–65 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Homerian, Wenlock, Silurian, Rauchkofel Boden Section, Carnic Alps, Austria.

Material: 8 left valves and 3 right valves.

Diagnosis: *Isiola zila* sp. n. differs from most closely related species *Isiola lyra* Kříž, 1976 by wider radial ribs than radial gutters in stage II, by less convex growth bands and by a distinctly wider umbonal part in the stage IV.

Description: Stage II (Kříž, 1979): Valve subcircular in outline, opisthocline, obese; posterior slope of the valve slightly steeper than anterior slope. Umbones prominent, in central position, beaks prosogyrate. Cardiolid sculpture of outer surface sculpture consists of distinct, moderately convex and regularly spaced growth bands combined with more prominent wide radial ribs. The width of radial gutters is much smaller than width of the radial ribs; they are deeper than growth furrows. Inner surface sculpture coarser. Shell thickness is 0.1–0.31 mm. Other features unknown.

Stage III: Developed as first wide growth band after narrow growth bands of stage II; there is no distinct change of the commissural angle developed between stage II and III. Swollen band asymmetrical, anterior part larger than posterior part. Valve opisthocline, broadly ovate, obese. Umbones formed by stage II are prosogyrate. Outer and inner surface with distinct, convex radial ribs almost of the same width like radial gutters. Inner surface sculpture coarser. Shell thickness is 0.14 mm. Other features unknown.

Stage IV: Valve opisthocline, broadly ovate, obese; the width equals 70–74 % the height of the shell. Umbones in central position, prosogyrate. Anterior slope steeper than posterior slope of the valve. Radial ribs (34–35 in number) relatively narrow, anteriorly curved. The ratio of the width of radial ribs to that of radial gutters is 1:1. Both the radial ribs and gutters broaden ventrally. Growth bands wide, broader than radial ribs, moderately convex, regularly spaced. Shell thickness is 0.17–0.35 mm. Other features unknown.

Stage V: Ventral band well developed. Radial ribs and gutters of the same type as in stage IV. Growth bands weak, narrow, regularly spaced. Other features unknown.

Remarks: *Isiola zila* sp. n. is most closely related to the contemporary species *Isiola lyra* known from the Prague Basin, Bohemia. Sardinia and Montagne Noire. Both species were most probably adapted to byssate infaunal or semi-infaunal mode of life.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/3 | II | 2.5 | 2.5 | 1.0 |
| | III | 3.1 | 3.1 | 1.2 |
| | IV | 9.6 | 10.6 | 3.7 |
| | V | 21.4 | 20.2 | 7.3 |
| GBA 1998/2/4 | IV | 26.7 | 28.4 | 10.5 |
| | V | – | 33.0 | 11.7 |
| GBA 1998/2/6 | V | – | 34.0 | 11.2 |

Occurrence: *Isiola zila* sp. n. is known only from the type locality.

### 3.3.8. Genus *Cardiolinka* Kříž, 1981

Type species – *Cardiolita bohemica* (Barrande, 1881)

Remarks: The genus Cardiolinka represents most probably infaunal Cardiolidae which occur from the Ludlow to uppermost Přídolí mainly within the Gondwana and Perunica regions.

#### 3.3.8.1. *Cardiolinka bohemica* (Barrande, 1881)

Pl.6, Figs. 28, 29, Fl. 7, Figs. 1–3

1881 *Cardiola Bohemica* Barr. – Barrande, pl. 164, figs. IV/19–22; pl. 168, figs. I/5, 6, II/3–4, III/1–6, IV/ 1, 2, V/3, 4, VI/3, 4, VIII/1, 2, X/1, 2, XI/1–4, XII/1, 2; pl. 169, figs. 1–5, 14–23, 26–28, 31/38; pl. 170, figs. 8–20.

1979 *Cardiolita bohemica* (Barrande) – Kříž, p. 106–110, pl. 32, figs. 1–10; pl. 39, figs. 1–3, 5–11; pl. 40, fig. 7, text-figs. 41, 42 (for complete previous synonymy see this paper).

1996 *Cardiolita bohemica* (Barrande) – Kříž, p. 48, pl. 4, figs. 7, 12, 16.

Lectotype (designated by Kříž, 1974b): Internal mould of a

## Plate 7

Figs. 1–3: ***Cardiolinka bohemica*** (BARRANDE).
Mt. Cellon, bed no. 32, Alticola Kalk Formation, earliest Přídolí, right valve, GBA 1998/2/5.
Fig. 1: Lateral view, x 1.8.
Fig. 2: Dorsal view, x 2.1.
Fig. 3: Postero-lateral view, x 2.2.

Figs. 4, 6: ***Slava fibrosa*** (SOWERBY in MURCHISON).
Rauchkofel Boden Section, 0–30 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, GBA 1998/2/290.
Fig. 4: Lateral view, x 2.05.
Fig. 6: Dorso-lateral view, x 2.45.

Figs. 5, 7, 9, 10: ***Slava fibrosa*** (SOWERBY in MURCHISON).
Rauchkofel Boden Section, 65–105 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock.
Fig. 5: Right valve, CGS JK 3393, lateral view, x 1.35.
Fig. 7: Right valve, CGS JK 3393, detail of posterior sculpture, x 3.25.
Fig. 9: Left valve, CGS JK 3394a, postero-lateral view, x 1.7.
Fig. 10. Left valve, CGS JK 3394a, lateral view, x 1.7.

Figs. 8, 12, 16: ***Slava pelerina*** KŘÍŽ.
Rauchkofel Boden Section, 0–40 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, right valve, GBA 1998/2/39a.
Fig. 8: Posterior view, x 1.9.
Fig. 12: Detail of postero-ventral margin, x 4.2.
Fig. 16: Lateral view, x 1.85.

Figs. 11, 13, 14: ***Slava pelerina*** **Kříž**.
Rauchkofel Boden Section, 41–64 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, GBA 1998/2/36.
Fig. 11: Posterior view, x 1.9.
Fig. 13: Dorsal view, x 2.7.
Fig. 14: Lateral view, x 1.35.

Fig. 15: ***Slavinka elevata*** (BARRANDE).
Mt. Cocco, Kok Formation, Ludlow, left valve, GBA 1929/1/64, ventro-lateral view, x 5.3. (For lateral view and antero-lateral view see Pl. 8, Figs. 1,2).

Figs. 17, 18, 19, 21 : ***Slava pelerina*** **Kříž**.
Rauchkofel Boden Section, 0–40 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock.
Fig. 17: Left valve, GBA 1998/2/60, postero-lateral view, x 1.6.
Fig. 18: Left valve, GBA 1998/2/60, lateral view, x 1.35.
Fig. 19: Left valve, GBA 1998/2/57, postero-lateral view, x 2.0.
Fig. 21: Left valve, GBA 1998/2/55a, antero-lateral view. X 1.7.

Figs. 20, 22, 24, 26–28: ***Slavinka*** **aff. *damona*** **Kříž**.
Rauchkofel Boden Section, 260 cm above the Silurian base, Kok Formation, Ludlow.
Fig. 20: Left valve, CGS JK 3390, dorso-lateral view, x 2.05.
Fig. 22: Left valve, CGS, JK 3402, posterior view of the stage III, later stages blocked out), x 5.3.
Fig. 24: Left valve, CGS, JK 3402, lateral view, 2.05.
Fig. 26: Left valve, CGS, JK 3402, anterior view, x 1.9.
Fig. 27: Left valve, CGS JK 3390, lateral view, x 2.75.
Fig. 28: Left valve, CGS, JK 3402, detail of anterior margin, x 9.6.

Fig. 23: ***Slava*** **cf. *sathon*** **Kříž**.
Rauchkofel Boden Section, 65–105 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, GBA 1998/2/50, lateral view, x 1.65.

Fig. 25: ***Slava pelerina*** **Kříž**.
Rauchkofel Boden Section, 25–65 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, CGS JK 3400, detail of outer sculpture, x 3.05.

All photos by Jiří KŘÍŽ, Czech Geological Survey, Praha.

left valve figured by Barrande (1881) on pl. 169, figs. 16–19, re-figured by KŘÍŽ (1979) on pl. 32, figs. 4, 7, 10; deposited in the National Museum, Prague under no. L 6874.

Type horizon and type locality: Silurian, Přídolí, *Monograptus parultimus* Zone, Bohemia, Prague Basin, Dlouhá hora Hill near Beroun.

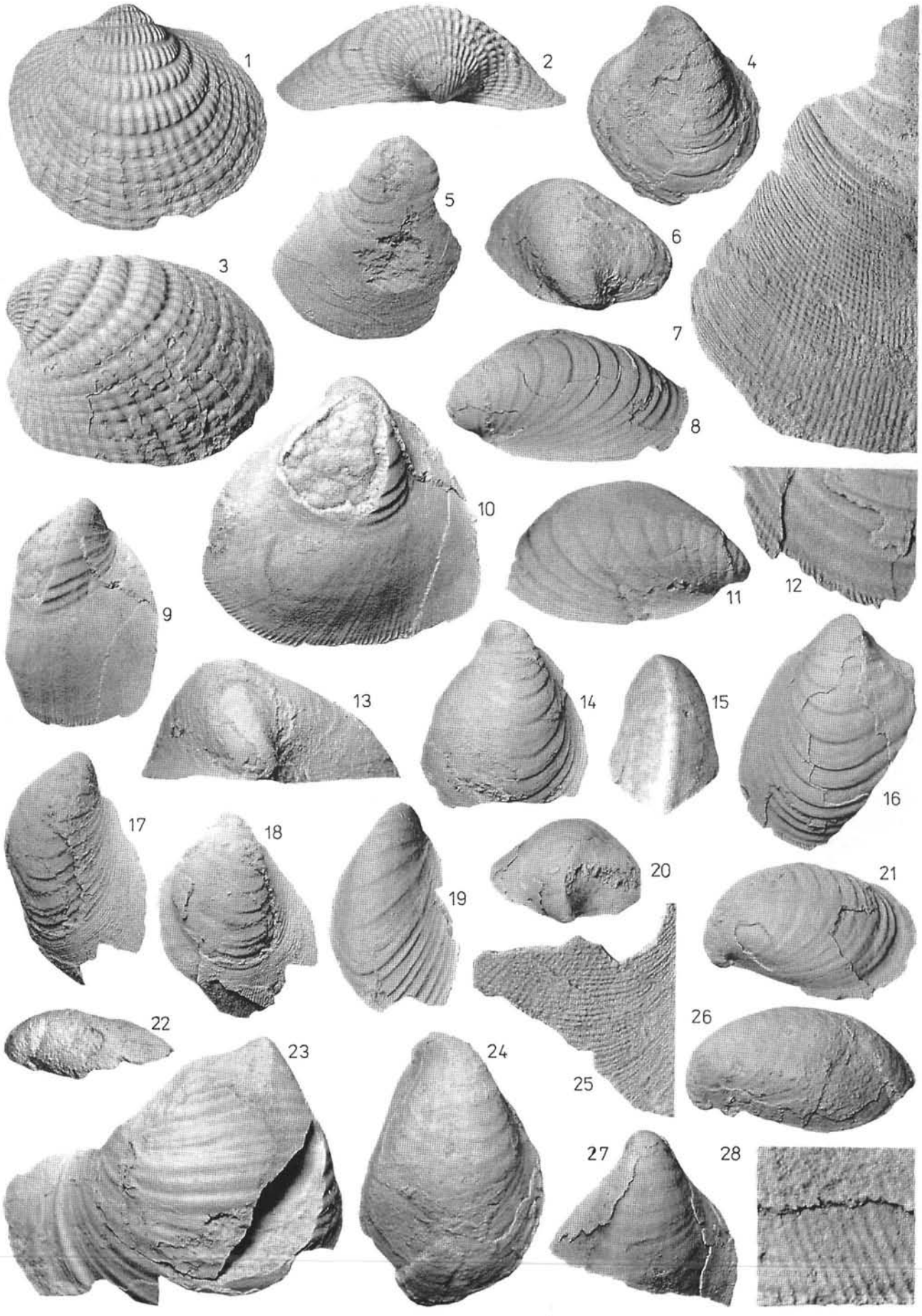
Material: 4 left and 4 right valves, numerous juveniles.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/5 | IV | 18.0 | 16.6 | 7.4 |
| | V | 26.6 | 23.8 | 9.4 |

Occurrence: *Cardiolinka bohemica* is a common Silurian representative of the Cardiolidae. The species is dominant in the *Cardiolinka bohemica* Community of the *Cardiola* Community Group (KŘÍŽ, 1998) which occurs in the Carnic Alps at the locality Mt. Cellon, bed no. 32 (WALLISER,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1964), base of the Přídolí, Alticola Kalk, *Monograptus parultimus* Zone (uppermost *crispa* Zone). The species occurs also at numerous Ludlow and lower Přídolí localities in the Prague Basin, Bohemia (Kříž, 1979) and in the Montagne Noire, France (Kříž, 1996). *Cardiolinka bohemica* Community with dominant *Cardiolinka bohemica* occurs in Bohemia exclusively at the base of the Přídolí within the *Monograptus parultumus* Zone. This is important for the correlation with the Mt. Cellon Section, since *Cardiolinka bohemica* Community occurs here in bed no. 32, just below the occurrence of *Monograptus parultimus* (Jaeger, 1975) and the Ludlow–Přídolí boundary should be placed at the base of bed no. 32 and not above bed no. 32 (Schönlaub, 1985). *Cardiolinka bohemica* has been also found in bed no. 33, upper Ludlow, at the locality Base of Seewarte Section (Schönlaub, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, and at the locality Rauchkofel Boden Section, in upper Přídolí.

#### 3.3.8.2. *Cardiolinka* cf. *irregularis* (Barrande, 1881)

Pl. 6, Fig. 22

Material: 1 right valve.

Remarks: Only a small fragment of the posterior ventral part is preserved showing typical sculpture for *Cardiolinka irregularis*. As the whole shell is not preserved I cannot be sure that it is conspecific with Barrande's types.

Occurrence: *Cardiolinka irregularis* occurs abundantly in the lowermost Přídolí of the Prague Basin, Bohemia. In the Carnic Alps *Cardiolinka* cf. *irregularis* occurs in bed no. 33, Alticola Kalk, lower Přídolí at the locality Mt. Cellon.

#### 3.3.8.3. *Cardiolinka* cf. *concubina* (Kříž, 1979)

Pl. 6, Fig. 24

Material: 1 left valve.

Remarks: The specimen is related to *Cardiolinka concubina* by very similar surface sculpture, especially by the development of growth bands. They are divided into two unequal parts by a shallow growth furrow; the ventral part being usually larger. The umbonal part is too poorly preserved to compare the general shape which is characteristic of *Cardiolinka concubina*.

| Dimensions (in mm) | | | | |
|---|---|---|---|---|
| specimen | stage | length | height | width/2 |
| 1998/2/288 | IV | 8.8 | 9.3 | 4.2 |

Occurrence: *Cardiolinka concubina* occurs abundantly in the upper Přídolí of the Prague Basin, Bohemia (Kříž, 1988, in press a), in Massif Armoricain (Kříž & Paris, 1982), in Poland (Korejwo & Teller, 1964) and in eastern Serbia (Kříž & Veselinović, 19975). In the Carnic Alps *Cardiolinka* cf. *concubina* occurs in bed no. 331, uppermost Přídolí, at the Rauchkofel Boden Section.

### 3.3.9. Genus *Pygolfia* Kříž, 1974

Type species – *Cardiola Nina* Barrande, 1881

#### 3.3.9.1. *Pygolfia* cf. *nina* (Barrande, 1881)

Pl. 6, Figs. 26, 27

Material: 1 left valve.

Remarks: The specimen is closely related to *Pygolfia nina* by very similar surface sculpture, especially by the triangular cross-section of radial ribs and moderately inflated shells. *Pygolfia* cf. *nina* differs only by slightly more opisthocline shells. Umbonal part is poorly preserved.

Occurrence: *Pygolfia nina* occurs locally abundantly in the upper Přídolí of the Prague Basin, Bohemia (Kříž, in press a). In the Carnic Alps *Pygolfia* cf. *nina* occurs in bed no. 331, uppermost Přídolí, at the Rauchkofel Boden Section.

## 3.4 Family Slavidae Kříž, 1982

### 3.4.1. Genus *Slava* Barrande, 1881

Type species – *Slava bohemica* Barrande, 1881

#### 3.4.1.1. *Slava fibrosa* (Sowerby in Murchison, 1839)

Pl. 7, Figs. 4–7, 9, 10

1839 *Cardiola fibrosa* – Sowerby in Murchison, p. 617, pl. 8, fig. 4.

1985 *Slava fibrosa* (Sowerby in Murchison) – Kříž, p. 63–66, pl. 3, figs. 1–7, pl. 4, figs. 1–8; text-figs. 4, 8 (for complete previous synonymy see this paper).

1993 *Slava fibrosa* (Sowerby in Murchison) – Kříž in Kříž & Serpagli, p. 325, pl. 7, figs. 10–11, 14–16.

1996 *Slava fibrosa* (Sowerby in Murchison) – Kříž, p. 49, pl. 4, figs. 9, 15, 17, 19, 22–24.

Lectotype (designated by Kříž, 1985): Composite mould of a left valve figured by Sowerby in Murchison (1939) on pl. 8, fig. 4 (the specimen on the right), re-figured by Kříž (1985) on pl. 3, fig. 4; deposited in the British Geological Survey Museum, London under no. 6652.

Type horizon and type locality: Silurian, Ludlow, *Neodiversograptus nilssoni – M. tumescens* Zones, Great Britain, Wistanstow.

Material: 3 left and 3 right valves. Another 5 left valves are assigned as *Slava* and with the material described by Kříž (1985).

Remarks: Specimens from the Carnic Alps are conspecific with Kříž's type material (1985).

| Dimensions (in mm) | | | | |
|---|---|---|---|---|
| specimen | stage | length | height | width/2 |
| GBA 1998/2/41 | II | 2.3 | 2.7 | 0.8 |
| | III | 5.4 | 6.9 | 1.5 |
| | IV | 10.0 | 11.2 | 3.9 |
| GBA 1998/2/290 | IV | 14.0 | 16.2 | 4.4 |
| CGS JK 3394a | IV | 14.9 | 16.7 | – |
| | V | 30.4 | 29.7 | – |
| CGS JK 3395a | IV | 17.5 | 22.8 | – |
| | V | 23.6 | 25.8 | – |

Occurrence: *Slava fibrosa* is a common Silurian representative of the Slavidae. The species is abundant in the *Cardiola agna* Community and in the *Cardiola gibbosa* Community (Kříž, in press a) in Bohemia, Prague Basin. For occurrences apart from Bohemia see Kříž (1985). In the Carnic Alps *Slava fibrosa* occurs at the locality Rauchkofel Boden Section, 0–105 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Home-rian, Wenlock and at the locality Mt. Cocco, in the Kok Formation, Wenlock. *Slava* cf. *fibrosa* has been found at the same localities.

#### 3.4.1.2. *Slava pelerina* Kříž, 1985

Pl. 7, Figs. 8, 11–14, 16–19, 21, 25

1985 *Slava pelerina* Kříž – Kříž, p. 61–63, pl. 2, figs. 1–7.
1987 *Slava novaterra* n. sp. – Pojeta & Norford, p. 515, figs. 5/1–6.
1993 *Slava pelerina* Kříž – Kříž in Kříž & Serpagli, p. 324–325, pl. 7, figs. 13, 17–20.

Holotype (designated by Kříž, 1985): Internal mould of conjoined shell figured by Kříž (1985) on pl. 2, figs. 1, 2, 6; deposited in the Czech Geological Survey, Prague under no. JK 3172.

Type horizon and type locality: Silurian, Ludlow, *Cyrtograptus lundgreni* Zone, *Testograptis testis* Subzone, Motol Formation, Wenlock, Bohemia, Prague Basin, Praha – Řeporyje, Arethusina Gorge locality.

Material: 17 left and 8 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with Kříž's type material (1985).

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/60 | IV | 15.0 | 21.6 | 5.8 |
| CGS JK 3400 | IV | 17.9 | 22.9 | 7.0 |
| GBA 1998/2/36 | IV | 18.9 | 23.0 | 6.9 |
| CGS JK 3399 | V | 28.0 | 31.8 | – |
| CGS JK 3401 | V | – | 39.7 | – |

Occurrence: *Slava pelerina* is common Silurian representative of the Slavidae. The species is abundant in the *Cardiola agna* Community and rare in the *Cardiola gibbosa* Community (Kříž, in press a) in Bohemia, Prague Basin. The species is also abundant in the *Cardiola figusi* (*Cardiola agna figusi*) Community described from the upper Wenlock – lower Ludlow, Sardinia (Kříž in Kříž & Serpagli, 1993) and in the uppermost Wenlock, Canada, Arctic Archipelago, Cornwallis Island (Pojeta & Norford, 1987). In the Carnic Alps *Slava pelerina* is dominant in the *Slava pelerina* Subcommunity at the locality Rauchkofel Boden Section, 0–65 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Homerian, Wenlock and at the locality Mt. Cocco, in the Kok Formation, Wenlock.

#### 3.4.1.3. *Slava* cf. *sathon* Kříž, 1985
Pl. 7, Fig. 23

Material: 1 right valve.

Remarks: This deformed specimen is closely related to *Slava sathon* by the size, numerous growth bands, steep anterior slope and prosocline adult shells. Umbonal part and most of ventral part is not preserved.

Occurrence: *Slava sathon* occurs in upper Wenlock and lower Ludlow of the Prague Basin, Bohemia (Kříž, 1985) and in the Montagne Noire (Kříž, 1996). In the Carnic Alps *Slava* cf. *sathon* occurs at the locality Rauchkofel Boden Section, 65–105 cm above the base of the "Orthoceras" limestone (Kok Formation), upper Wenlock and at the locality Mt. Cocco.

### 3.4.2. Genus *Slavinka* Kříž, 1982
Type species – *Slava acuta* Barrande, 1881

#### 3.4.2.1. *Slavinka* aff. *damona* Kříž, 1985
Pl. 7, Figs. 20, 22, 24, 26–28

1929 *Gloria (Slava) discrepans* Barr. – Heritsch, p. 44, pl. 4, figs. 444–446.
1929 *Gloria (Slava) imperficiens* Barr. – Heritsch, p. 45, pl. 3, figs. 283–285.

Material: 4 left valves and 1 right valve.

Remarks: The specimens are closely related to *Slavinka damona* by the similar shape of the shell. *Slavinka* aff. *damona* differs by well developed and by almost regularly spaced growth bands and by the wider umbonal part. The specimens may represent the ancestral form of the species *Slavinka damona*.

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| CGS JK 3390 | II | 1.4 | 1.2 | 0.5 |
| | III | 2.9 | 3.3 | 0.9 |
| | IV | 9.7 | 11.5 | 4.1 |
| CGS JK 3402 | IV | 15.8 | 22.8 | 6.9 |

Occurrence: *Slavinka damona* is a relatively rare Silurian, lower Ludlovian representative of the Slavidae in the Prague Basin (Kříž, 1985). In the Carnic Alps *Slavinka* aff. *damona* occurs in the *Cardiola consanguis* Community at the locality Rauchkofel Boden Section, 260 cm above the base of the "Orthoceras" limestone (Kok Formation), Ludlow and at the locality Mt. Cocco, in Ludlow, Cardiola Formation?.

#### 3.4.2.2. *Slavinka cubula* Kříž, 1985
Pl. 8, Figs. 6–8

1985 *Slavinka cubula* sp. n. – Kříž, p. 88–89, pl. 15, figs. 1–5, 8. 11.

Holotype (designated by Kříž, 1985): Internal mould of a left valve with recrystallized fragments of the shell figured by Kříž (1985) on pl. 15, figs. 1–5, 11; deposited in the Czech Geological Survey, Prague under no. JK 3040.

Type horizon and type locality: Silurian, Ludlow, *Saetograptus linearis* Zone, Kopanina Formation, Ludlow, Bohemia, Lištice near Beroun, left bank of the Berounka River.

Material: 1 left valve. Another incomplete right valve is assigned as *Slavinka* aff. *cubula* (pl. 8, figs. 3–5).

Remarks: The specimen from the Carnic Alps is conspecific with Kříž's type material (1985). The specimen of *Slavinka* aff. *cubula* (GBA 4955) differs from the types by a larger stage III and generally not so obese shells.

| Dimensions (in mm) specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| GBA 1998/2/38 | II | 2.4 | 2.4 | 0.7 |
| | III | 3.2 | 4.5 | 1.3 |
| | IV | 5.9 | 8.0 | 2.4 |

Occurrence: *Slavinka cubula* is a rare Silurian representative of the Slavidae. The species occurs in the Ludlow of the Prague Basin, Bohemia (Kříž, 1985). In the Carnic Alps *Slavinka cubula* occurs in the *Cardiola consanguis* Community at the locality Rauchkofel Boden Section, 260 cm above the base of the "Orthoceras" limestone (Kok Formation), Ludlow.

#### 3.4.2.3. *Slavinka elevata* (Barrande, 1881)
Pl. 7, Fig. 15, Pl. 8, Figs. 1, 2

1881 *Hemicardium elevatum* Barr. – Barrande, pl. 244, figs. VII/1–8.
1929 *Patrocardium elevatum* Barr. – Heritsch, p. 37, pl. 4, figs. 441–443.

## Plate 8

Figs. 1, 2: ***Slavinka elevata*** (BARRANDE).
Mt. Cocco, Kok Formation, Ludlow, left valve, GBA 1929/1/64
Fig. 1: Lateral view, x 6.4.
Fig. 2: Antero-lateral view, x 5.7. (For ventro-lateral view see Pl. 7, Fig. 15).

Figs. 3–5: ***Slavinka* cf. *cubula*** KŘÍŽ.
Mt. Cocco, Kok Formation, Ludlow, right valve, GBA 4955.
Fig. 3: Lateral view, x 2.05.
Fig. 4: Postero-lateral view, x 3.15.
Fig. 5: Detail of posterior margin sculpture, x 8.25.

Figs. 6–8: ***Slavinka cubula*** KŘÍŽ.
Rauchkofel Boden Section, 260 cm above the Silurian base, Kok Formation, Ludlow, left valve, GBA 1998/2/38.
Fig. 6: Lateral view, x 2.15.
Fig. 7: Dorso-lateral view, x 2.3.
Fig. 8: Anterior view, x 2.1.

Fig. 9: ***Mila complexa*** BARRANDE.
Mt. Cocco, Cardiola Formation, Ludlow, left valve, GBA 1998/2/302, lateral view, x 3.4.

Fig. 10, 17, 22: ***Mila complexa*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow.
Fig. 10: Right valve, GBA 1998/2/381a, dorso-lateral view, x 1.7.
Fig. 17: Right valve, GBA 1998/2/378, lateral view, x 2.05.
Fig. 22: Right valve, GBA 1998/2/381a, lateral view, x 2.6.

Fig. 11: ***Maminka comata*** BARRANDE.
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, CGS JK 3811a, lateral view, x 3.2.

Fig. 12: ***Maminka comata*** BARRANDE.
Rauchkofel Boden Section, 14–33 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, CGS JK 3812, lateral view, x 1.55.

Fig. 13: ***Maminka comata*** BARRANDE.
Rauchkofel Boden Section, 0–30 cm above the Silurian base, Kok Formation, lower Homerian, Wenlock, left valve, CGS JK 3823a, lateral view, x 2.35.

Fig. 14: **Ambonychiidae gen. et sp. indet.**
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, right valve, GBA 1998/2/395, lateral view, x 5.2.

Figs. 15, 18, 19, 27: ***Mila janina* sp. n.**
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 15: Right valve, paratype, GBA 1998/2/439, detail of outer surface sculpture in anterior, x 7.9.
Fig. 18: Right valve, paratype, GBA 1998/2/440, lateral view, x 2.7.
Fig. 19: Right valve, paratype, GBA 1998/2/440, detail of posterior part with adductor muscle scar, x 6.5.
Fig. 27: Right valve, paratype, GBA 1998/2/439, lateral view, x 5.75.

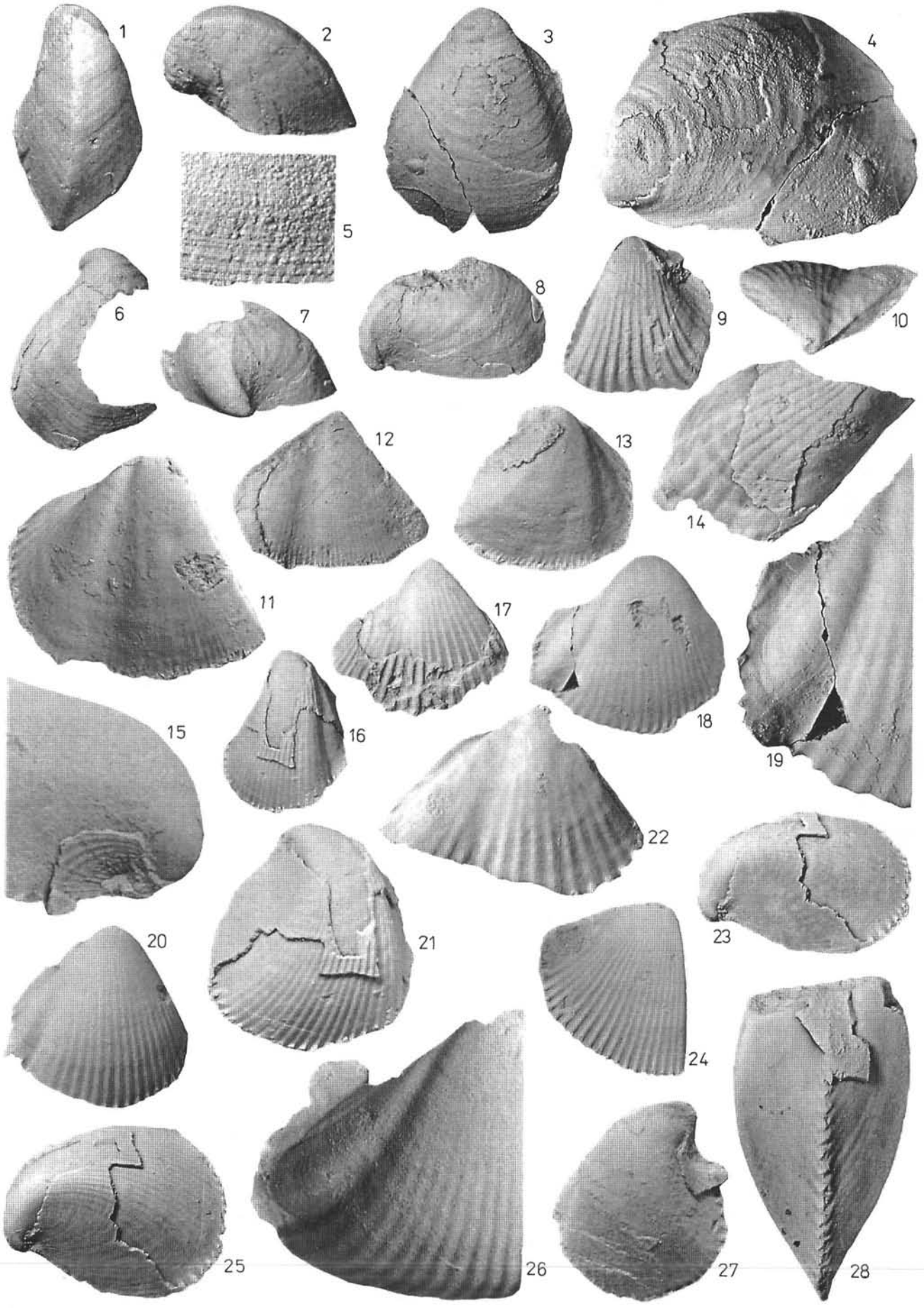
Figs. 16, 21, 23, 25: ***Mila janina* sp. n.**
Mt. Cellon, bed no. 23, Cardiola Formation, Ludlow, left valve, paratype, GBA 1998/2/482.
Fig. 16: Postero-lateral view, x 4.7.
Fig. 21: Lateral view, x 6.3.
Fig. 23: Antero-lateral view, x 5.2.
Fig. 25: Antero-lateral view (different angle of light), x 5.55.

Figs. 20, 26: ***Mila janina* sp. n.**
Mt. Cellon, bed no. 23a, Cardiola Formation, Ludlow, right valve, holotype, GBA 1998/2/258.
Fig. 20: Lateral view, x 3.3.
Fig. 26: Detail of posterior part with adductor muscle scar, x 6.15.

Fig. 24: ***Spanila aspirans*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, right valve, GBA 1998/2/451a, lateral view, x 2.45. (For antero-lateral view see Pl. 9, Fig. 2).

Fig. 28: ***Spanila aspirans*** BARRANDE.
Mt. Cocco, Kok Formation, Ludlow, shell with conjoined valves, GBA 4927, anterior view, x 5.6. (For left lateral view see Pl. 9, Fig. 3).

All photos by Jiří Kříž, Czech Geological Survey, Praha.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1982 *"Hemicardium" elevatum* BARRANDE – KŘÍŽ & PARIS, p. 403, pl. 3, fig. 10.
1985 *Slavinka elevata* (Barrande) – Kříž, p. 95–97, pl. 19, figs. 1–15, text-fig. 3a.

Lectotype (designated by KŘÍŽ, 1985): Internal mould of a left valve with recrystallized fragments of the shell figured by BARRANDE (1881) on pl. 244, figs. VII/5–8 and re-figured by KŘÍŽ (1985) on pl. 19, fig. 10; deposited in the National Museum, Prague under no. L 18 094.

Type horizon and type locality: Silurian, Ludlow, upper parts of the horizon with *Cromus beaumonti*, Kopanina Formation, Ludlow, Bohemia, Kosoř near Praha – Radotín.

Material: 1 left valve.

Remarks: The specimen from the Carnic Alps is conspecific with KŘÍŽ'S type material (1985).

Dimensions (in mm)

| specimen | stage | length | height | width/2 |
|---|---|---|---|---|
| 1929/1/64 | IV | 3.7 | 6.4 | 3.1 |

Occurrence: *Slavinka elevata* is a quite rare Silurian representative of the Slavidae in the Ludfordian, Ludlow in the Prague Basin, Bohemia (KŘÍŽ, 1985) and in France, Massif Armoricain at the la Meignanne locality, Ludfordian, Ludlow, together with ostracode *Entomis migrans* (KŘÍŽ & PARIS, 1982). In the Carnic Alps *Slavinka elevata* occurs at the Mt. Cocco locality in the Kok Formation, Ludlow.

## Superfamily Ambonychiacea S. A. MILLER, 1887

### 3.5. Family Ambonychiidae S. A. MILLER, 1887

#### 3.5.1. Ambonychiidae gen. et sp. indet.

Pl. 8, Fig. 14

Material: 1 right valve (GBA 1998/2/395).

Remarks: Probably representative of the family. Only the general mytiliform shape and coarse, broad, wavy radial ribs and thin shell are preserved. Umbonal part not known.

Occurrence: The specimen was found in Layer no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Mt. Cellon, Austria.

### 3.6. Family Lunulacardiidae FISCHER, 1887

#### 3.6.1. Genus *Maminka* Barrande, 1881

Type species – *Maminka comata* BARRANDE, 1881

Remarks: The genus *Maminka* is very closely related to the genus *Mila* from which it differs by the distinct deep sulcus near the middle of the upper valve and by fine radial ribs. It shows adaptation to a semi-infaunal mode of life on the relatively firm surface of the bottom and enantiomorphous shells (KŘÍŽ in KŘÍŽ & SERPAGLI, 1993).

##### 3.6.1.1. *Maminka comata* BARRANDE, 1881

Pl. 8, Figs. 11–13

1881 *Maminka comata* BARR. – BARRANDE, pp. 105–106, pl. 183, figs. VII/1–6; pl. 186, figs. I/1–34.
1881 *Maminka rarissima* BARR. – BARRANDE, pp. 105–106, pl. 186, figs. 1–10.
1881 *Maminka tenax* BARR. – BARRANDE, pp. 105–106, pl. 183, figs. VI/3–9; pl. 187, figs. 1–36; pl. 279, figs. 6–11.
1881 *Mila Arachne* BARR. – BARRANDE, pl. 216, figs. III/1–2.
1881 *Mila innotata* BARR. – BARRANDE, pl. 216, figs. IV/1–5.
1909 *Maminka italica* n. f. – GORTANI & VINASSA DE REGNY, p. 195, pl. 1, figs. 12a-c.
1937 *Maminka comata* BARR. – CHAUBET, p. 166, pl. VI, fig. 3.
1969 *Maminka comata* – NEWELL & LA ROCQUE, p. N295, figs. C32/3a–3c.
1984 *Maminka* sp. - LILJEDAHL, p. 73–78, figs. 32–34.
1993 *Maminka comata* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, p. 328, pl. 8, figs. 3–12.
1996 *Maminka comata* BARRANDE – KŘÍŽ, p. 51, pl. 5, figs. 15,19, 20, 24–26.

Lectotype: Chosen by RŮŽIČKA & PRANTL 1960. Incomplete shell with conjoined valves figured by Barrande 1881 on pl. 186/I, figs. 14–19, deposited in the National Museum, Prague under the number L 20 125.

Type horizon and type locality: Silurian, Ludlow, lower Gorstian, Kopanina Formation, *Colonograptus colonus* Zone (*Neodiversograptus nilssoni* Zone), Bohemia, Prague Basin, Praha – Butovice, Na břekvici Section no. 584 (KŘÍŽ, 1992).

Material: 7 left valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| CGS JK 3811a | 16.2 | 13.7 | 2.8 |
| CGS JK 3823a | 14.4 | 12.7 | 3.7 |

Occurrence: *Maminka comata* is abundant in the *Cardiola agna* Community and in the *Cardiola gibbosa* Community (KŘÍŽ, in press a) in Bohemia, Prague Basin. For occurrences apart from Bohemia see KŘÍŽ & SERPAGLI (1993) and KŘÍŽ (1996). In the Carnic Alps *Maminka comata* occurs rarely at the locality Mt. Cellon in bed no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Rauchkofel Boden Section, 0–40 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Homerian, Wenlock, 195–225 cm above the base of the "Orthoceras" limestone (Kok Formation), Gorstian?, Ludlow and at the locality Mt. Pal Picolo.

#### 3.6.2. Genus *Mila* BARRANDE, 1881

Type species – *Mila complexa* BARRANDE, 1881 (designated by NEWELL & LA ROCQUE, 1969, see KŘÍŽ in KŘÍŽ & SERPAGLI, 1993)

Remarks: The genus *Mila* is very closely related to the genus *Maminka* from which it differs by the distinct sulcus near the wing like posterior end of the upper valve and by coarse radial ribs. It also shows the same kind of adaptation to the semi-infaunal or reclining mode of life on the relatively firm surface of the bottom and enantiomorphous shells (KŘÍŽ in KŘÍŽ & SERPAGLI, 1993).

##### 3.6.2.1. *Mila complexa* BARRANDE, 1881

Pl. 8, Figs. 9, 10, 17, 22

1881 *Mila complexa* BARR. – BARRANDE, p. 106, pl. 216, figs. I/1–16.

1881 *Mila opposita* BARR. – BARRANDE, pl. 216, figs. II/1–9.
1881 *Lunulicardium residuum* BARR. – BARRANDE, pl. 243, figs. IV/1–5.
1929 *Lunulicardium rostrum* BARR. – HERITSCH, p. 37, pl. 4, figs. 423–427.
1969 *Mila complexa* – NEWELL & LA ROCQUE, p. N296–N297, figs. C32/10a–10b.
1996 *Mila opposita* BARRANDE – KŘÍŽ, p. 51, pl. 6, figs. 8, 9.

Lectotype: (designated herein). Shell with conjoined valves figured by BARRANDE 1881 on pl. 216, figs. I/1–8, deposited in the National Museum, Prague under the number L 21 795.

Type horizon and type locality: Silurian, Ludlow, Ludfordian, Kopanina Formation, Bohemia, Prague Basin, Dlouhá Hora near Beroun.

Material: Shell inclined to the right (2 right valves and 1 left valve); *shell inclined to the left* (5 *right valves*, 3 *left* valves).

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/302 | – | 9.0 | 3.1 |
| GBA 1998/2/381a | 20.7 | 15.4 | 3.9 |

Occurrence: *Mila complexa* is a quite common Silurian representative of the Lunulacardiidae. The species is common in the *Cardiola alata* Community of the *Cardiola* Community Group (KŘÍŽ, 1998) and occurs in Bohemia in the upper parts of the horizon with *Cromus beaumonti* (*Neocucullograptus kozlowskii* Zone), Ludlow. In the Carnic Alps *Mila complexa* occurs rarely in the *Cardiola consanguis* Community at the locality Rauchkofel Boden Section 260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow. It also occurs in the higher *Cardiola docens* Community in the Cardiola Formation, lower Ludfordian at the localities Mt. Cellon (bed no. 20), Mt. Cocco, and abundantly at Rauchkofel Boden Section. At the Base of Seewarte Section (SCHÖNLAUB, 1980) *Mila complexa* occurs in the *Cardiola pectinata* Subcommunity in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, lower Ludlow.

### 3.6.2.2. *Mila janina* sp. n.

Pl. 8, Figs. 15, 16, 18, 19, 20, 21, 23, 25–27

Holotype: Right valve figured herein on pl. 8, figs. 20, 26, deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/258.

Paratype: Other specimen figured herein on pl. 8, figs. 15, 16, 18, 19, 21, 23, 25, 27, deposited in the Geologische Bundesanstalt, Vienna, under nos. 1998/2/310, 344, 349–352, 439–441, 444a, 482.

Derivation of name: Specific name is derived from the Czech name Janina which I call my wife Jana who helped me to find a better balance between science and life.

Type horizon and type locality: Bed no. 23a (SCHÖNLAUB, 1997), Ludfordian, Ludlow, Carnic Alps, Mt. Cellon, Austria.

Material: 1 right valve (shell inclined to the right), 4 right valves and 7 left valves (*shell inclined to the left*).

Diagnosis: *Mila janina* sp. n. differs from other species of *Mila* by fine and numerous radial ribs and by relativelly gentle and smaller shells.

Description: Shell subtriangular in outline, inequivalve and inequilateral. Right valve opisthocline, anterior slope overhanging, obese, the width equals 70 % the height of the shell. Umbones in anterior position, prominent. Inner surface sculpture consists of fine and numerous (27–33 in number) radial ribs. Both the radial ribs and radial gutters broaden ventrally. Posteriorly developed distinct wing in the form of wide and prominent radial fold separated from the rest of shell by prominent radial sulcus. On the inner surface of the fold a large and deep posterior adductor scar is developed. Left valve obese, the width equals 65–89 % the height of the shell. Posterior slope steeper than anterior slope. Anterior slope overhanging. Umbones prominent, prosogyrate. Outer surface sculpture consists of indistinct growth bands and furrows and of fine and numerous radial ribs and gutters, which are deeper than growth furrows. Both the radial ribs and radial gutters broaden *ventrally. Posteriorly developed distinct wing in the form of* a wide and prominent radial fold separated from the rest of shell by a prominent radial sulcus. Shell thickness is 0.1–0.31 mm. Other features unknown.

Remarks: *Mila janina* sp. n. is the closest relative of *Mila rudis* BARRANDE, 1881. It differs from the latter mainly by larger shells and coarser ribs. *Mila complexa* differs by more prominent and coarser radial ribs. GORTANI & VINASSA de REGNY (1909) described the species *Mila carnica* sp. n. Since I was unable to locate the type specimen, only their figure 11 a-c on plate 1 can be used for comparison. *Mila janina* sp. n. differs from *Mila carnica* mainly by a posteriorly developed distinct wing in the form of a wide and prominent radial fold separated from the rest of shell by a prominent radial sulcus.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/352 | 4.8 | 5.4 | 2.4 |
| GBA 1998/2/439 | 6.3 | 6.6 | 2.3 |
| GBA 1998/2/48 | 6.4 | 7.0 | 2.6 |
| GBA 1998/2/351 | 6.8 | 7.5 | 3.3 |
| GBA 1998/2/310 | 8.8 | 8.7 | 3.6 |
| GBA 1998/2/258 | 9.8 | 9.9 | 3.2 |
| GBA 1998/2/441 | 11.7 | 10.5 | 3.7 |
| GBA 1998/2/310 | 11.5 | 12.4 | 3.7 |

Occurrence: *Mila janina* sp. n. occurs in the Carnic Alps at the type locality and at the locality Rauchkofel Boden Section in the *Cardiola consanguis* Community of the *Cardiola* Community Group (KŘÍŽ, in press a), 260 cm above the base of the "Orthoceras" limestone (Kok Formation), and at the locality Base of Seewarte Section (SCHÖNLAUB, 1980) in the *Cardiola pectinata* Subcommunity in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, lower Ludlow.

### 3.6.3. Genus *Spanila* BARRANDE, 1881

Type species – *Spanila discipulus* BARRANDE, 1881

### 3.6.3.1. *Spanila aspirans* BARRANDE, 1881

Pl. 8, Figs. 24, 28, Pl. 9, Figs. 1–3, 6, 7, 16

1881 *Spanila aspirans* BARR. – BARRANDE, pl. 215, figs. III/1–29.
1929 *Amita aspirans* BARR. – HERITSCH, p. 38, pl. 4, figs. 353–356.
1929 *Amita* aff. *accedens* BARR. – HERITSCH, p. 38, pl. 4, figs. 350–352.

## Plate 9

Figs. 1, 6: ***Spanila aspirans*** BARRANDE.
Mt. Cellon, bed no. 21, Cardiola Formation, Ludlow, left valve, GBA 1998/2/327.
Fig. 1: Antero-lateral view, x 7.3.
Fig. 6: Lateral view, x 6.3.

Fig. 2, 7, 16: ***Spanila aspirans*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 2: Right valve, GBA 1998/2/451a, antero-lateral view, x 4.4. (For lateral view see Pl. 8, Fig. 24).
Fig. 7: Right valve, GBA 1998/2/450, lateral view, x 3.9.
Fig. 16: Right valve, GBA 1998/2/450, antero-lateral view, x 2.45.

Fig. 3: ***Spanila aspirans*** BARRANDE.
Mt. Cocco, Kok Formation, Ludlow, left valve, GBA 4927, lateral view, x 5.15. (For anterior view of the complete shell with conjoined valves see Pl. 8, Fig. 28).

Figs. 4, 5: ***Spanila celer*** BARRANDE.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow.
Fig. 4: Right valve, GBA 1998/2/373, lateral view, x 4.3.
Fig. 5: Left valve, GBA 1998/2/375, lateral view, x 5.0.

Figs. 8, 14: ***Spanila gracilis*** BARRANDE.
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, right valve, GBA 1998/2/346.
Fig. 8: Lateral view, x 4.5.
Fig. 14: Antero-lateral view, x 4.7.

Fig. 9, 18: ***Tenka bohemica*** BARRANDE.
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 9: Left valve, GBA 1998/2/452a, lateral view, x 4.0.
Fig. 18: Left valve, GBA 1998/2/454a, lateral view, x 3.9.

Figs. 10, 12, 20: ***Patrocardia celloni* sp. n.**
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock.
Fig. 10: Left valve, paratype, GBA 1998/2/415, lateral view of prodissoconch, x 11.3.
Fig. 12: Juveniles, paratypes, GBA 1998/2/426, lateral view, x 5.7.
Fig. 20: Post-prodissoconch stage, paratype, GBA 1998/2/427, lateral view, x 9.0.

Figs. 11, 13, 15: ***Patrocardia* aff. *novella* (BARRANDE)**.
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock.
Fig. 11: Left valve, GBA 1998/2/399, lateral view, x 7.0.
Fig. 13: Left valve, GBA 1998/2/328, lateral view, x 3.5.
Fig. 15: Left valve, GBA 1998/2/328, anterior view, x 4.75.

Fig. 17: ***Tenka bohemica*** BARRANDE.
Mt. Cellon, bed no. 23a, Cardiola Formation, Ludlow, left valve, GBA 1998/2/318a, lateral view, x 3.75.

Fig. 19: ***Patrocardia* aff. *analoga* (BARRANDE)**.
Rauchkofel Boden Section, bed no. 331, latest Přídolí, right valve, GBA 1998/2/341, dorso-lateral view, x 3.35. (For lateral view see Pl. 10, Fig. 2).

Fig. 21: ***Patrocardia simplex* (BARRANDE)**.
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, left valve, GBA 1998/2/380, anterior view, x 4.25. (For lateral view see Pl. 10, Fig. 9).

All photos by Jiří KŘÍŽ, Czech Geological Survey, Praha.

1993 *Spanila aspirans* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, pp. 330–331, pl. 8, figs. 19, 23, 27, 28, 30, 32.
1996 *Spanila aspirans* BARRANDE – KŘÍŽ, p. 53, pl. 6, figs. 2, 3, 6, 7.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague. The species has to be revised together with the study and revision of the whole genus which in Bohemia includes several species. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohe-mia are compared with the specimens from the Carnic Alps.

Type horizon and type locality: Silurian, Ludlow, Ludfordian, Kopanina Formation, Bohemia, Prague Basin.

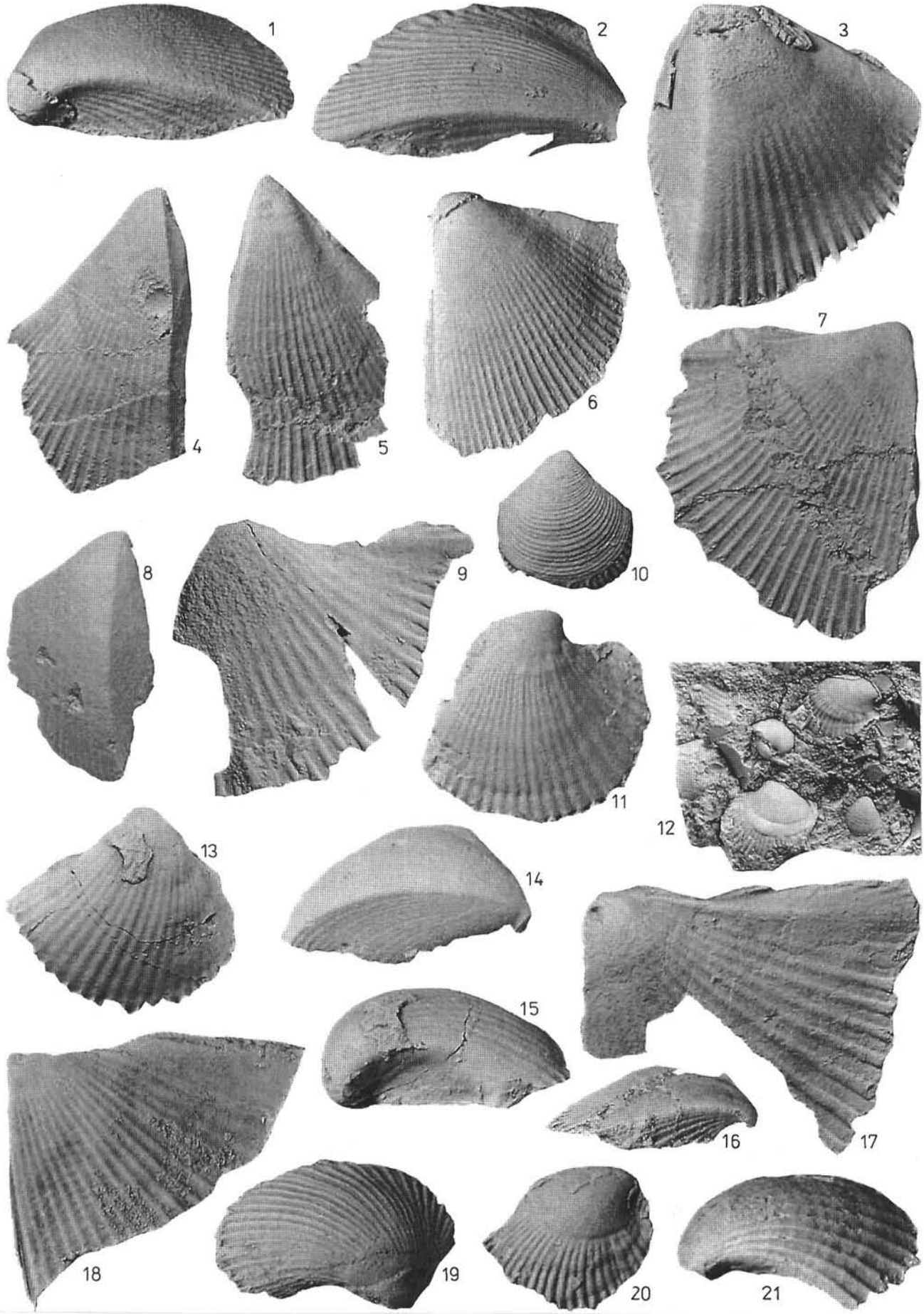
Material: 11 right valves and 1 shell with conjoined valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/327 | 5.3 | 7.0 | 1.9 |
| GBA 1998/2/311 | 8.8 | 12.5 | 2.3 |
| GBA 4927 | 9.3 | – | 3.1 |

Occurrence: *Spanila aspirans* is a quite common Silurian representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin (KŘÍŽ, in press a), Sardinia (KŘÍŽ in KŘÍŽ & SERPAGLI, 1993) and in the Montagne Noire, France (KŘÍŽ, 1996) in the Ludlow, Ludfordian. In the Carnic Alps *Spanila aspirans* occurs in the *Cardiola consanguis* Community at the locality Rauchkofel Boden Section 260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow. It also occurs in the higher *Cardiola docens* Community in the Cardiola Formation, lower Ludfor-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dian at the localities Mt. Cellon (bed no. 21), Mt. Cocco, and in the *Cardiola pectinata* Subcommunity at the locality base of Seewarte Section (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian.

#### 3.6.3.2. *Spanila gracilis* BARRANDE, 1881

Pl. 9, Figs. 8, 14

1881 *Spanila gracilis* BARR. – BARRANDE, pl. 214, figs. I/1–8.
1996 *Spanila gracilis* BARRANDE – KŘÍŽ, p. 53, pl. 6, figs. 8,9.
Lectotype: (designated herein) – Shell with conjoined valves figured by Barrande (1881) on pl. 214, figs. I/1–5, deposited in the National Museum, Prague under the number L 26 522 (ČD 979).
Type horizon and type locality: Silurian, Ludlow, Ludfordian, Kopanina Formation, Bohemia, Prague Basin, Kosoř locality.
Material: 1 right valve.
Remarks: Specimen from the Carnic Alps is conspecific with BARRANDE'S type material. The specimen represents probably a younger ontogenetic stage, since the posterior wing is not developed.

| Dimensions (in mm) | | | |
|---|---|---|---|
| specimen | length | height | width/2 |
| GBA 1998/2/346 | 5.4 | 9.8 | 3.1 |

Occurrence: *Spanila gracilis* is a rare Silurian representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin (BARRANDE, 1881) and in the Montagne Noire, France (KŘÍŽ, 1996) in the Ludlow, Ludfordian. In the Carnic Alps *Spanila gracilis* occurs at the locality Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, Ludfordian.

#### 3.6.3.3. *Spanila celer* BARRANDE, 1881

Pl. 9, Figs. 4, 5

1881 *Spanila celer* BARR. – BARRANDE, pl. 214, figs. II/1–8.
Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus which in Bohemia includes several species. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Type horizon and type locality: Silurian, Ludlow, Ludfordian, Kopanina Formation, Bohemia, Prague Basin.
Material: 1 left valve and 1 right valve.
Remarks: The specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

| Dimensions (in mm) | | | |
|---|---|---|---|
| specimen | length | height | width/2 |
| GBA 1998/2/373 | 6.8 | 13.9 | 2.7 |
| GBA 1998/2/375 | 5.8 | 11.0 | 2.2 |

Occurrence: *Spanila celer* is rare Silurian representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin (BARRANDE, 1881) in the Ludlow, Ludfordian. In the Carnic Alps *Spanila celer* occurs rarely at the locality Rauchkofel Boden Section, bed between nos. 325–326, Cardiola Formation, Ludlow, Ludfordian.

### 3.6.4. Genus *Tenka* BARRANDE, 1881

Type species – *Tenka bohemica* BARRANDE, 1881

#### 3.6.4.1. *Tenka bohemica* BARRANDE, 1881

Pl. 9, Figs. 9, 17, 18

1881 *Tenka Bohemica* BARR. – BARRANDE, pl. 217, figs. I/1–14.
1937 *Tenka bohemica* BARR. – CHAUBET, p. 164, pl. 4, fig. 1.
1996 *Tenka bohemica* BARRANDE – KŘÍŽ, p. 52, pl. 5, figs. 6, 7.
Lectotype (designated herein): Shell with conjoined valves figured by BARRANDE 1881 on pl. 217, figs. I/1–4, deposited in the National Museum, Prague under the number L 21 841.
Type horizon and type locality: Silurian, Ludlow, upper Ludfordian, Kopanina Formation, Bohemia, Prague Basin, Praha – Velká Chuchle.
Material: 3 left valves and 1 right valve.
Remarks: The specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

| Dimensions (in mm) | | | |
|---|---|---|---|
| specimen | length | height | width/2 |
| GBA 1998/2/318a | 16.6 | – | 1.9 |

Occurrence: *Tenka bohemica* is a quite rare Silurian representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin (KŘÍŽ, 1998, in press a), and in the Montagne Noire, France (KŘÍŽ, 1996) in the Ludlow, Ludfordian. *Tenka* sp. was recorded from Sardinia (KŘÍŽ & SERPAGLI, 1993). In the Carnic Alps *Tenka bohemica* occurs in the *Cardiola docens* Community in the Cardiola Formation, lower Ludfordian at the locality Mt. Cellon (bed no. 23a) and in the *Cardiola pectinata* Subcommunity at the locality Base of Seewarte (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, Ludlow.

### 3.6.5. Genus *Patrocardia* FISCHER, 1887

Type species – *Hemicardium dimidiatum* BARRANDE, 1881

Remarks: The genus *Patrocardia* (nomen novum) for *Hemicardium* BARRANDE, 1881) differs from the genus *Lunulacardium* MÜNSTER, 1840 by the lack of byssal gape. KŘÍŽ in KŘÍŽ & SERPAGLI, 1993 pointed out that most of the Bohemian species described in the past as members of the genus *Lunulacardium* belong actually to the genus *Patrocardia.* Without modern revision the genus *Patrocardia* should be considered as genus *sensu lato* because it may contain two closely related genera. The genus *Patrocardia* s. s. is represented for example by the type species, by *Patrocardia fraterna* (BARRANDE, 1881), *Patrocardia* sp. A and *Patrocardia* sp. B with straight or convex lunule and without posterior wing. The other genus is represented for example by the species *Patrocardia* sp. C, *Patrocardia simplex* (BARRANDE, 1881), *Patrocardia evolvens evolvens* (BARRANDE, 1881) and *Patrocardia* sp. D with straight or concave lunule and posterior wing. Since the genus *Patrocardia* s. l. contains numerous species, a detailed study should show if the concave lunule, convex lunule and presence of posterior wing represent good features of generic value or not.

#### 3.6.5.1. *Patrocardia* aff. *novella* (BARRANDE, 1881)

Pl. 9, Figs. 11, 13, 15

Material: 1 adult left valve, 8 left and 6 right, juvenile valves.
Remarks: Probably ancestral form of *Patrocardia novella* known from lowermost Ludlow. *Patrocardia* aff. *novella* differs from Bohemian species only by the presence of radial ribs on the lunule. General shape and type of radial surface sculpture is identical.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/399 | 4.7 | 5.4 | 1.7 |
| GBA 1998/2/328 | 9.0 | 9.7 | 3.4 |

Occurrence: In the Carnic Alps *Patrocardia* aff. *novella* is found only rarely at the locality Mt. Cellon in layer no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock.

### 3.6.5.2. *Patrocardia celloni* sp. n.

Pl. 9, Figs. 10, 12, 20, Pl. 10, Figs. 4, 5, 8

Holotype (designated herein): Right valve with preserved shell outer surface sculpture, figured herein on pl. 10, fig. 8, and deposited in the Geologische Bundesanstalt, Vienna under no. 1998/2/429.

Paratypes: Other specimens figured herein on pl. 9, figs. 10, 12, 20, pl. 10, figs. 4, 5, and unfigured specimens deposited in the Geologische Bundesanstalt, Vienna under nos. 1998/2/394, 396, 400, 404, 405, 412, 415, 418, 424–432, 434, 435, 437.

Derivation of name: Specific name is derived from the name of the type locality – Mt. Cellon.

Type horizon and type locality: Layer no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock, Carnic Alps, Mt. Cellon, Austria.

Material: 1 adult right valve and 6 left and 10 right juvenile valves.

Diagnosis: *Patrocardia celloni* sp. n. differs from *Patrocardia novella* (BARRANDE, 1881) by the higher number of radial ribs (34) and regular flat growth bands.

Description: Prodissoconch transversely broadly ovate to subtrigonal. Umbo opisthogyre, shell prosocline, inflated. Posteriorly a wing like structure is developed and separated from the rest of the valve by a shallow indistinct radial sulcus. Outer surface sculpture formed by distinct growth lines, inner surface sculpture smooth. Shell thickness is 0.03 mm. Postprodissoconch stage is characterised by subtrigonal, prosocline, well inflated shells with approximately equal length and height. Anterior is formed by long straight lunule. Outer surface sculpture is formed by wide, regularly spaced growth bands separated by wider and deeper growth lines in combination with prominent fine radial ribs (34 in number). Shell thickness is 0.07 mm. Other features unknown.

Remarks: It is easy to recognise early post–prodissoconch ontogenetic stages from *Patrocardia* aff. *novella* which has coarser and less numerous radial ribs. They are usually much more common in the sediment than adult specimens.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/421 | 3.4 | 3.7 | 1.0 |

Occurrence: In the Carnic Alps *Patrocardia* aff. *novella* occurs rarely at the locality Mt. Cellon in layer no. 12b, *Cyrtograptus rigidus* Zone (*Kockelella patula* Zone), Kok Formation, Sheinwoodian, Wenlock.

### 3.6.5.3. *Patrocardia simplex* (BARRANDE, 1881)

Pl. 9, Figs. 21, Pl. 10, Fig. 9

1881 *Lunulicardium simplex* BARR. – BARRANDE, pl. 234, figs. I/1–28.

Types: Figured by Barrande (1881) and deposited in the National Museum, Prague. The species has to be revised together with the study and revision of the whole genus which in Bohemia includes many species. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Type horizon and type locality: Silurian, Ludlow, Ludfordian, Bohemia, Prague Basin.

Material: 1 right valve.

Remarks: The specimen from the Carnic Alps is conspecific with BARRANDE'S type material. Bohemian specimens are in general slightly larger.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/380 | 9.7 | 10.3 | 3.2 |

Occurrence: *Patrocardia simplex* is a quite rare Ludfordian, Ludlow representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin in the *Cardiola docens* Community (KŘIŽ, in press a). In the Carnic Alps *Patrocardia simplex* occurs in the *Cardiola docens* Community in the Cardiola Formation, lower Ludfordian at the locality Rauchkofel Boden Section (bed between nos. 325–326 – SCHÖNLAUB, 1997).

### 3.6.5.4. *Patrocardia* aff. *analoga* (BARRANDE, 1881)

Pl. 9, Fig. 19, Pl. 10, Fig. 2.

Material: 1 right valve.

Remarks: Probably ancestral form of *Patrocardia analoga* known from the Lochkovian. *Patrocardia* aff. *analoga* differs from Bohemian species only by generally smaller shells with more gentle radial sculpture. General shape and type of radial surface sculpture is identical.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/341 | 13.5 | 12.0 | 3.2 |

Occurrence: In the Carnic Alps *Patrocardia* aff. *analoga* is not very common in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity at the locality Rauchkofel Boden Section, bed no. 331, uppermost Přídolí.

### 3.6.5.5. *Patrocardia sulcifera* (BARRANDE, 1881)

Pl. 10, Fig. 6

1881 *Lunulicardium sulciferum* BARR. – BARRANDE, pl. 238, figs. I/1–15.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus which in Bohemia includes many species. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Type horizon and type locality: Silurian, Ludlow, Ludfordian, Bohemia, Prague Basin.

Material: 1 right valve.

Remarks: The specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

## Plate 10

Figs. 1, 3: ***Patrocardia* aff. *sulcifera* (BARRANDE).**
Mt. Cocco, Kok Formation, Ludlow, right valve, GBA 4915.
Fig. 1: Lateral view, x 5.0.
Fig. 3: Antero-lateral view, x 3.1.

Fig. 2: ***Patrocardia* aff. *analoga* (BARRANDE).**
Rauchkofel Boden Section, bed no. 331, latest Přídolí, right valve, GBA 1998/2/341, lateral view, x 3.2. (For dorso-lateral view see Pl. 9, Fig. 19).

Fig. 4, 5, 8: ***Patrocardia celloni* sp. n.**
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock.
Fig. 4: Left valve, paratype, GBA 1998/2/426, postero-lateral view, x 8.0
Fig. 5: Right valve, paratype, GBA 1998/2/400, lateral view, x 12.0.
Fig. 8: Right valve, holotype, GBA 1998/2/429, lateral view, x 8.0.

Fig. 6: ***Patrocardia sulcifera* (BARRANDE).**
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, right valve, GBA 1998/2/314, lateral view, x 2.5.

Fig. 7: ***Patrocardia* cf. *fraterna* (BARRANDE).**
Rauchkofel Boden Section, bed no. 331, latest Přídolí, right valve, GBA 1998/2/298, lateral view, x 3.6.

Fig. 9: ***Patrocardia simplex* (BARRANDE).**
Rauchkofel Boden Section, layer between beds no. 325 and 326, Cardiola Formation, Ludlow, left valve, GBA 1998/2/380, lateral view, x 4.25. (For anterior view see Pl. 9, Fig. 21).

Fig. 10: ***Patrocardia* sp. C.**
Mt. Cellon, bed no. 20, Cardiola Formation, Ludlow, left valve, GBA 1998/2/321, lateral view, x 3.1.

Figs. 11, 16, 17: ***Patrocardia evolvens evolvens* (BARRANDE).**
Seekopf Sockel, limestone lenses below bed no. 358, early Lochkovian.
Fig. 11: Right valve, GBA 1998/2/481, lateral view, x 2.35.
Fig. 16: Right valve, GBA 1998/2/479, lateral view, x 23.5.
Fig. 17: Left valve with prodissoconch, GBA 1998/2/480, lateral view, x 22.0.

Figs. 12, 21, 22, 26: ***Patrocardia evolvens evolvens* (BARRANDE).**
Rauchkofel Boden Section, bed no. 331, latest Přídolí.
Fig. 12: Right valve, GBA 1998/2/322, lateral view, x 5.1.
Fig. 21: Right valve, GBA 1998/2/312, lateral view, x 5.0.
Fig. 22: Right valve, GBA 1998/2/324, lateral view, x 3.1.
Fig. 26: Right valve, GBA 1998/2/317, ventro-lateral view, x 3.1.

Fig. 13: ***Patrocardia* sp. B.**
Rauchkofel Boden Section, bed no. 331, latest Přídolí, left valve, GBA 1998/2/299, lateral view, x 4.55.

Fig. 14: ***Patrocardia* sp. A.**
Rauchkofel Boden Section, bed no. 331, latest Přídolí, left valve, GBA 1998/2/319, lateral view, x 4.40.

Figs. 15, 25: ***Butovicella medea* KŘÍŽ.**
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow.
Fig. 15: Left valve, GBA 1998/2/442, lateral view, x 13.6.
Fig. 25: Left valve, GBA 1998/2/443, lateral view, x 9.0.

Fig. 18. ***Procarinaria zephyrina* (BARRANDE).**
Mt. Cocco, Kok Formation, early Ludlow, left valve, GBA 4955, anterior view, x 5.75.

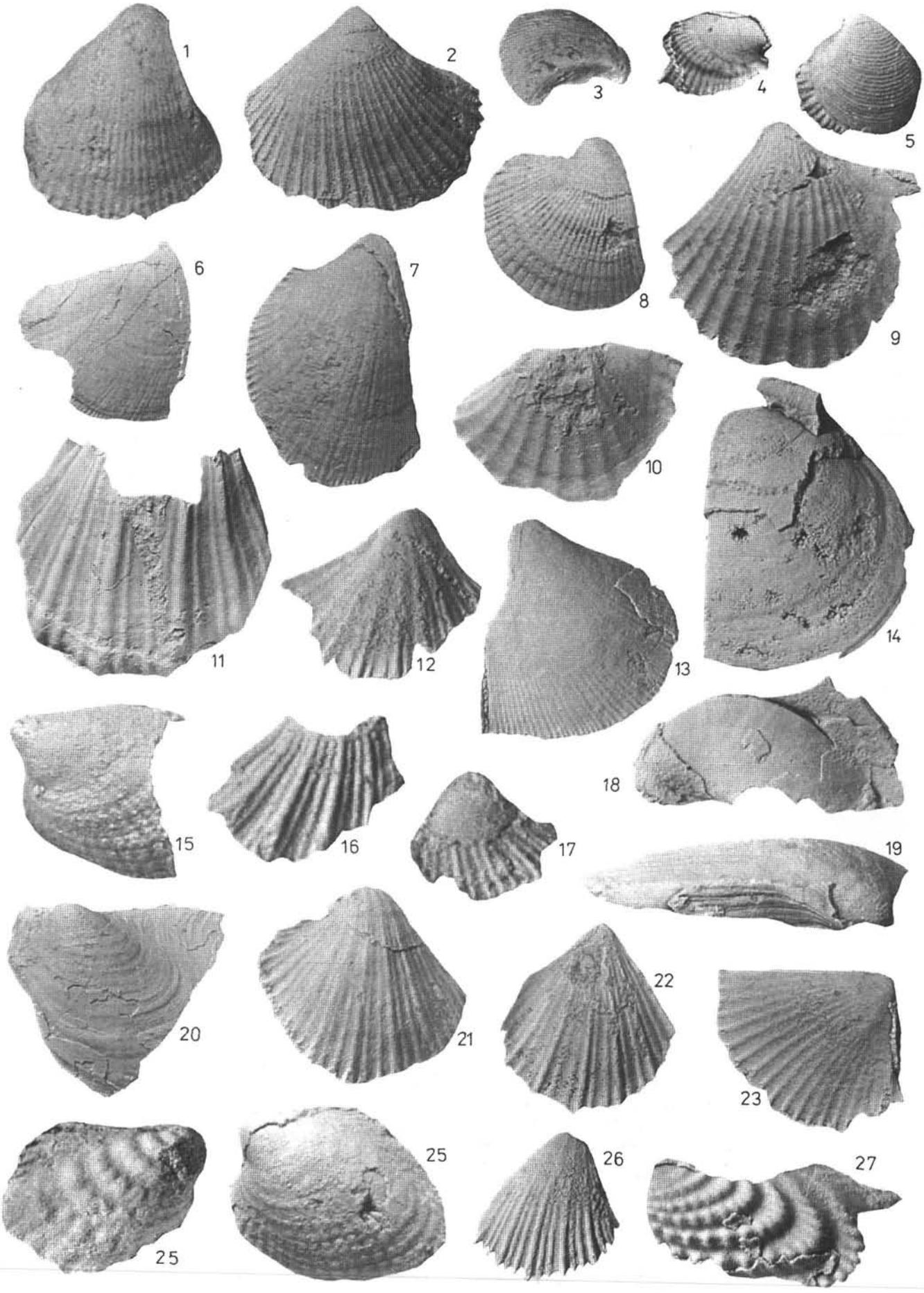
Figs. 19, 23: ***Patrocardia* sp. D.**
Base of Seewarte, uppermost 30 cm of the Cardiola Formation, Ludlow, right valve, GBA 1998/2/447.
Fig. 19: Anterior view, x 4.6.
Fig. 23: Lateral view, x 3.85.

Fig. 20: ***Leiopteria (L.)* sp.**
Mt. Cellon, layer no. 12b, *Cyrtograptus rigidus* Zone, Kok Formation, Sheinwoodian, Wenlock, left valve, GBA 1998/420, lateral view, x 3.7.

Fig. 24: ***Butovicella migrans* (BARRANDE).**
Mt. Cocco, Kok Formation, Wenlock – Ludlow, right valve, GBA 4942, lateral view, x 12.5.

Fig. 27: ***Butovicella migrans* (BARRANDE).**
Rauchkofel Boden Section, 195–225 cm above the Silurian base, Kok Formation, early Ludlow, left valve, GBA 1998/2/342, lateral view, x 9.4.

All photos by Jiří KŘÍŽ, Czech Geological Survey, Praha.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Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/314 | 12.6 | 13.5 | 2.8 |

Occurrence: *Patrocardia sulcifera* is a quite rare Ludfordian, Ludlow representative of the Lunulacardiidae. The species occurs in Bohemia, Prague Basin in the *Cardiola docens* Community (Kříž, in press a). In the Carnic Alps *Patrocardia sulcifera* occurs in the *Cardiola docens* Community in the Cardiola Formation, lower Ludfordian at the locality Rauchkofel Boden Section, bed between nos. 325–326 (Schönlaub, 1997).

### 3.6.5.6. *Patrocardia* aff. *sulcifera* (Barrande, 1881)

Pl. 10, Figs. 1, 3

1929 *Lunulicardium sulciferum* Barr. – Heritsch, p. 36–37, pl. 4, figs. 430–433.

Material: 1 right valve.

Remarks: *Patrocardia* cf. *sulcifera* is similar to Bohemian species by general shape and type of radial surface sculpture. Closer comparison is impossible because of poor preservation of the posterior side.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 4915 | – | 7.3 | 2.3 |

Occurrence: In the Carnic Alps *Patrocardia* cf. *sulcifera* occurs rarely at the locality Mt. Cocco in the Ludlow.

### 3.6.5.7. *Patrocardia* cf. *fraterna* (Barrande, 1881)

Pl. 10, Fig. 7

Material: 1 right valve.

Remarks: *Patrocardia* cf. *fraterna* is very similar to Bohemian species by general shape and size. Radial ribbing is slightly finer.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/298 | 8.4 | 12.9 | 3.7 |

Occurrence: In the Carnic Alps *Patrocardia* cf. *fraterna* occurs rarely in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity at the locality Rauchkofel Boden Section, bed no. 331, uppermost Přídolí. In Bohemia *Patrocardia fraterna* (*Hemicardium fraternum* Barrande, 1881) occurs in the Prague Basin, lowermost Lochkov. Lower Devonian.

### 3.6.5.8. *Patrocardia* sp. A

Pl. 10, Fig. 14

Material: 1 left valve.

Remarks: *Patrocardia* sp. A is similar to younger shells of the Bohemian species *Patrocardia tenuissima* (Barrande, 1881) from the lowermost Lochkov, Lower Devonian and to the species *Patrocardia omissa* (Barrande, 1881) from the upper Přídolí with almost smooth outer surface. Characteristic for *Patrocardia* sp. A are generally little inflated shells, straight lunule, smooth outer surface and thick shells (0.21 mm).

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/319 | 8.7 | 11.2 | 3.4 |

Occurrence: In the Carnic Alps *Patrocardia* sp. A occurs rarely in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity at the locality Rauchkofel Boden Section, bed no. 331, uppermost Přídolí.

### 3.6.5.9. *Patrocardia* sp. B

Pl. 10, Fig. 13

Material: 2 left valves.

Remarks: *Patrocardia* sp. B is similar by general shape to *Patrocardia fraterna* (Barrande, 1881) from the lowermost Lochkov. It differs by generally finer and regular radial ribs and by less inflated shells. Shell thickness is 0.1 mm. *Patrocardia* sp. B is also closely related to *Patrocardia decora* (Barrande, 1881) (*Hemicardium decorum* Barrande, 1881) by more regular radial ribs.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/299 | 7.9 | 19.5 | 2.0 |
| GBA 1998/2/297 | 9.0 | – | 2.4 |

Occurrence: In the Carnic Alps *Patrocardia* sp. B occurs rarely in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity at the locality Rauchkofel Boden Section, bed no. 331, uppermost Přídolí.

### 3.6.5.10. *Patrocardia* sp. C

Pl. 10, Fig. 10

Material: 1 left valve.

Remarks: *Patrocardia* sp. C is similar by general shape to *Patrocardia simplex* Barrande from Ludlow and to *Patrocardia peralatum* (Barrande, 1881) from Ludlow. It differs by smaller number of radial ribs (15) and wider radial gutters. Umbonal part not preserved.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/321 | 13.2 | 10.4 | 3.6 |

Occurrence: In the Carnic Alps *Patrocardia* sp. C occurs rarely in the *Cardiola docens* Community at the locality Mt. Cellon, bed no. 20, Ludlow.

### 3.6.5.11. *Patrocardia* sp. D

Pl. 10, Figs. 19, 23

Material: 1 right valve.

Remarks: *Patrocardia* sp. D is similar by general shape to *Patrocardia alifera* (Barrande, 1881) from lower Ludlow and to *Patrocardia simplex* (Barrande, 1881) from upper Ludlow of the Prague Basin, Bohemia. *Patrocardia* sp. D differs by coarser radial ribs (19 in number), less convex shell and very low straight lunule from *Patrocardia alifera* and by finer radial ribs, less convex shell and very straight low lunule from *Patrocardia simplex*. Shell thickness is 0.1–0.28 mm.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/447 | 7.1 | 8.5 | 1.4 |

Occurrence: In the Carnic Alps *Patrocardia* sp. D occurs rarely in the *Cardiola pectinata* Subcommunity at the Base

of Seewarte (SCHÖNLAUB, 1980) in uppermost 30 cm of the Cardiola Formation, Ludlow.

#### 3.6.5.12. *Patrocardia evolvens evolvens* (BARRANDE, 1881)
Pl. 10, Figs. 11, 12, 16, 17, 21, 22, 26

1881 *Lunulicardium evolvens* BARR. – BARRANDE, pl. 231, figs. I–IV; pl. 232, figs. I–V.
1982 *Lunulacardium evolvens* BARRANDE – KŘÍŽ & PARIS, p. 400, pl. 4, figs. 6–9 (for complete previous synonymy see this paper).
1993 *Patrocardia evolvens evolvens* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, p. 334–336, pl. 9, figs. 17, 20–21.
1996 *Patrocardia evolvens evolvens* BARRANDE – KŘÍŽ, p. 54–55, pl. 6, figs. 17–19.

Types: Figured by BARRANDE (1881) and deposited in the National Museum, Prague.

The species has to be revised together with the study and revision of the whole genus which in Bohemia includes many species. This is the reason why a lectotype is not indicated in this paper, in which only the specimens described from Bohemia are compared with the specimens from the Carnic Alps.

Type horizon and type locality: Silurian, lowermost Lochkovian, Lower Devoniian, Bohemia, Prague Basin.

Material: 2 left valves and 11 right valves.

Remarks: Specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/312 | 6.1 | 6.8 | 1.9 |
| GBA 1998/2/25 | 13.2 | 10.9 | 3.1 |

Occurrence: *Patrocardia evolvens evolvens* is a common uppermost Silurian and lowermost Devonian representative of the Lunulacardiidae. The species is dominant in the *Patrocardia evolvens evolvens* Community in Bohemia, Prague Basin (KŘÍŽ, in press a). Apart from Bohemia it occurs in France, in the uppermost Přídolí and lowermost Lochkovian of the Massif Armoricain (KŘÍŽ & PARIS, 1982), in the uppermost Přídolí of Normandie (BABIN & ROBARDET, 1974), Poland, Chelm borehole (KOREJWO & TELLER, 1964) and the Montagne Noire (KŘÍŽ, 1996), in the lowermost Lochkovian of Ukraina, Podolia (Sinicyna 1968) and in Sardinia (KŘÍŽ in KŘÍŽ & SERPAGLI, 1993). In the Carnic Alps *Patrocardia evolvens evolvens* occurs in uppermost Přídolí, Silurian in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity, at the locality Rauchkofel Boden Section in bed no. 331 and in the nodules within the shales just below bed no. 358, lower Lochkov, Devonian at the locality Seekopf Sockel Section (SCHÖNLAUB, 1980).

## Superfamily Pteriacea GRAY, 1847
## 3.7. Family Pterineidae MILLER, 1877

### 3.7.1. Genus *Leiopteria (Leiopteria)* HALL, 1883
Type species – *Leiopteria dekayi* HALL, 1883

#### 3.7.1.1. *Leiopteria (Leiopteria)* sp.
Pl. 10, Fig. 20

Material: 1 left valve.

Remarks: One incomplete specimen shows general shape and sculpture characteristic for the genus (MCALESTER, 1962). It can be compared only with Middle Devonian Leiopteria (Leiopteria) from the Hamilton Group of New York.

Occurrence: In the Carnic Alps *Leiopteria (Leiopteria)* sp. occurs rarely at the locality Mt. Cellon in layer no. 12b, *Cyrtograptus rigidus* Zone.

## Superfamily Modiomorphacae MILLER, 1877
## 3.8. Family Modiomorphidae MILLER, 1877

### 3.8.1. Genus *Procarinaria* PERNER, 1911
Type species – *Goniophora zephyrina* BARRANDE, 1881

#### 3.8.1.1. *Procarinaria zephyrina* (BARRANDE, 1881)
Pl. 10, Fig. 18

1881 *Goniophora zephyrina* BARR. – BARRANDE, pl. 263, figs. VI/1–12.
1903 *Carinaria bohemica* PERNER – PERNER, p. 53, figs. 19–21.
1911 *Procarinaria bohemica* (PERNER) – PERNER, p. 300–302, pl. 53, figs. 19–21; text-fig. 323.
1964 *Procarinaria zephyrina* (BARRANDE) – HORNÝ, pp. 15–16, pl. I, ,figs. 1–6 (for complete synonymy see this paper).
1993 *Procarinaria zephyrina* (BARRANDE) – KŘÍŽ in KŘÍŽ & SERPAGLI, pp. 340–341, pl. 11, figs. 18–19.
1996 *Procarinaria zephyrina* (BARRANDE) – KŘÍŽ, pp. 57, pl. 6, figs. 31, 35.

Lectotype (designated by HORNÝ 1964): Internal mould of a left valve, figured by BARRANDE (1881), pl. 263, figs. VI/1–6, deposited in the National Museum, Prague under the number L 5917.

Type horizon and type locality: Silurian, Ludlow, lower Gorstian, Kopanina Formation, *Colonograptus colonus* Zone (*Neodiversograptus nilssoni* Zone), Bohemia, Prague Basin, Praha – Butovice, Na břekvici Section no. 584 (KŘÍŽ, 1992).

Material: 1 left valve.

Remarks: The specimen from the Carnic Alps is conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 4955 | – | 8.6 | 4.6 |

Occurrence: *Procarinaria zephyrina* is a quite rare cosmopolitan Silurian representative of the Modiomorphidae. The species occurs in lowermost Ludlow of Bohemia, Prague Basin (KŘÍŽ, 1998, in press a), in Sardinia (KŘÍŽ & SERPAGLI, 1993), in the Montagne Noire, France (KŘÍŽ, 1996) and in Skane and Gotland. In the Carnic Alps *Procarinaria zephyrina* occurs in the Kok Formation, lower Ludfordian at the locality Mt. Cocco.

## 3.9. Family Butovicellidae KŘÍŽ, 1965

### 3.9.1. Genus *Butovicella* KŘÍŽ, 1965
Type species – *Cardiola migrans* BARRANDE, 1881

#### 3.9.1.1. *Butovicella migrans* (BARRANDE, 1881)
Pl. 10, Figs. 24, 27

1881 *Cardiola migrans* BARR. – BARRANDE (partim), p. 268, pl. 183, figs. I/12–15; pl. 184, fig. I/1–12, fig. II/1–4, figs. III–V. Non: pl. 184, fig. I/13–16 (= *Butovicella mima* KŘÍŽ, 1969) and pl. 184, fig. II/5–16 (= *Butovicella medea* KŘÍŽ, 1969).
1909 *Cardiola migrans* BARRANDE – GORTANI & VINASSA de REGNY, p. 197, pl. 1, figs. 16.
1929 *Cardiola migrans* BARR. – HERITSCH, p. 40, pl. 4, figs. 401–402.
1969 *Butovicella migrans* BARRANDE – KŘÍŽ, p.117–120, pl. 1,2,4, 5–7 (for complete previous synonymy see this paper).
1976 *Butovicella migrans* BARRANDE – POJETA & KŘÍŽ, p. 17, Pl. 2, figs. 9–11.
1993 *Butovicella migrans* BARRANDE – KŘÍŽ in KŘÍŽ & SERPAGLI, p. 342, pl. 11, figs. 8–11.
1996 *Butovicella migrans* BARRANDE – KŘÍŽ, p. 58, pl. 6, figs. 20, 27, 30.

Lectotype (designated by KŘÍŽ, 1965): Internal mould of a left valve, figured by BARRANDE (1881), pl. 184, figs. V/1–4, deposited in the National Museum, Prague under the number L 6116.
Type horizon and type locality: Silurian, Ludlow, lower Gorstian, Kopanina Formation, *Colonograptus colonus* Zone (*Neodiversograptus nilssoni* Zone), Bohemia, Prague Basin, Praha – Butovice, Na Břekvici Section no. 584 (KŘÍŽ, 1992).
Material: 1 left valve and 1 right valve.
Remarks: The specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 4942 | 3.1 | 2.2 | 1.0 |
| GBA 1998/2/342 | 3.2 | 1.8 | 0.8 |

Occurrence: *Butovicella migrans* is a common cosmopolitan Silurian representative of the Butovicellidae. The species occurs in the Wenlock (Homerian) to Ludlow (Ludfordian) of Bohemia, Prague Basin (KŘÍŽ, in press a). For occurrences apart from Bohemia see KŘÍŽ (1969, 1996) and KŘÍŽ & SERPAGLI (1993). In the Carnic Alps *Butovicella migrans* occurs in the *Cardiola consanguis* Community, Ludfordian, at the locality Rauchkofel Boden Section, 195–260 cm above the base of the "Orthoceras" limestone (Kok Formation), lower Ludlow, in the Kok Formation, lower Ludfordian at the locality Mt. Cocco and Mt. Pal Picolo.

#### 3.9.1.2. *Butovicella medea* KŘÍŽ, 1969
Pl. 10, Figs. 15, 25

1881 *Cardiola migrans* BARR. – BARRANDE (partim), p. 268, pl. 184, figs. II/5–16; Non: pl. 183, fig. I/12–15, pl. 184, figs. I/1–12, figs. II/1–4, figs III–V (= *Butovicella migrans* BARRANDE) and pl. 184, fig. II/5–16 (= *Butovicella medea* KŘÍŽ, 1969).
1969 *Butovicella medea* sp. n. – KŘÍŽ, p. 120–123, pl. 3. 4, and 8.
Holotype (designated by Kříž 1969): Internal mould of a right valve, figured by KŘÍŽ, pl. 3, fig. 7 and pl. 4, fig. 1, deposited in the Czech Geological Survey, Prague under the number JK 121.
Type horizon and type locality: Silurian, Ludlow, upper Ludfordian, Ludlow, Kopanina Formation, the upper parts of the upper parts of the horizon with *Cromus beaumonti, Neocucullograptus kozlowskii* Zone (KŘÍŽ, 1998a), Prague Basin, Praha – Malá Chuchle, locality Vyskočilka, old pits on the slope S of the turn to Filmařská Street, east of the southeastern margin of the film studio Barrandov.
Material: 2 left valves.
Remarks: The specimens from the Carnic Alps are conspecific with BARRANDE'S type material.

Dimensions (in mm)

| specimen | length | height | width/2 |
|---|---|---|---|
| GBA 1998/2/442 | – | 2.3 | 0.8 |
| GBA 1998/2/443 | 4.4 | 3.4 | 1.1 |

Occurrence: *Butovicella medea* is a common representative of the Butovicellidae in upper Ludfordian, Prague Basin, Bohemia (KŘÍŽ, 1969; in press a). It probably occurs also in Sardinia (KŘÍŽ & SERPAGLI, 1996) and in the Montagne Noire, France (KŘÍŽ, 1996). In the Carnic Alps *Butovicella medea* occurs in the *Cardiola pectinata* Subcommunity at the Base of Seewarte Section (SCHÖNLAUB, 1980) in the uppermost 30 cm of the Cardiola Formation, higher Ludfordian, Ludlow.

## 4. Bivalve dominated communities

Bivalve dominated communities of Bohemian type from the Silurian and Lower Devonian carbonate facies were described and defined by KŘÍŽ & SERPAGLI, 1993 and by KŘÍŽ (1996; in press a). The Silurian and Lower Devonian communities of "Bohemian type" form five natural community groups containing homologous and analogous (BOUCOT & KŘÍŽ, in press) communities. They are related to micritic or biodetrital limestone facies deposited in the shallow to deeper water subtidal environment of the Gondwanan European region (KŘÍŽ, in press a).

### 4.1. Cardiola Community Group

The *Cardiola* Community Group (KŘÍŽ, in press a) includes eleven recurring communities (five of them have been recognised to date in the Carnic Alps) which mainly reflect the Wenlockian and Ludlovian evolutionary history of epibyssate Cardiolacea (*Slavinka, Cardiola*). In this community group epibyssate forms are dominant (39–100 %) and most characteristic (KŘÍŽ, in press a). In general, diversity and population densities are usually high. The gradual and special adaptation of the Cardiolacea to the cylindrical surface of the cephalopod shells was documented in detail by KŘÍŽ (1979). Each horizon of the cephalopod limestone forms a distinct marker bed in the Silurian and Devonian sequences. The distribution of the recurring cephalopod limestone biofacies in the Silurian and lowermost Devonian of Gondwanan Europe and Perunica was described by KŘÍŽ (1998a). Epibyssate Cardiolacea lineages end at the Ludlow–Přídolí boundary (KŘÍŽ, 1979). In younger horizons the epibyssate Cardiolacea were replaced by representatives of the epibyssate Lunulacardiidae (KŘÍŽ, in press a). The *Cardiola* Community Group sequence of communities is very important for stratigraphic purposes. Each cephalopod limestone level corresponds to a well–known graptolite biozone (KŘÍŽ, in press b), and may be recognised and correlated just on the basis of bivalve community composition even if graptolites are rare or missing in the carbonate facies.

#### 4.1.1. *Carnalpia nivosa* Community
(Table 1)

**Name:** Introduced by KŘÍŽ (in press a).

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition:** *Carnalpia nivosa, Carnalpia rostrata, Cardiolopsis alpina, Cardicarnia barrandei, Dualina secunda, Patrocardia* aff. *novella, Patrocardia celloni* sp. n., *Cardiola bifasciata, Cardiola tinda* sp. n., *Cardiola stachei* sp. n., *"Ctenodonta" simplicitor,* Ambonychiidae gen. et sp. indet., *Slava* sp., *Spanila gracilis, Spanila* sp., *Maminka comata, Leiopteria (L.)* sp. rare trilobites *(Aulacopleura, Cheiruridae, Proetidae, Encrinuridae* and *Odontopleuridae),* common juvenile stages of bivalves and gastropods, few cephalopods and very rare brachiopods.

**Age:** Wenlock, Sheinwoodian, *Cyrtograptus rigidus* Biozone (KŘÍŽ, 1979; in press a), layer no. 12b (WALLISER, 1964).

**Type locality:** Mt. Cellon Section in the Carnic Alps, Austria (KŘÍŽ, 1979; in press).

**Geographic distribution:** The Carnic Alps (Mt. Cellon in Austria, Mt. Cocco in Italy).

**Community and environment interpretation in the Carnic Alps:** The shells occur disarticulated in biodetrital limestone which forms lenses in the dark graptolitic shales. The horizon is a part of the limestone formation (Kok Formation). Population densities are reasonably high; bivalves, brachiopods and trilobites occur mostly disarticulated. All bivalves are filtrators, 58.6 % of which are epibyssate, 21.2 % semi–infaunal and 6.1 % reclining. Epibyssate bivalves show adaptations to life on the bottom surface (KŘÍŽ, 1979). Current activity is documented by their disarticulation and presence of current oriented cephalopods (HISTON, in press). Relative high diversity, and presence of common juvenile bivalves and gastropods also indicate, at least periodically, a well–ventilated sea bottom. Sediment type and fossil preservation suggest an environment below wave base.

The *Cardiola nivosa* Community represents the oldest known community of the *Cardiola* Community Group (KŘÍŽ, in press a) characterised by the presence of common epibyssate bivalves adapted to life on the bottom and on shell fragments. Bottom conditions were also suitable for semi–infaunal and reclining forms. Biodetrital sediment was probably low in nutrition and conditions within it were probably abiotic. This may explain why free burrowing deposit feeders ("nuculoids") are missing. Juvenile bivalves and gastropods were probably living interstitially between coarse shell debris (biodetrital limestone) and were periodically killed during the lack of ventilation by currents while adults survived.

The community is homologous and analogous to younger communities of the *Cardiola* Community Group (KŘÍŽ, in press a, BOUCOT & KŘÍŽ, in press) containing different but evolutionary related species of *Cardiola, Maminka, Patrocardia* and *Slavinka.*

Table 1.
Numerical and ranked abundance of bivalves in the *Carnalpia nivosa* Community, Sheinwoodian, Wenlock, Silurian, Mt. Cellon, the Carnic Alps (KŘÍŽ, in press a). For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Carnalpia nivosa* | epibyssate | 31 | | 30.7 | | 1 |
| *Patrocardia celloni* | epibyssate | 20 | | 19.8 | | 2 |
| *Patrocardia* aff. *novella* | epibyssate | 16 | | 15.8 | | 3 |
| *Cardiolopsis alpina* | semi–infaunal | 15 | | 14.9 | | 4 |
| *Cardicarnia barrandei* | semi–infaunal | 5 | | 5.0 | | 5 |
| *Cardiola bifasciata* | semi–infaunal | 1 | 1 | 3.0 | 2.0 | 6 |
| *Cardiola tinda* | epibyssate | 2 | | 2.0 | | 7 |
| *Carnalpia rostrata* | epibyssate | 2 | | 2.0 | | 7 |
| *"Ctenodonta" simplicitor* | infaunal | 1 | | 1.0 | | 8 |
| *Cardiola stachei* | semi–infaunal | 1 | | 1.0 | | 8 |
| *Slava* sp. | infaunal | 1 | | 1.0 | | 8 |
| Ambonychiidae indet. | semi–infaunal | 1 | | 1.0 | | 8 |
| *Maminka comata* | semi–infaunal | 1 | | 1.0 | | 8 |
| *Spanila gracilis* | epibyssate | 1 | | 1.0 | | 8 |
| *Leiopteria (L.)* sp. | epibyssate | 1 | | 1.0 | 2.0 | 8 |
| Totals | | 99.00 | 2 | 100.2 | 2.0 | |

### 4.1.2. *Cardiola agna* Community – *Slava pelerina* – *Isiola zila* Subcommunity
(Table 2)

**Name:** Used here for the first time.

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Rauchkofel Boden Section):** *Slava pelerina, Isiola lyra, Cardiola schoenlaubi, Slava fibrosa, Maminka comata, Mila* sp., relatively common trilobites (*Aulacopleura, Cheiruridae, Harpetidae,* and *Odontopleuridae*). Abundant, mostly fragmentary and unsorted cephalopod shells and gastropods (especially loxonematids), problematic (corals?) spheroid colonies, rugose coral (*?Petraia*) and rare small articulate brachiopods. Limestone contains more common juvenile bivalves and gastropods.

Bivalves are relatively rare higher in the Rauchkofel Boden Section (41–65 cm above the base of the Silurian). Mostly disarticulated trilobites of the species *Aulacopleura* aff. *haueri* are common here. Less common are other trilobites (*Cheiruridae, Harpetidae,* and *Odontopleuridae*). Problematical (corals?) small spheroid colonies are also abundant here.

**Age:** Wenlock, lower Homerian, most probably *Cyrtograptus lundgreni* Zone, cephalopod limestone 0–105 cm above the base of the Silurian.

**Type locality:** Rauchkofel Boden Section in the Carnic Alps, Austria.

**Geographic distribution:** Austria, the Carnic Alps, Rauchkofel Boden Section.

**Community and environment interpretation in the Carnic**

**Alps:** Not very common bivalves occur in micritic limestone with common shell detritus. Relatively very common are fragments and complete shells of nektobenthic cephalopods, mostly orthocones (FERRETTI & HISTON, 1997; HISTON, in press). They represented a hard substrate on the sea bottom surface available for epibyssate bivalves (*Cardiola schoenlaubi*). The majority of bivalves were byssate and infaunal (*Slava* and *Isiola*).

Population density is relatively low; bivalves, brachiopods and trilobites occur mostly disarticulated. All bivalves are filtrators. Bottom conditions were not suitable (probably low in nutrients) for free burrowing "nuculoid" deposit feeders which are entirely missing. Nektobenthic cephalopods are locally current oriented. Interesting are relatively very common gastropods (loxonematids), which have not yet been studied. The community indicates a relatively shallow environment below wave base, influenced by current activity. The *Slava pelerina – Isiola zila* Subcommunity has very low diversity in comparison with other contemporary communities. The conditions were somehow restricted in comparison with the conditions of the upper Wenlock (Homerian) cephalopod limestone biofacies in the Prague Basin, Sardinia and Montagne Noire.

The *Slava pelerina – Isiola zila* Subcommunity from the Carnic Alps is very closely related to the *Cardiola agna* Community known from the Prague Basin, Bohemia and to the *Cardiola figusi* (= *Cardiola agna figusi*) Community known from Sardinia and from the Montagne Noire, France. All the communities are homologous and analogous (BOUCOT & KŘÍŽ,1997). They contain different but evolutionary related species of *Slava, Cardiola, Isiola, Mila* and *Maminka*.

**Age:** Ludlow, upper Gorstian, probably upper *Saetograptus chimaera* Zone (*Lobograptus scanicus* Zone) or lowermost Ludfordian, *Monograptus linearis* Zone (*Monograptus leintwardensis* Zone).

**Type locality:** Austria, the Carnic Alps, Rauchkofel Boden Section, 260 cm above base of the Silurian (0–50 cm below the Cardiola Formation).

**Geographic distribution:** Montagne Noire, France; Mt. Cellon, below the Cardiola Formation (SCHÖNLAUB, 1980); Prague Basin, Bohemia, Mušlovka Quarry, *Monograptus linearis* Zone, layers bellow the bank no. 1/2 (KŘÍŽ, 1992).

**Community and environment interpretation in the Carnic Alps:** The shells occur mostly disarticulated in biomicrite to biodetrital limestone with relatively common nektobenthic adult and juvenile cephalopods, abundant trilobites (*Harpetidae, Proetidae* and *Encrinuridae*) and small, mostly indeterminable adult brachiopods (FERRETTI & HISTON, 1997; HISTON, in press a). All of bivalves are filtrators, 69.5 % of which are epibyssate and 16.7 % semi–infaunal. The *Cardiola consanguis* Community is homologous and analogous (BOUCOT & KŘÍŽ, in press) with other communities of the *Cardiola* Community Group (KŘÍŽ, in press a). A very similar *Cardiola signata* Community was described by KŘÍŽ & BOGOLEPOVA (1995) from Tajmyr, Russia, uppermost parts of the *Monograptus chimaera* Zone. The *Cardiola consanguis* Community is characterised by relatively high population density and diversity than later *Cardiola docens* Community. Reclining and infaunal forms are absent or very rare. Small adult brachiopods form local accumulations of articulated shells. Well–oriented cephalopod shells document current activity favourable for epibyssate bivalves. High diversity, and presence of common juvenile bivalves and gastropods also indicate, at least periodically, a well–ventilated sea bottom. Sediment type and fossil preservation suggest an environment below wave base. The community is very close to that which occurs in the Prague Basin in the Mušlovka Quarry just below and within the lower parts of the *Monograptus linearis* Biozone. *Cardiola docens* sometime already represents the dominant species of the community but diversity of the *Cardiola consanguis* Community is much higher than in the later *Cardiola docens* Community.

The *Cardiola consanguis* Community in the Carnic Alps and in other regions developed most probably from the *Cardiola donigala* Community described by KŘÍŽ & SERPAGLI (1993).

Table 2.
Numerical and ranked abundance of bivalves in the *Slava fibrosa* Community, lower Homerian Wenlock, Silurian, Rauchkofel, Rauchkofel Boden Section, 0–105 cm above the base of the Silurian, the Carnic Alps. For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Slava pelerina* | infaunal | 25 | – | 43.1 | – | 1 |
| *Isiola zila* | infaunal | 11 | – | 19.0 | – | 2 |
| *Cardiola schoenlaubi* | epibyssate | 8 | – | 13.8 | – | 3 |
| *Slava fibrosa* | infaunal | 6 | – | 10.3 | – | 4 |
| *Maminka comata* | semi–infaunal | 3 | – | 5.2 | – | 5 |
| *Slava* sp. | Infaunal | 2 | – | 3.4 | – | 6 |
| *Cardiola* aff. *figusi* | epibyssate | 1 | – | 1.7 | – | 7 |
| *Slava* cf. *fibrosa* | infaunal | 1 | – | 1.7 | – | 7 |
| *Slava* cf. *sathon* | infaunal | 1 | – | 1.7 | – | 7 |
| Totals | | 58 | | 99.9 | | |

### 4.1.3. *Cardiola consanguis* Community
(Table 3)

**Name:** Used here for the first time.

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Rauchkofel Boden Section):** *Cardiola docens, Cardiola consanguis, Cardiola signata, Cardiola* cf. *docens, Slavinka* aff. *damona, Cardiola* cf. *docents, Cardiola spectabilis, Cardiola* cf. *consanguis, Cardiola* cf. *signata, Slavinka cubula, Mila complexa, Mila janina* sp. n., *Spanila aspirans, Patrocardia* sp., *Dualina* sp., abundant cephalopods, adults and juveniles, trilobites (*Harpetidae, Proetidae,* and *Encrinuridae*), juvenile gastropods and small indeterminable adult brachiopods.

Table 3.
Numerical and ranked abundance of bivalves in the Cardiola consanguis Community, 260 cm above the base of the Silurian (0–50 cm below the Cardiola Formation), uppermost Gorstian, Ludlow, Silurian, Rauchkofel, Rauchkofel Boden Section, the Carnic Alps. For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Cardiola docens* | epibyssate | 7 | – | 19.4 | – | 1 |
| *Cardiola consanguis* | epibyssate | 5 | – | 13.9 | – | 2 |
| *Cardiola signata* | epibyssate | 5 | – | 13.9 | – | 2 |
| *Slavinka* aff. *damona* | semi–infaunal | 4 | – | 11.1 | – | 3 |
| *Cardiola* cf. *docens* | epibyssate | 3 | – | 8.3 | – | 4 |
| *Cardiola spectabilis* | epibyssate | 1 | – | 2.8 | – | 5 |
| *Cardiola* cf. *consanguis* | epibyssate | 1 | – | 2.8 | – | 5 |
| *Cardiola* cf. *signata* | epibyssate | 1 | – | 2.8 | – | 5 |
| *Slavinka cubula* | semi–infaunal | 1 | – | 2.8 | – | 5 |
| *Mila complexa* | semi–infaunal | 1 | – | 2.8 | – | 5 |
| *Mila janina* | semi–infaunal | 1 | – | 2.8 | – | 5 |
| *Spanila aspirans* | epibyssate | 1 | – | 2.8 | – | 5 |
| *Patrocardia* sp. | epibyssate | 1 | – | 2.8 | – | 5 |
| *Dualina* sp. | ? | 1 | – | 2.8 | – | 5 |
| Indet. | | 2 | 1 | 11.1 | 5.6 | |
| Totals | | 34 | 2 | 102.9 | 5.6 | |

In a level 195–225 cm above the base of the Silurian in the Rauchkofel Boden Section an unnamed Bivalvia dominated community occurs which is analogous and homologous to the other communities of the *Cardiola* Community Group. The presence of the bivalves *Maminka comata, Cardiola docens* and trilobite *Balizoma* aff. *transiens* indicate most probably the base of the *Saetograptus chimaera* Zone (*Lobograptus scanicus* Zone) when correlated with the Prague Basin (Bohemia), Montagne Noire (France) and Sardinia (Italy) (KŘÍŽ & SERPAGLI, 1993, KŘÍŽ, 1996, 1998a, in press a).

Disarticulated epibyssate (*Cardiola docens, Cardiola signata,* and *Butovicella migrans*), semi–infaunal (*Maminka comata*) and infaunal (*Dualina* sp.) bivalves occur in biomicrite to biodetrital limestones with relatively common nektobenthic adult and very common juvenile cephalopods, rare gastropods (loxonematids) and trilobites (*Balizoma* aff. *transiens* and *Cheiruridae*) (FERRETTI & HISTON, 1997; HISTON, in press a).

### 4.1.4. *Cardiola docens* Community
(Table 4)

**Name:** Introduced by KŘÍŽ & SERPAGLI (1993) and KŘÍŽ (in press a).

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Rauchkofel Boden Section):** *Cardiola docens, Mila* sp., *Cardiola consanguis, Cardiola signata, Patrocardia* sp., *Spanila* sp., abundant nektobenthic cephalopods, brachiopods *Septatrypa* cf. *sapho* and *Bleshidium patellinum.*

**Age:** Ludlow, lower Ludfordian, most probably *Monograptus linearis* Zone.

**Type locality:** BARRANDE'S test pit near the road from Koledník Hamlet to Koněprusy Village near Beroun, Prague Basin (Bohemia).

**Geographic distribution:** Prague Basin (Bohemia); Montagne Noire (France); Sardinia (Italy); Spain; Morocco; Caucasus, Russia; Carnic Alps, Mt. Cocco (Italy), Rauchkofel Boden Section, Cardiola Formation (between layers nos. 325 and 326 – SCHÖNLAUB, 1980, 1997), Mt. Cellon (Bed no. 20 – Carnic Alps – KŘÍŽ in SCHÖNLAUB, 1980), Mt. Hoher Trieb (Austria).

**Community and environment interpretation in the Carnic Alps:** Disarticulated bivalves occur in biodetrital limestone with abundant small nektobenthic cephalopod shells (FERRETTI & HISTON, 1997; HISTON, 1999, in press). The community is characterised by very high population density (*Cardiola docens*). The presence of epibyssate suspension feeders (100%) is characteristic. They are adapted to the byssate mode of life on firm substrate formed by cephalopod shells concentrated in the cephalopod limestone facies. Small brachiopods (*Bleshidium* and *Septatrypa* cf. sapho) are locally abundant. Well–oriented cephalopod shells document current activity favourable for epibyssate bivalves. The *Cardiola docens* Community is a good example of specialised adaptation to a special environment, the cephalopod limestone biofacies. The community is homologous and analogous (BOUCOT & KŘÍŽ, 1997) to the earlier *Cardiola consanguis* Community known also from other Gondwanan regions (e.g. the Prague Basin, Sardinia and the Montagne Noire). They occurred in a relatively shallow water environment influenced by current activity but protected against stronger wave action.

### 4.1.5. *Cardiola alata* Community – *Cardiola pectinata* Subcommunity
(Table 5)

**Name:** Introduced by KŘÍŽ (1998a)

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Base of the Seewarte Section):** *Cardiola pectinata, Spanila aspirans, Cardiola alata, Mila janina* sp. n., *Mila complexa, Tenka bohemica, Butovicella medea, Cardiolinka* cf. *bohemica, Cardiola eximia, Cardiola* aff. *tix, Dualina longiuscula, Maminka* sp., *Patrocardia* sp., abundant disarticulated crinoid stem plates, common nektobenthic cephalopods, brachiopods *Bleshidium patellinum* and *Plagiorhyncha* sp. which is closely related to the Bohemian *Plagiorhyncha thisbe* (BARRANDE) and archinaceliform gastropod.

**Age:** Ludlow, higher Ludfordian, *Neocucullograptus kozlowskii* Zone (KŘÍŽ, 1998a).

**Type locality:** Požáry section, Praha – Řeporyje, Prague

Table 4.
Numerical and ranked abundance of bivalves in the *Cardiola docens* Community, Ludlow, Ludfordian (most probably contemporaneous with the *Monograptus linearis* Biozone), between layers nos. 325 and 326, Rauchkofel Boden Section, Cardiola Formation, the Carnic Alps, Austria (SCHÖNLAUB, 1980). For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Cardiola docens* | epibyssate | 55 | – | 74.3 | – | 1 |
| *Mila complexa* | epibyssate | 7 | – | 9.5 | – | 2 |
| *Cardiola consanguis* | epibyssate | 3 | – | 4.1 | – | 3 |
| *Cardiola* cf. *signata* | epibyssate | 2 | – | 2.7 | – | 4 |
| *Spanila celler* | epibyssate | 2 | – | 2.7 | – | 4 |
| *Dualina longiuscula* | reclining | 1 | – | 1.4 | – | 5 |
| *Cardiola signata* | epibyssate | 1 | – | 1.4 | – | 5 |
| *Patrocardia simplex* | epibyssate | 1 | – | 1.4 | – | 5 |
| *Patrocardia sulcifera* | epibyssate | 1 | – | 1.4 | – | 5 |
| *Patrocardia* sp. | epibyssate | 1 | – | 1.4 | – | 5 |
| Totals | | 74 | | 100.3 | | |

Basin, Bohemia (KŘÍŽ et al., 1986), layers no. 33–34, Kopanina Formation, Ludlow. At the type locality *Cardiola alata* is dominant and *Cardiola pectinata* is subdominant. Biodetrital limestone developed above layers with mass occurrence of *Atrypoidea linguata* and just below the horizon with *Ananaspis fecunda. Neocucullograptus kozlowskii* Zone (ŠTORCH, 1995) occurs in the Kosov Quarry near Beroun at the same level. Conodonts of the *Polygnathoides siluricus* Zone (rich fauna of *P. emarginatus* and *P. siluricus*) were identified by SCHÖNLAUB (1980) from this level in the Mušlovka Quarry section.

Table 5.
Numerical and ranked abundance of bivalves in the *Cardiola alata* Community – *Cardiola pectinata* Subcommunity, Ludlow, Ludfordian, uppermost 30 cm of the Cardiola Formation (most probably contemporaneous with the *Neocucullograptus kozlowskii* Zone) base of the Seewarte Section, the Carnic Alps, Austria (SCHÖNLAUB, 1980). For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Cardiola pectinata* | semiinfaunal | 24 | – | 44.4 | – | 1 |
| *Mila janina* | reclining | 9 | – | 16.7 | – | 4 |
| *Spanila aspirans* | epibyssate | 6 | – | 11.1 | – | 2 |
| *Cardiola alata* | infaunal | 4 | – | 7.4 | – | 4 |
| *Tenka bohemica* | epibyssate | 3 | – | 5.6 | – | 5 |
| *Butovicella medea* | epibyssate | 2 | – | 3.7 | – | 6 |
| *Cardiola eximia* | semiinfaunal | 1 | – | 1.9 | – | 7 |
| *Cardiola* cf. *tix* | epibyssate | 1 | – | 1.9 | – | 7 |
| *Dualina longiuscula* | reclining | 1 | – | 1.9 | – | 7 |
| *Maminka* sp. | reclining | 1 | – | 1.9 | – | 7 |
| *Mila complexa* | reclining | 1 | – | 1.9 | – | 7 |
| *Patrocardia* sp. D | epibyssate | 1 | – | 1.9 | – | 7 |
| Totals | | 54 | | 100.3 | | |

**Geographic distribution:** Prague Basin, Bohemia (KŘÍŽ, 1998a); Montagne Noire, France (KŘÍŽ, 1996); Base of the Seewarte Section, Carnic Alps, Austria (SCHÖNLAUB, 1980).

**Community and environment interpretation in the Carnic Alps:** Disarticulated bivalves occur in biodetrital limestone with abundant disarticulated crinoid stem plates, common nektobenthic cephalopods, and the brachiopod *Bleshidium patellinum,* in the uppermost 30 cm of the Cardiola Formation. The community is characterised by high population density and diversity, by the presence of the infaunal and semi-infaunal *Cardiola alata, Cardiola pectinata* and *Cardiola eximia* (53.7 %), reclining *Mila janina* sp. n., *Mila complexa, Maminka* sp., *Dualina longiuscula* (22.4 %). Well-oriented, common cephalopod shells document current activity favourable for epibyssate *Cardiola* cf. tix, *Tenka bohemica, Spanila aspirans, Patrocardia* sp. D, and *Butovicella medea* (24.2). The *Cardiola alata – Cardiola pectinata* Community is homologous and analogous (BOUCOT & KŘÍŽ, 1997) to the other communties of the *Cardiola* Community Group known also from other Gondwanan regions (e.g. the Prague Basin, Sardinia and most probably the Montagne Noire). They occurred in an environment influenced by current activity and protected against wave action. When compared with the Prague Basin type community, it may be concluded, that the living conditions in the Carnic Alps were more restricted.

### 4.1.6. *Cardiolinka bohemica* Community

**Name:** Introduced by KŘÍŽ (in press a).

**Community group assignment:** *Cardiola* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Cellon Section):** *Cardiolinka bohemica,* adults and juveniles, rare rhynchonelid

brachiopod, locally common *Monograptus parultimus,* abundant fragmentary cephalopod shells.

**Age:** Lowermost Přídolí, *Monograptus parultimus* Zone.

**Type locality:** Cephalopod Quarry near Praha–Lochkov, Bohemia.

**Geographic distribution:** Prague Basin, Carnic Alps, Mt. Cellon section, layer no. 32 (WALLISER, 1964), Duoro Range on Devon Island in the Canadian Arctic (KŘÍŽ, 1979), Nagelschmiedpalfen near Dienten, Austria, and Elbersreuth, Frankenwald, Lindener Mark bei Giessen, Germany.

**Community and environment interpretation in the Carnic Alps:** Disarticulated endobyssate (KŘÍŽ, 1979) *Cardiolinka bohemica,* adults and very common juveniles occur in biomicrite and biodetrital limestone with relatively common nektobenthic cephalopods and planktic *Monograptus parultimus* JAEGER, 1975. The *Cardiolinka bohemica* Community is homologous (BOUCOT & KŘÍŽ, in press) with other communities of the *Cardiola* Community Group (KŘÍŽ, in press a) but functionally different in the presence of a dominant infaunal form. In comparison with other known older communities of the *Cardiola* Community Group with more than 50% epibyssate forms there is a very distinct abrupt change corresponding to the Gondwanan paleogeographic changes at the Ludlow–Přídolí boundary. The *Cardiolinka bohemica* Community is a good example of the abrupt functional change in the community group due to the abrupt change of the environment conditions. The change was probably limited to conditions related to water circulation, food supply or temperature since the depth change was certainly negligible and bottom structure was similar to that in the uppermost Ludlow (KŘÍŽ, 1991, 1992; in press a). In Bohemia the thin limestone horizon with the *Cardiolinka bohemica* Community forms the highest horizon of the biodetrital limestone with cephalopods which occurs locally prior to sedimentation of the Přídolí micrites and calcareous shales (KŘÍŽ, 1991, 1992).

Adaptation of the Cardiolidae to an infaunal mode of life in the higher Ludlow (KŘÍŽ, 1979) made the movement of the family's infaunal representatives into the micritic limestone environment possible, where they formed homogenous but not analogous communities of the *Cardiola* Community Group.

### 4.2. *Cheiopteria* Community Group

The *Cheiopteria* Community Group (KŘÍŽ, in press a) is related to the micritic facies which was a deeper water facies than the contemporary cephalopod limestone facies. This facies has not been so far found in the Silurian sections of the Carnic Alps.

### 4.3. *Snoopyia* Community Group

The *Snoopyia* Community Group (KŘÍŽ, in press a) is also related to a deeper micritic limestone facies which prevailed in the Gondwanan European region after an abrupt change in paleogeography and sedimentation at the Ludlow–Přídolí boundary. This change eliminated many epibyssate forms including all epibyssate Cardiolacea (*Cardiola* and *Slavinka*) which became extinct when the shallower cephalopod limestone facies was replaced by the micritic limestone facies. Soft bottom conditions were favourable for infaunal, semi-infaunal and reclining forms of Bivalvia. There is no record of the *Snoopyia* Community group in the Carnic Alps.

### 4.4. *Patrocardia* Community Group

The *Patrocardia* Community Group (KŘÍŽ, in press a) is usually characterised by high density populations of the epibyssate Lunulacardiidae. The oldest known community of this group (*Patrocardia–Dualina* Community) is represented in the Carnic Alps by its *Dualina nigra–Patrocardia* Subcommunity for which well diversified and common infaunal Antipleuridae (*Dualina*) are characteristic. The subcommunity is developed in the highest Přídolí in a micritic to biodetrital limestone facies.

#### 4.4.1. *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity

(Table 6)

**Name:** Used here for the first time.

Table 6.
Numerical and ranked abundance of bivalves in the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity, latest Přídolí, layer no. 331, Rauchkofel Boden Section, the Carnic Alps, Austria (SCHÖNLAUB, 1980). For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Dualina nigra* | reclining | 33 | – | 38.8 | | 1 |
| *Dualina socialis* | reclining | 15 | – | 17.6 | – | 2 |
| *Dualina* cf. *socialis* | reclining | 9 | – | 10.6 | – | 3 |
| *Patrocardia evolvens evolvens* | epibyssate | 7 | – | 8.2 | – | 4 |
| *Dualina* sp. | reclining | 4 | – | 4.7 | – | 5 |
| *Dualina* cf. *nigra* | reclining | 2 | – | 2.4 | – | 6 |
| *Patrocardia* sp. B | epibyssate | 2 | – | 2.4 | – | 6 |
| *Dualina inexplicata* | reclining | 1 | – | 1.2 | – | 7 |
| *Cardiolinka* cf. *bohemica* | infaunal | 1 | – | 1.2 | – | 7 |
| *Cardiolinka* cf. *concubina* | infaunal | 1 | – | 1.2 | – | 7 |
| *Pygolfia* cf. *nina* | infaunal | 1 | – | 1.2 | – | 7 |
| *Patrocardia* aff. *analoga* | epibyssate | 1 | – | 1.2 | – | 7 |
| *Patrocardia* cf. *fraterna* | epibyssate | 1 | – | 1.2 | – | 7 |
| *Patrocardia* sp. A | epibyssate | 1 | – | 1.2 | – | 7 |
| *Patrocardia* sp. indet. | epibyssate | 1 | – | 1.2 | – | 7 |
| | | 5 | – | 5.9 | | |
| Totals | | 85 | | 100.2 | | |

**Community group assignment:** *Patrocardia* Community Group.

**Composition (in the Carnic Alps, Rauchkofel Boden Section):** *Dualina nigra, Dualina socialis, Dualina* cf. *socialis, Patrocardia evolvens evolvens, Dualina* sp., *Dualina* cf. *nigra, Patrocardia* sp. A, *Dualina inexplicata, Cardiolinka* cf. *bohemica, Cardiolinka* cf. *concubina, Pygolfia* cf. *nina, Patrocardia* aff. *analoga, Patrocardia* cf. *fraterna, Patrocardia* sp. A, *Patrocardia* sp., common cephalopod shells, mostly in fragments, abundant juveniles of cephalopods and bivalves and rare trilobites (*Encrinuridae*).

**Age:** Latest Přídolí, most probably *Monograptus transgrediens* Zone, bed no. 331 (SCHÖNLAUB, 1980).

**Type locality:** Austria, the Carnic Alps, Rauchkofel Boden Section (SCHÖNLAUB, 1980).

**Geographic distribution:** Prague Basin, Bohemia; the Carnic Alps, Austria.

**Community and environment interpretation in the Carnic Alps:** Disarticulated reclining *Dualina* (75.3 %), epibyssate *Patrocardia evolvens evolvens* and *Patrocardia* div. sp. (15.4 %), infaunal *Cardiolinka* and *Pygolfia* (3.6 %), adults and very common juveniles occur in biomicrite and biodetrital limestone with relatively common nektobenthic cephalopods (FERRETTI & HISTON, 1997; HISTON, in press). The community is especially characterised by the high population density of reclining *Dualina*. For the majority of reclining forms (75.3 %) soft bottom conditions were favourable. The presence of relatively common oriented nektobentic cephalopods documents water current above the bottom which supported the existence of relatively common epibyssate patrocardiids. The community is contemporaneous with the *Joachimia–Cardiolinka–Pygolfia* Community described from the Prague Basin (KŘÍŽ, in press) and homologous but not analogous (BOUCOT & KŘÍŽ, 1997) to the *Patrocardia evolvens evolvens* Community and *Antipleura bohemica* Community. The community lived in the deeper environment below wave base. The bottom was influenced by low current activity favourable only for suspension feeders at the sediment – sea water interface.

## 4. 5. *Antipleura–Hercynella* Community Group

The *Antipleura–Hercynella* Community Group (KŘÍŽ, in press a) is represented in the Carnic Alps by the *Antipleura bohemica* Community. It occurs in the lowermost Lochkovian in micritic limestones with abundant disarticulated stem plates of *Scyphocrinites*. Generally low diversity indicates restricted deeper water living conditions.

### 4. 5. 1. *Antipleura bohemica* Community
(Table 7)

**Name:** Introduced by KŘÍŽ & PARIS (1982) as *Antipleura bohemica* assemblage.

**Community group assignment:** *Antipleura – Hercynella* Community Group (KŘÍŽ, in press a).

**Composition (in the Carnic Alps, Rauchkofel Boden Section ):** *Antipleura bohemica, Scyphocrinites* sp., trilobites (*Proetidae*) and rugose corals. At the locality Seekopf Sockel Section: *Vlasta bohemica, Patrocardia evolvens evolvens, Silurina percalva, Dualina annulosa, Dualina inexplicata* and *Silurina* sp., fragmentary cephalopods, trilobites and smooth articulated brachiopods.

**Age:** Devonian, Lowermost Lochkov, *Monograptus uniformis* Zone, base of *Scyphocrinites* bed, the layer 40 cm above bed no. 331 (SCHÖNLAUB, 1980, 1997).

**Type locality:** Antipleura Gorge near Praha–Radotín, Prague Basin, Bohemia.

**Geographic distribution:** Prague Basin, Bohemia; Anti–Atlas, Morocco; Rauchkofel Boden Section (SCHÖNLAUB, 1980, 1997) and Seekopf Sockel Section (SCHÖNLAUB, 1980) in the Carnic Alps, Austria.

**Community and environment interpretation in the Carnic Alps:** At the Rauchkofel Boden Section locality occurs the disarticulated and reclining bivalve *Antipleura bohemica* rarely occurs in the dark micrite with abundant disarticulated stem plates of *Scyphocrinites,* trilobites (*Proetidae*) and rugose corals. The community is characterised by a low diversity and very low densities. The environment was certainly deeper than in Bohemia and with very low current activity. At the Seekopf Sockel locality (SCHÖNLAUB, 1980), lower Lochkov, Devonian, mostly disarticulated and fragmentary *Vlasta bohemica, Patrocardia evolvens evolvens, Silurina percalva, Dualina annulosa, Dualina inexplicata* and the articulated brachiopod *Septatrypa* sp. occur in the dark gray micritic limestone nodules within the shales found between the dark micritic limestone beds, just below bed no. 358. The community shows a relatively high diversity and density. Infaunal forms are dominant (61.5 %) *Vlasta bohemica, Silurina percalva* and *Dualina annulosa.* Epibyssate forms are represented only by *Patrocardia evolvens evolvens.* All these species are especially common in Bohemia, Prague Basin, at the Dvorce Locality in the lowermost Lochkov (KŘÍŽ, 1992, 1998b). At both localities *Antipleura bohemica* is rare or locally (Seekopf Sockel ) even missing. The environment was in the Carnic Alps certainly much deeper, but at least temporary water currents were present.

Table 7.
Numerical and ranked abundance of bivalves in the *Antipleura bohemica* Community. Seekopf Sockel Section, the limestone nodules within the shales just below bed no. 358, lower Lochkov, Devonian , the Carnic Alps, Austria (SCHÖNLAUB, 1980). For explanation see the list of abbreviations.

| Species, species group genus | Life habits | R+L | A | RA | AA | R |
|---|---|---|---|---|---|---|
| *Vlasta bohemica* | infaunal | 9 | – | 34.6 | – | 1 |
| *Patrocardia e. evolvens* | epibyssate | 6 | – | 23.1 | – | 2 |
| *Silurina percalva* | infaunal | 2 | 1 | 15.4 | 7.7 | 3 |
| *Dualina annulosa* | infaunal | 2 | – | 7.7 | – | 4 |
| *Dualina inexplicata* | reclining | 1 | – | 3.8 | – | 5 |
| *Silurina* sp. | infaunal | 1 | – | 3.8 | – | 5 |
| Indet. | | 3 | – | 11.5 | – | |
| *Totals* | | 24 | 2 | 99.9 | 7.7 | |

## 5. Paleogeographic and stratigraphic conclusions

Fossil bivalves represent a very useful group for paleogeographic conclusions. Their transport over the oceans is provided at the pelagic larval stage by surface currents and is mainly dependent on the length of this larval life and on the availability of the proper environment in the place where they have to settle. The length of the Recent Bivalvia larval life and the conditions of their distribution was studied especially by THORSON (1961, 1964 and 1966). According to Thorson (1961, p. 466–467) almost 80 % of the bivalves settle within 5 weeks after hatching and thus represent among all the groups which he studied "the one most unfit for long–distance transportation. Like the gastropod veligers, their shells are heavy; the velum is withdrawn when they are disturbed, which makes them sink toward the bottom and counteracts transportation." According to the same author the Recent surface current average velocity represents mostly in 1 week less than 200 km (e.g. surface current from Cape Hatteras in U. S. A. to the Azores is 4000 km in 22 weeks, winter current from Peru to Galápagos Islands is 880 km in 6 weeks and summer current in 3 weeks, winter current from Galápagos Islands to Christmas Island is 7150 km in 38 weeks and summer current in 25 weeks ). It means that in maximally 5 weeks 80 % of the bivalve planktic larval stages can cover less than 1000 km distance before they settle on the bottom to continue their development. Even the longest larval life of Bivalvia given by THORSON (1961, p. 460) for some species (13 weeks) makes it possible to cover no longer a distance than 2500 km. The impossibility for bivalve planktic larvae to cross longer distances by surface currents are in the Recent best documented by the fact that on the North American Atlantic and the European Atlantic shelves in the same climatic zone occur different species of Bivalvia occur with the exception of the few species transported artificially by man in historical times.

The cephalopod limestone facies in which most of the bivalve communities occur in the Carnic Alps represents the result of the surface currents and sea bottom interaction. This facies is mainly distributed in the Northern Gondwana region (KŘÍŽ, 1998a). All benthic forms which inhabit this environment were transported here as the larval stages by surface currents. Besides bivalves cephalopods, gastropods and crinoids are most common. About 80% of them have in Recent conditions approximately the same maximal length of larval life of 5 to 9 weeks. Brachiopods with a much shorter larval life are missing, generally rare or restricted to a few small size species which could be distributed also as adult epiplankton. The length of the larval life of trilobites was probably also quite short as may be seen from the limited distribution at species level of most of them.

The presence of numerous larval stages of bivalves, gastropods and cephalopods is characteristic for the Silurian and lowermost Devonian cephalopod limestone facies (KŘÍŽ, 1969, 1979, 1998a; FERRETTI & KŘÍŽ, 1995). It can be the result of the mass extinction during the temporal anoxic conditions when the surface current was not ventilating the bottom or it can be the result of macrofauna predation e. g. by nematodes and turbellarians which are able to swallow, digest and eject the empty shells of prodissoconchal stage of bivalves (THORSON, 1966, p. 277).

All the regions where the Silurian and lower Devonian cephalopod limestone facies occurs, especially in Prague Basin (Perunica), the Carnic Alps Basin, the North Gondwana Montagne Noire, Mouthoumet and Sardinia Basins were relatively close to each other and connected by a surface current system which made it possible for common larval stages to cross from one island group or microcontinent within the North Gondwana to its neighbouring group. Comparison with Recent conditions accounts for maximal distances of less than 1000 km.

This may be documented especially by the presence of the same Bivalvia dominated communities in all the regions in which even the same species occur. When new species occur, they are very closely related to the species of other regions and this can be the result of quick adaptation to slightly different conditions caused by depth, type of sediment or temperature.

### 5. 1. Paleogeographic Position of the Carnic Alps Basin in the Silurian and Lowermost Devonian

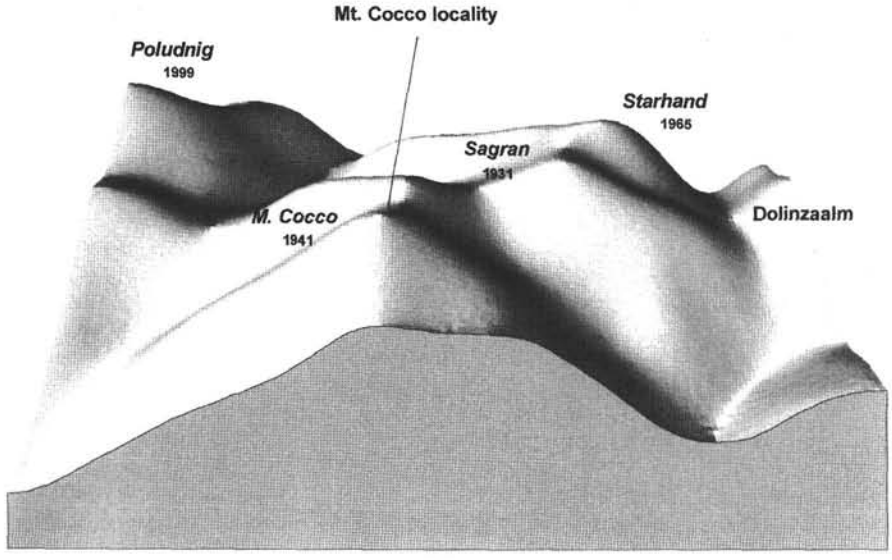
In general the Silurian and lowermost Devonian Bivalvia dominated communities recognised in the Carnic Alps occur in the Wolayer and Plöcken facies (SCHÖNLAUB, 1998) characterised by relatively shallow water carbonates and current activity in contrast to the deep–water basinal Findenig and Bischofalm facies with restricted living conditions for the benthos, mainly anoxic conditions. When compared with the similar Prague Basin Bivalvia dominated communities in the middle Ludlow, the lower diversity and density characteristic to the Carnic Alps indicates more restricted conditions caused most probably by the position of the sedimentation basin of the Carnic Alps more to the south in somewhat colder climatic zones than the Prague Basin in Perunica. This is supported by the fact that bivalve communities occur in both regions generally in the same facies and that the sea bottom in both regions had to be at least temporally ventilated by surface water currents reaching generally the same depths.

### 5.2. Correlation and Relationships of the Carnic Alps Basin with Other World Regions in the Silurian and Lowermost Devonian

Since the Sheinwoodian (Wenlock) up to the early Devonian (early Lochkovian) bivalves represent (besides cephalopods, brachiopods, crinoids and trilobites) the most easily recognisable and relatively abundant forms, which are important for stratigraphic and paleogeographic interpretation and correlation of the Carnic Alps with other regions.

The stratigraphic distribution of the Silurian and lower Devonian Bivalvia of Bohemian type dominated communities is best known in the Prague Basin (KŘÍŽ, 1998a) and in the Sardinian Wenlock – Ludlow boundary (KŘÍŽ & SERPAGLI, 1993) where it can be correlated with the graptolite zones (Text – Fig. 6). Since the composition of most Bivalvia dominated communities in the Carnic Alps is very similar they may be successfully used for stratigraphic correlation with the Prague Basin and Sardinia.

The earliest Silurian community from the Carnic Alps known from the Mt. Cellon and Mt. Cocco Sections represents a very interesting step in the history of the *Cardiola* Community Group. The *Carnalpia nivosa* Community from the *Cyrtograptus rigidus* Biozone (KŘÍŽ, 1979, 1997), layer no. 12b (WALLISER, 1964), Sheinwoodian, Wenlock is composed mainly of bivalve species which are known only from the region of the Carnic Alps (*Cardiobeleba ava, Cardiobeleba lavina, Cardiobeleba obstetrix, Cominicula kokiana, Carnalpia nivosa, Carnalpia rostrata, Cardiolopsis alpina, Cardicarnia monticola, Cardicarnia barrandei* sp. n., *Patrocardia celloni* sp.




Text–Fig. 5.
Mountain ridge of the Carnic Alps in the region of Dolinzaalm showing the location of the Mt. Cocco locality in Italy. View from the south. South–east of Hermagor (Österreichische Karte 1 : 50 000, no. 199, Hermagor).

n., *Cardiola bifasciata, C. tinda* sp. n. *Cardiola stachei* sp. n.). Only some very closely related species of the genus *Cardiobeleba* are known from Bohemia and France (KŘÍŽ, 1979 and 1996). The carbonate facies of the same age as in the Carnic Alps is known from the Prague Basin, in the vicinity of the Svatý Jan Volcanic Centre (KŘÍŽ, 1991) but the same bivalves have never been found there. On the other hand, in the Sheinwoodian in the *Carnalpia nivosa* Community some bivalves occur (*"Ctenodonta" simplicitor, Dualina secunda, Maminka comata* and *Spanila gracilis*), which also occur later in the Carnic Alps Basin and in other regions in the upper Wenlock, Homerian (Montagne Noire, Sardinia and Prague Basin).

It can be postulated that in the Sheinwoodian the region of the Carnic Alps Basin was more isolated from the Perunica and other Gondwana regions. The *Carnalpia nivosa* Community represents one of the oldest known occurrences of the Silurian cephalopod limestone biofacies (KŘÍŽ, 1979, 1998a, FERRETTI & KŘÍŽ, 1995), which shows all the characteristics of the temporary ventilated bottom facies, especially with very common juvenile stages of bivalves and gastropods as the result of temporary mortality during relatively short anoxic conditions which were survived by adult individuals.

The later Wenlock, Homerian, *Cardiola agna* Community – *Slava pelerina – Isiola zila* Subcommunity contains more bivalves known also from other Gondwana regions and from Prague Basin (*Slava pelerina, Slava fibrosa* and *Maminka comata*) but still contains species known only from the Carnic Alps region (*Isiola zila* sp. n. and *Cardiola schoenlaubi* sp. n.) but which are related to the forms from other regions. This certainly indicates that closer currents communication started between Gondwana, Perunica and the Carnic Alps Basin regions.

The relationships with Gondwana and Perunica increased distinctly during Ludlow time, especially during the *Colonograptus colonus, Saetograptus chimaera, Saetograptus linearis* zones and up to the *Neocucullograptus kozlowskii* Zone. This interval is characterised by the presence of the *Cardiola consanguis* Community, *Cardiola docens* Community and *Cardiola pectinata* Subcommunity. They all contain identical species of bivalves and show very close relationships to the contemporaneous communities known from Bohemia (Perunica), Sardinia and Montagne Noire (Gondwana) as opposed to relationships with Baltica and Avalonia (SCHÖNLAUB, 1998a). In general they show lower diversity in the Carnic Alps than in other regions, but this may be related to the more restricted conditions, e. g. temperature.

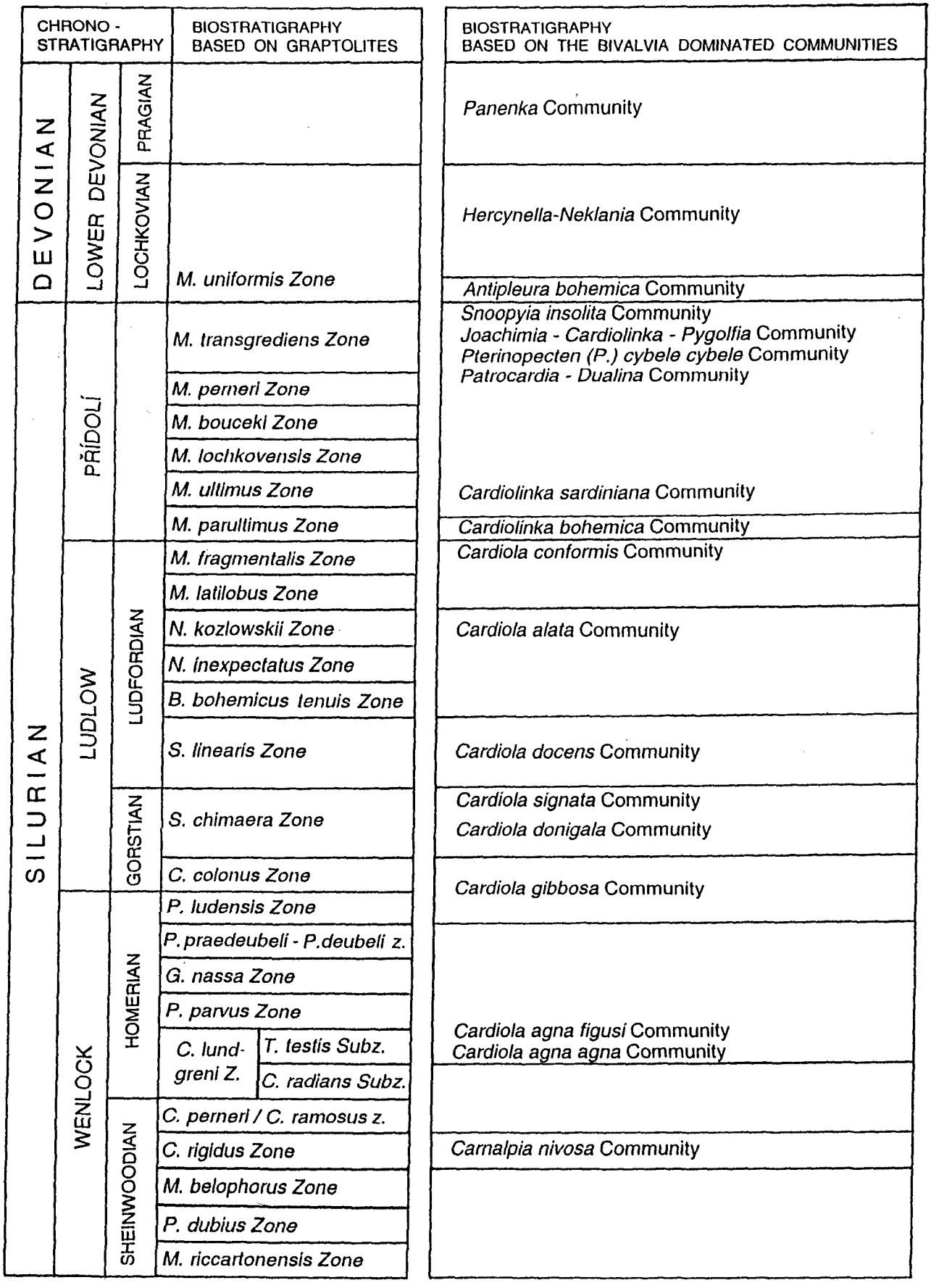
Changes in relationships between the Carnic Alps (Austria), Montagne Noire (France), Sardinia (Italy) and the Prague Basin (Bohemia) during the Silurian can be best demonstrated by the species distribution of the most intensively studied family Cardiolidae (KŘÍŽ, 1979, 1966 and KŘÍŽ in KŘÍŽ & SERPAGLI, 1993).

In the Sheinwoodian (Text – Fig. 7) 12 species representing six different genera (*Cardiobeleba, Carnalpia, Cardicarnia, Cominicula, Cardiolopsis* and *Cardiola*) are known from the Carnic Alps. From other regions (Prague Basin and the Montagne Noire) only two related species of the genus *Cardiobeleba* are known.

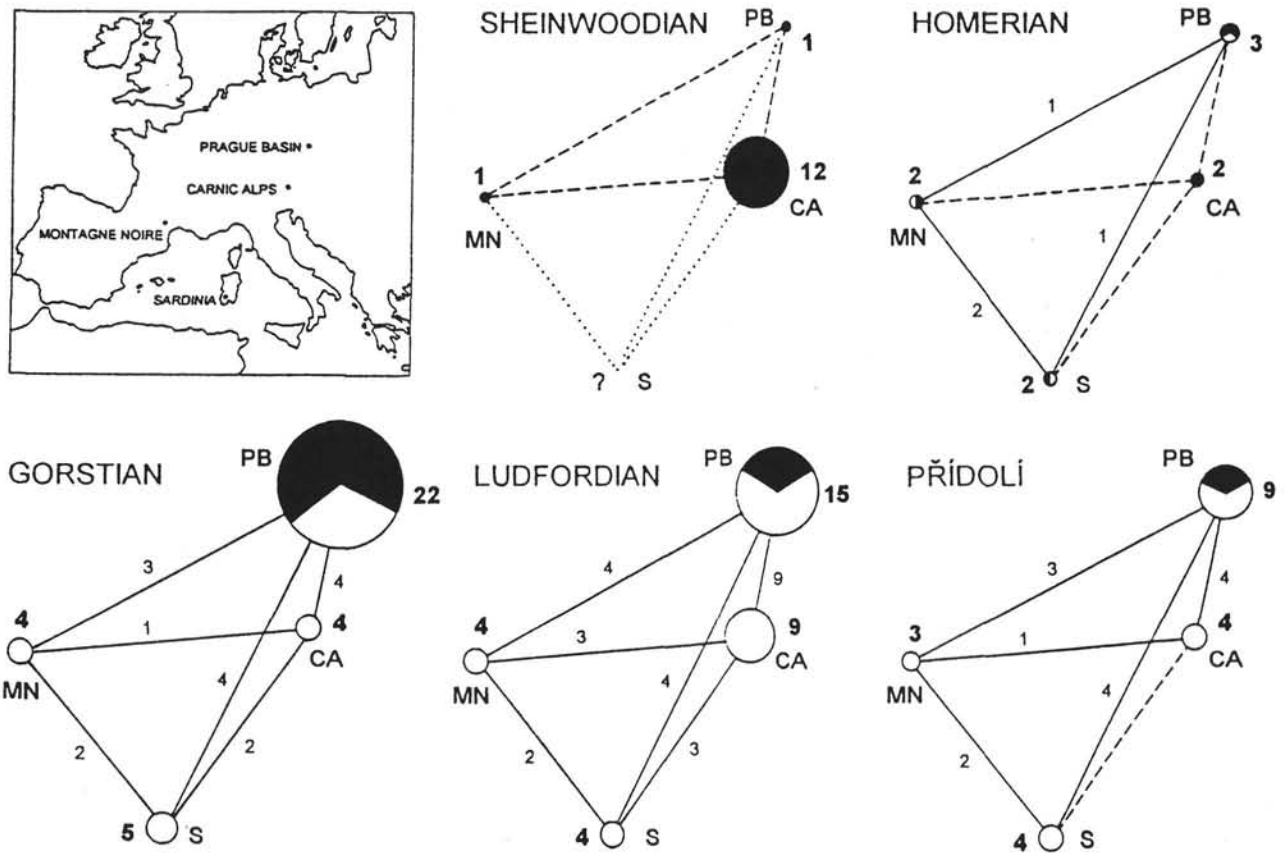
Relationships change slightly during the Homerian (Text – Fig. 7). From the Prague Basin three species are known. *Nutricula gravida* is known only from the Prague Basin but *Isiola lyra* is known also from the Montagne Noire and Sardinia. The species *Cardiola agna* from the Prague Basin is closely related to the species *Cardiola figusi* which occurs in Sardinia and the Montagne Noire and demonstrates somewhat closer relationships between these regions than with the Carnic Alps. Here two species occur, which are not known from other regions (*Cardiola schoenlaubi* sp. n. and *Isiola zila* sp. n.) but they are very closely related to the species *Cardiola figusi* and *Cardiola agna* and to the species *Isiola lyra*.

The situation changes dramatically in the Gorstian (Text – Fig. 7) where in the Prague Basin 22 species of the Cardiolidae representing mostly the genus *Cardiola* occur. Seven Bohemian species are known from other regions. It is interesting that between the Carnic Alps and the Prague Basin there are closer relationships (4 common species) than with Sardinia (two species) and Montagne Noire (just one species).

During the Ludfordian (Text – Fig. 7) the number of species in the Prague Basin slightly decreases (15), but the relationship with other regions increases when compared with the Gorstian (10 species in common). The closest relationship existed between the Prague Basin and the Carnic Alps with 9 species in common. During this time there are less species common to the Prague Basin, the Montagne Noire and Sardinia and this shows a slow decrease occured in the relationship between those regions. The same decrease in




Text–Fig. 6.
Biostratigraphy of the Silurian based on the Bivalvia dominated communities.




Text–Fig. 7.
Relationships between the Carnic Alps (CA), Montagne Noire (MN), Sardinia (S) and the Prague Basin (PB) during the Silurian, based on the distribution of the Cardiolidae species and genera. Bold numbers near the pie chart = total number of the species in the region; dark slice of the pie chart = total number of the species known only in that region; solid line connecting the regions with number shows relationships between the regions at species level and number of common species to the two compared regions; dashed lines express the relationship between the regions at generic level only; dotted lines express the supposed relationship between the regions at generic level

the relationship occured between the Carnic Alps, the Montagne Noire and Sardinia.

In the Přídolí (Text – Fig. 7) the number of species further decreases in the Prague Basin (9). The relationship with other regions is approximately similar to that in the Ludfordian (9 species in common). Few species are common between the Carnic Alps, the Montagne Noire and Sardinia but this is mainly because different facies and a strong reduction in sedimentation existed during the Přídolí in the Carnic Alps.

A similar situation may be also seen with other families (Antipleuridae, Lunulacardiidae and Butovicellidae). A very close relationship between the Carnic Alps and the Prague Basin is demonstrated at the Přídolí – Lochkov (Silurian – Devonian) boundary where many common representatives of the Antipleuridae and Lunulacardiidae occur in both regions. Again, more species are known from the Prague Basin than from the Carnic Alps.

In general, the sedimentation conditions during the upper Ludlow were not favourable for bivalves in the Carnic Alps. The *Cardiolinka bohemica* Community occurs only at the base of the Přídolí with a very low diversity, which indicates very restricted conditions.

In the uppermost Přídolí the conditions for bivalves improved in the shallowest known Wolayer Facies (SCHÖNLAUB, 1998a). The black limestones here contain the *Patrocardia–Dualina* Community – *Dualina nigra–Patrocardia* Subcommunity. The *Antipleura bohemica* Community occurs just above in the lower Lochkovian (Devonian) black micritic limestones in the same shallow water Wolayer Facies. Both communities show very close relationships with the Prague Basin (Perunica).

### 5. 3. Chronostratigraphic Position of the Cardiola Formation

It is interesting that the upper limit of the Cardiola Formation, Ludlow, is according to bivalves, not isochronous at different localities within the Carnic Alps Basin itself. At the Mt. Cellon Section, at the Rauchkofel Boden Section and Hoher Trieb Section it is developed only within the time interval corresponding to the range of the *Cardiola docens* Community, while at the Base of Seewarte Section the Cardiola Formation extends into the later time interval in which the *Cardiola pectinata* Subcommunity existed. When correlated with the Prague Basin region, where the correlation with graptolite zones is well established, the *Cardiola docens* Community flourished in the *Saetograptus linearis* Zone (KŘÍŽ, 1998a) and the *Cardiola pectinata* Subcommunity flourished in the later *Neocucullograptus kozlowskii* Zone.

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## 7. Abbreviations used in this work

A – articulated shells
AA – percentage relative abundance of articulate shells
CGS – collections of the Czech Geological Survey
GBA – collections of the Geologische Bundesanstalt, Vienna.
R – rank abundance
RA – percentage relative abundance
R + L – right and left valves (disarticulated).

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