

Middle Frasnian (Devonian) ostracods from the Frasnes railway section (Dinant Synclinorium, Belgium); taxonomy, biostratigraphy, paleoecology

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Abstract

Eighty-nine samples have been collected for ostracods, from the stratotypes for the upper part of the Moulin Liénaux Formation and the Grands Breux Formation, in the Frasnes railway section. Forty-seven taxa were recognised, of which 20 have been recorded for the first time in the Middle Frasnian (Devonian) of the Dinant Synclinorium (Belgium). The stratigraphic distributions of a series of already known species are stated more precisely. The investigated part of the section belongs to the *Favulella lecomptei* Zone. A new species, *Bairdiacypris breuxensis* nov. sp. is described. The ostracods present in the upper part of the Moulin Liénaux Formation and in the Grands Breux Formation belong exclusively to the Eifelian Mega-Assemblage and their distribution is principally controlled by the energy of the environment, linked to sea level fluctuations.

Keywords: Ostracods, Palaeoecology, Middle Frasnian, Devonian, Dinant Synclinorium, Belgium.

Résumé

Quatre-vingt-neuf échantillons ont été récoltés pour l'étude des ostracodes dans les stratotypes de la partie supérieure de la Formation du Moulin Liénaux et de la Formation des Grands Breux situés dans la tranchée du chemin de fer de Frasnes. Quarante-sept taxons sont reconnus dont 20 pour la première fois dans le Frasnien Moyen (Dévonien) du Bassin de Dinant (Belgique). La distribution stratigraphique d'une série d'espèces déjà reconnues est précisée. La partie de la coupe étudiée appartient à la Zone à *Favulella lecomptei*. Une nouvelle espèce, *Bairdiacypris breuxensis* nov. sp. est décrite. Les ostracodes présents dans la partie supérieure de la Formation du Moulin Liénaux et dans la Formation des Grands Breux, appartiennent exclusivement au Méga-Assemblage de l'Eifel et leur distribution est principalement contrôlée par l'énergie du milieu lui-même lié aux variations de la bathymétrie.

Mots-clefs: Ostracodes, Paléocéologie, Frasnien Moyen, Bassin de Dinant, Dévonien, Belgique.

Introduction

A large number of ostracod species are known from the Frasnian of the type region (southern border of the Dinant Synclinorium, Belgium), but their stratigraphical distribution is poorly constrained. In order to define their ranges more precisely, we have begun the study of ostracods present in several classic reference sections, taking advantage of the recently re-examined lithostratigraphy of the Frasnian in the type locality, by the Belgian Subcommission on Devonian Stratigraphy (BOULVAIN *et al.*, 1999). This paper presents the distribution of ostracods in the famous Frasnes railway section, which exposes the stratotypes for the upper boundary of the Moulin Liénaux Formation and the Grands Breux Formation.

The Frasnes railway section

The Frasnes railway section (Fig. 1) is located along the Couvin-Charleroi line (SNCB 134 line) at Frasnes, and on both sides of the bridge holding up the road connecting the N5 (Philippeville-Couvin) to Boussu-en-Fagne (GPS: N50°04'311; E4°30'381).

The Frasnes railway section has been briefly described and schematised in 1963 by LECOMPTE, and later studied for conodonts by MOURAVIEFF (1974), VANDELAER *et al.* (1989) and SANDBERG *et al.* (1992). In 1994, COEN-AUBERT described and schematised the Frasnes railway section in more detail.

This section was proposed as the stratotype for the Grands Breux Formation by COEN-AUBERT (1994), and has been confirmed as such by the Belgian Subcommission on Devonian Stratigraphy (see BOULVAIN *et al.*, 1999).

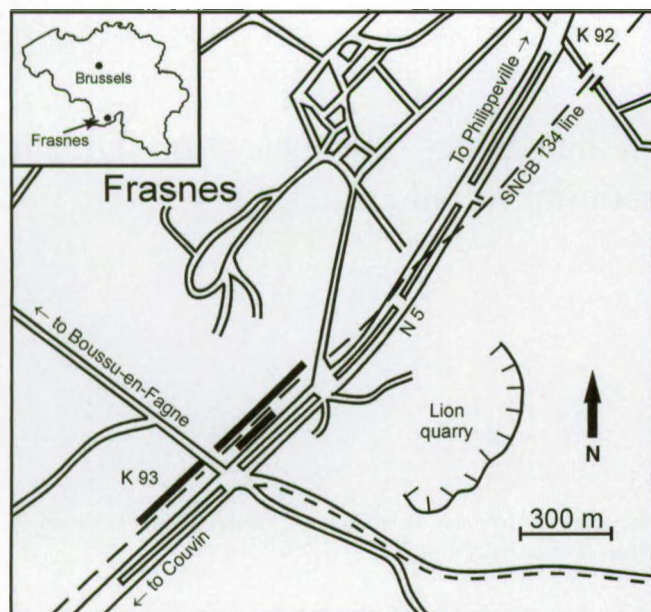


Fig. 1 — Geographic location of the Frasnian railway section.

The section is also the stratotype for the upper boundary of the underlying Moulin Liénaux Formation, established by BULTYNCK and MOURAVIEFF (*in* BOULVAIN *et al.*, 1999).

The Frasnian railway section (Fig. 2) exposes the upper 4.4 m of greenish shales belonging to the Ermitage Member of the Moulin Liénaux Formation. Some calcareo-argillaceous nodules are present in the top of the member. The Ermitage Member is overlain by the Grands Breux Formation, which is subdivided into two members: the Bieumont Member and the Boussu-en-Fagne Member. The base of the Bieumont Member is composed of 14.5 m of well-bedded, greyish, massive limestones, becoming more argillaceous upward. The upper part of the Bieumont Member is composed of 24 m of shales, rich in limestone lenses and calcareo-argillaceous nodules. The Boussu-en-Fagne Member is about 80 m thick and consists mainly of greenish shales with calcareo-argillaceous nodules and some thin limestone lenses in the upper part. The overlaying Neuville Formation and Matagne Formation are not studied herein.

Previous studies on ostracods in the Frasnian railway section

In 1977, CASIER recorded from the upper part of the Boussu-en-Fagne Member exposed in the Frasnian railway section: *Cryptophyllus* cf. *materni* (BASSLER & KELLETT, 1934), *Uchtovia materni* BECKER, 1971, *Asturiella blessi* BECKER, 1971, *Hollinella* indet., *Favulella lecomptei* BECKER, 1971, *Polytilites rabieni* BECKER, 1971, *Scrobicula capsula* BECKER, 1971, *Nodella* sp., *Urftella* sp. and *Aechminella* sp. He also recorded "*Kloedenia*" *dillensis* (MATERN, 1929) in the base of the Late Frasnian Matagne Formation (not studied herein).

In 1982, CASIER recorded from the base of the Late Frasnian Matagne Formation Member exposed in the Frasnian railway section (not studied herein): *Entomoprimitia* (*Entomoprimitia*) *concentrica* (MATERN, 1929), *E. (E.) sartenaeri* CASIER, 1975, *E. (E.)* cf. *nitida* (ROEMER, 1850), *E. (E.)* aff. *kayseri* WALDSCHMIDT, 1885, *Entomozoe* (*Nehdentomis*) *tenera* GÜRICH, 1896, and *Richterina* (*Volkina*) *zimmermanni* VOLK, 1939.

Previous studies on Middle Frasnian ostracods in the type region

In the Boussu-en-Fagne Member, MATERN (1929) recorded from "Les Abannets" close to Nismes: *Tetrasulcata fluens* MATERN, 1929 (= ? *Polyzygia neodevonica*), *Drepanellina laqueus* MATERN, 1929 [reported by BECKER (1971) to the genus *Plagionephrodes*], *Dizygopleura neodevonica* MATERN, 1929 (now ascribed to the genus *Polyzygia*), *Eridoncha rugosa* ULRICH & BASSLER, 1923 [= *Cryptophyllus materni* (BASSLER & KELLETT, 1934)], *Beyrichia* n. sp. A (an indeterminate ostracod) and *Bollia belgica* MATERN, 1929.

The most important contribution to the study of Middle Frasnian ostracods in the type region has been carried out by BECKER (1971). He described ostracods from a sample collected from the base of the Boussu-en-Fagne Member, which outcrops in the access path to the Lion quarry and very close to the reef (about 2 m), including: *Adelphobolbina europaea* BECKER & BLESS, 1971, *Hollinella* (*Keslingella*) sp. A, *H. (K.) lionica* BECKER & BLESS, 1971, *H. (K.)* sp. B, *H. (K.)* sp. C, *Parabolbinella vomis* BECKER & BLESS, 1971, *Urftella*? sp. A, *Amphissites* cf. *parvulus* (PAECKELMANN, 1913), *Polytilites rabieni* BECKER, 1971, *Amphissella* sp. A, *Roundyella* sp. A, *Scrobicula capsula* BECKER, 1971, *Aechmina* sp. A, *Moorites fallax* BECKER, 1971, *Aechminella minima* (LETHIERS, 1970), *Refrathella incompta* BECKER, 1971, *Nodella lefevrei* BECKER, 1971, *Nodella* sp. A, *Uchtovia materni* BECKER, 1971, *Hypotetragona tremula* BECKER, 1971, *Samarella* sp. A, *Cavellina* cf. *caduca* MCGILL, 1963, *Asturiella blessi* BECKER, 1971, *Plagionephrodes laqueus* (MATERN, 1929), *P?* *ineptus* BECKER, 1971, *Polyzygia neodevonica* (MATERN, 1929), *P.* cf. *neodevonica* (MATERN, 1929), *Favulella lecomptei* BECKER, 1971, *Jenningsina lethiersi* BECKER, 1971, *Quasillites geminatus* BECKER, 1971, *Graphiadactyllis frasnica* BECKER, 1971, *Svantovites magnei* BECKER, 1971, *S. inops* BECKER, 1971, *Punctomosea weyanti* BECKER, 1971, *Microcheilinella* sp. A, *Healdianella* sp. A, *H?* sp. B, *Orthocypris* sp. A, *Bairdia* (*Cryptobairdia*) sp. A, *Bairdia* (*Rectobairdia*) sp. A, *B. (R.)* sp. B, *B. (R.) paffrathensis* KUMMEROW, 1953, *Processobairdia* cf. *dorsonoda* (BLUMENSTENGEL, 1967), *Acratia* sp. B, *Schneideria?* *groosae* BECKER, 1971, *Cryptophyllus* cf. *materni* (BASSLER & KELLETT, 1934).

Finally, CASIER (1977) recorded from the Boussu-en-Fagne Member exposed formerly in the Ermitage path at Boussu-en-Fagne: *Healdianella?* sp. B, *Plagionephrodes*

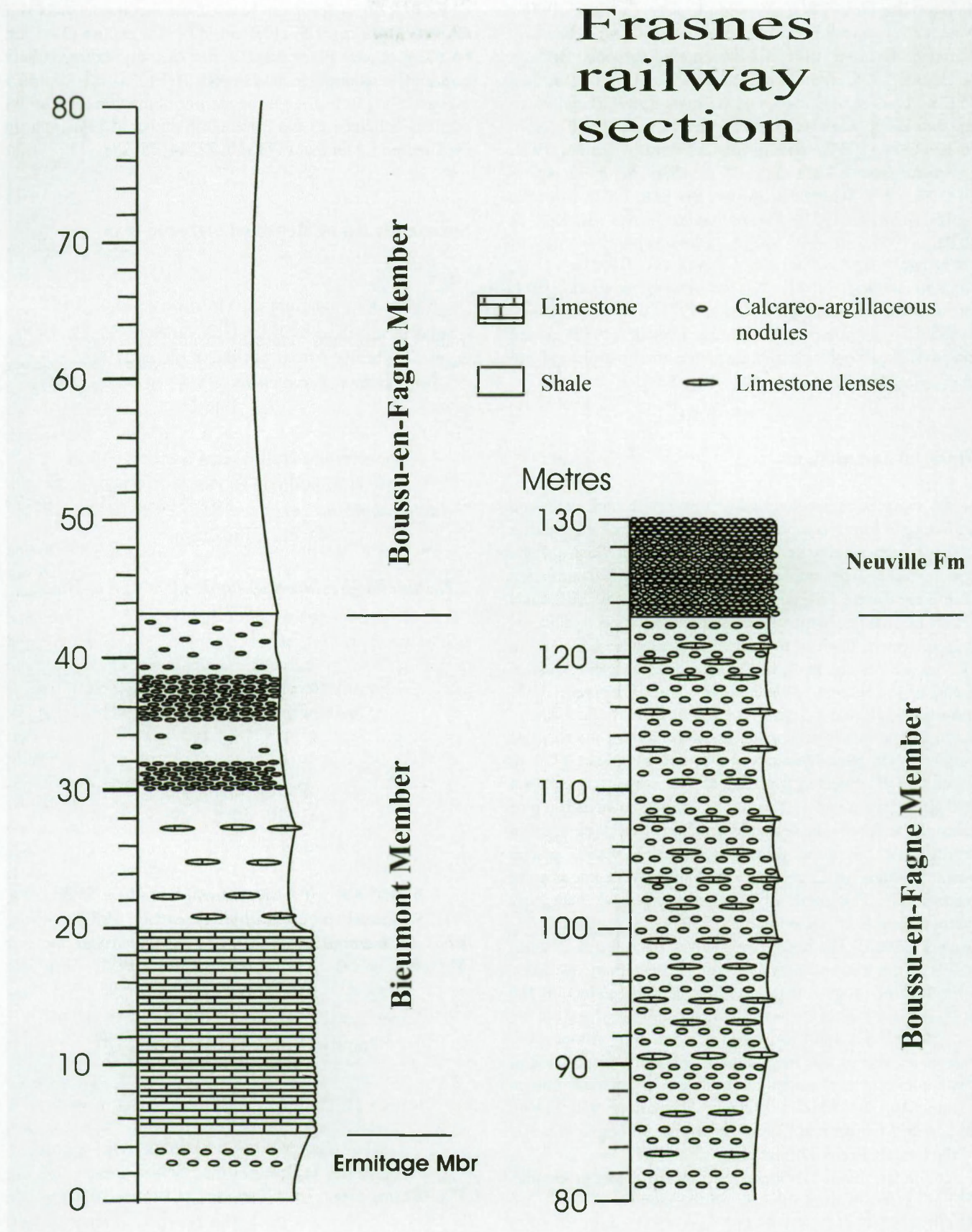


Fig. 2 — Lithological column of the upper part of the Moulin Liénaux Formation (Ermitage Member) and of the Grands Breux Formation (Bieumont Member and Boussu-en-Fagne Member). For the position of samples, see tables where their height from the bases of members is indicated.

ineptus BECKER, 1971, *Bekena beckeri* LETHIERS, 1974?, *Nodella*? cf. *hamata* BECKER, 1968, *Bairdia* sp., *Favulella lecomptei* BECKER, 1971, *Adelphobolbina europaea* BECKER & BLESS, 1971, *Amphissites* cf. *parvulus* (PAECKELMANN, 1913), *Polyzygia neodevonica* (MATERN, 1929), *Puntomosea weyanti* BECKER, 1971, *Cryptophyllus* cf. *materni* (BASSLER & KELLETT, 1934), *Jenningsina lethiersis* BECKER, 1971, *Uchtovia materni* BECKER, 1971, *Microcheilinella* sp. A BECKER, 1971, *Svantovites magnei* BECKER, 1971, *Asturiella blessi* BECKER, 1971, *Parabolbinella vomis* BECKER & BLESS, 1971, *Healdia* sp. A, *Plagionephrodes laqueus* (MATERN, 1929), *Quasillites geminatus* BECKER, 1971, *Nodella* BECKER, 1971, *Nodella lefevrei* BECKER, 1971, and *Refrathella incompta* BECKER, 1971. In a special paper devoted to entomozoid ostracods, CASIER (1982) added *Ungerella* sp. Now the Ermitage path is totally asphalted and the section is inaccessible.

Material and methods

Seven samples of approximately 500 g each and numbered CFF-1 to 7 were collected in the upper part of the Moulin Liénaux Formation exposed on the western flank of the trench. Eighty-two samples of the same weight and numbered CFF-8 to 80 and CFF-100 to 110 were collected in the Grands Breux Formation. Samples CFF-1 to 80 have been collected on the western flank of the trench, and samples CFF-100 to 109 on the eastern flank of the trench because the view of a part of the section is blocked by a wall. Carbonate rocks have been selected except in the top of the Moulin Liénaux Formation which is principally argillaceous. All the samples were crushed by a hydraulic press, and samples CFF-1 to 4 and CFF-7 collected from shales were directly sieved on 100 µm, 250 µm and 1600 µm mesh screens. About 100 g of each of the other samples collected from limestone or from argillaceous limestone were attacked with 99.8% glacial acetic, at nearly 90°C, generally for four days at a rate of eight hours a day. This mode of extraction called hot acetolysis method has been described by LETHIERS & CRASQUIN-SOLEAU (1988). The residue was sieved on 100 µm, 250 µm and 1600 µm mesh screens. For samples containing ostracods after this first process, that part of the sample retained by the 1600 µm mesh screen was again attacked by acid and sieved on 250 µm and 1600 µm mesh screens only. About 1400 carapaces, valves and fragments of ostracods identifiable at any taxonomic level were thus extracted, 230 in the Ermitage Member of the Moulin Liénaux Formation, 950 in the Bieumont Member and 220 in the Boussu-en-Fagne Member of the Grands Breux Formation.

In the Bieumont Member ostracods are absent in samples CFF-33 (10.6 m from the base of the member), 34 (11 m), 42 (13.9 m), 43 (14.3 m), 44 (14.7 m), 45 (15.4 m), 46 (16.1 m), 47 (16.5 m) and 100 (36 m). Ostracods are rare and unidentifiable in samples CFF-16 (4.4 m), 31 (10 m), 52 (20.7 m), 53 (22.3 m), 58 (29.4 m), and 59 (30.2 m). In the Boussu-en-Fagne Member ostracods are absent in samples

CFF-101 (2.0 m from the base of the member), 104 (11.5 m), 105 (14.5 m), 106 (17.2 m), 62 (35.2 m), 64 (38.2 m), 66 (42.0 m), 69 (47.9 m) and 80 (78.1 m). Ostracods are rare and unidentifiable in samples 109 (28.0 m), 71 (53.9 m), and 79 (76.1 m). Ostracods are abundant only in six samples collected in the Ermitage Member (CFF-6) and in the Bieumont Member (CFF-10, 22, 24, 25, 27).

Systematic list of identified ostracod taxa

Suborder Palaeocopina HENNINGSMOEN, 1953

Superfamily Kirkbyoidea ULRICH & BASSLER, 1906

Family Amphissitidae KNIGHT, 1928

Amphissites cf. *parvulus* (PAECKELMANN, 1913)

Pl. 1, Fig. 1

Superfamily Hollinoidea SWARTZ, 1936

Family Hollinellidae BLESS & JORDAN, 1971

Adelphobolbina europaea BECKER & BLESS, 1971

Pl. 1, Fig. 2a-b

Hollinella (*Keslingella*) *lionica* BECKER & BLESS, 1971?

Pl. 1, Fig. 3

Family Scrobiculidae POSNER, 1951

Scrobicula capsula BECKER, 1971

Pl. 1, Fig. 4a-b

Family unknown

Hollinoidea indet.

Pl. 1, Fig. 5

Superfamily Youngielloidea KELLETT, 1933

Family Youngiellidae KELLETT, 1933

Youngiella sp. F5 in MAGNE (1964).

Pl. 1, Fig. 6a-b

Superfamily Primitiopsioidea SWARTZ, 1936

Family Urftellidae BECKER, 1970

Urftella? sp. B

Pl. 1, Fig. 7

Superfamily unknown

Family Aechminellidae SOHN, 1961

Balantoides cf. *minima* (LETHIERS, 1970).

Pl. 1, Fig. 8

Family Kirkbyellidae SOHN, 1961

Refrathella sp. A

Pl. 1, Fig. 9a-b

Suborder Paraparchiticipina GRAMM in GRAMM &
IVANOV (1975)

Superfamily Paraparchitoidea SCOTT, 1959

Family Paraparchitidae SCOTT, 1959

Paraparchites sp. A

Pl. 1, Fig. 10a-b

Samarella sp. B

Pl. 1, Fig. 11

Suborder Platycopina SARS, 1866

Superfamily Kloedenelloidea ULRICH & BASSLER,
1908

Family Kloedenellidae ULRICH & BASSLER, 1908

Uchtovia materni BECKER, 1971

Pl. 1, Figs 12a-b, 13

Family Cavellinidae EGOROV, 1950

Cavellina? sp. indet.

Pl. 1, Fig. 14

Suborder Platycopina SARS, 1866?

Superfamily unknown

Famille Geisinidae SOHN, 1961

Hypotetragona tremula BECKER, 1971

Pl. 1, Fig. 15a-b

Suborder Metacopina SYLVESTER-BRADLEY, 1961

Superfamily Healdioidea HARLTON, 1933

Family Healdiidae HARLTON, 1933

Cytherellina sp. A

Pl. 1, Fig. 16a-b

Cytherellina? sp. B

Pl. 1, Fig. 17

Superfamily Thlipsuroidea ULRICH, 1894

Family Thlipsuridae ULRICH, 1894

Polyzygia neodevonica (MATERN, 1929)

Pl. 1, Figs 18, 19

Polyzygia neodevonica aragonensis GOZALO &
SANCHEZ DE POSADA, 1986

Pl. 1, Fig. 20

Favulella lecomptei BECKER, 1971

Pl. 2, Figs 1a-b, 2

Favulella lecomptei spissa ŻBIKOWSKA, 1983

Pl. 2, Fig. 3

Family Bufinidae SOHN & STOVER, 1961

Punctomosea weyanti BECKER, 1971

Pl. 2, Figs 6a-b, 7a-b

Punctomosea weyanti spiny subsp.

Pl. 2, Fig. 8a-b

Family Quasillitidae CORYELL & MALKIN, 1936

Jenningsina lethiersi BECKER, 1971

Pl. 2, Fig. 9

Svantovites magnei BECKER, 1971

Pl. 2, Figs 10, 11a-b

Family Ropolonellidae CORYELL & MALKIN, 1936

Plagionephrodes laqueus (MATERN, 1929)

Pl. 2, Figs 12, 13a-b

Superfamily Thlipsuroidea ULRICH, 1894?

Family unknown

Asturiella blessi BECKER, 1971

Pl. 2, Fig. 4a-b

Asturiella blessi spiny subsp.

Pl. 2, Fig. 5

Suborder Podocopina SARS, 1866

Superfamily Bairdiocypridoidea SHAVER, 1961

Family Bairdiocyprididae SHAVER, 1961

Healdianella sp. A in BECKER (1971)

Pl. 2, Fig. 14a-b

Healdianella? sp. indet.

Pl. 2, Fig. 15a-b

Bairdiocypris sp. 5 in MAGNE (1964)

Pl. 2, Fig. 16a-b

Bairdiocypris sp. A

Pl. 2, Fig. 17

Bairdiocypris sp. B

Pl. 2, Fig. 18a-b, Pl. 3, Figs 1, 2

Family Bairdiocyprididae SHAVER, 1961?

Orthocypris sp. A in BECKER (1971)

Pl. 3, Fig. 3a-b

Family Pachydomellidae BERDAN & SOHN, 1961

Tubulibairdia sp. A, aff. *T. clava* (KEGEL, 1933)

Pl. 3, Figs 4a-b, 5

Microcheilinella sp. A

Pl. 3, Fig. 6a-b

Superfamily Bairdioidea SARS, 1888

Family Acratiidae GRÜNDEL, 1962

Acratia evlanensis EGOROV, 1953

Pl. 3, Fig. 7a-b

Family Bairdiidae SARS, 1888

Bairdia (*Rectobairdia*) *paffrathensis* (KUMMEROW, 1953)

Pl. 3, Fig. 8a-b

Bairdia (*R.*) sp. B, aff. *B. (R.) paffrathensis*

(KUMMEROW, 1953)

Pl. 3, Fig. 9a-b

Bairdia (*R.*) sp. A in BECKER (1971)

Pl. 3, Fig. 10a-b

Bairdia (*R.*) sp. C

Pl. 3, Fig. 11a-b

Bairdia (*Orthobairdia*) sp. B

Pl. 3, Fig. 12

Bairdia (*O.*) sp. A

Pl. 3, Fig. 13a-b

Bairdiacypris breuxensis nov. sp.

Pl. 3, Figs 14a-b, 15, 16

Bairdiacypris sp. B, aff. *B. martinae* CASIER &

LETHIERS, 1997

Pl. 3, Fig. 17a-b

Schneideria groosae BECKER, 1971

Pl. 3, Fig. 18

Suborder Myodocopina SARS, 1866

Superfamily Entomozoidea Pribyl, 1951

Entomozoidea? indet.

Order Eridostraca ADAMCZAK, 1961

Family Cryptophyllidae ADAMCZAK, 1961

Cryptophyllus sp. indet.

Pl. 3, Fig. 19

Description of a new *Bairdiacypris* BRADFELD, 1935

Bairdiacypris breuxensis nov. sp.

Pl. 3, Figs 14a-b, 15, 16

Derivatio nominis

From the Grands Breux Formation.

Types

Holotype: Carapace (Pl. 3, Fig. 14a-b), CFF-10, Bieumont Mbr., IRScNB n° b4918, L = 0.81 mm; H = 0.47 mm; W = 0.29 mm. Paratype A: Carapace (Pl. 3, Fig. 15), CFF-76, Boussu-en-Fagne Mbr., IRScNB n° b4919, L = 0.67 mm; H = 0.41 mm; W = 0.27 mm. Paratype B: Carapace (Pl. 3, Fig. 16), CFF-68, Boussu-en-Fagne Mbr., IRScNB n° b4920, L = 0.78 mm; H = 0.46 mm; W = 0.31 mm.

Locus typicus

Frasnes railway section, Belgium.

Stratum trypticum

Middle Frasnian. Devonian. Grands Breux Formation.

Material

12 carapaces and several valves.

Diagnosis

Species of *Bairdiacypris* with strongly asymmetrical valves. Dorsal border of the right valve long and straight forming a 145° angle with the straight antero-dorsal border. In right lateral view, left valve of adult highly prominent in the postero-ventral sector.

Description

Middle sized, preplete *Bairdiacypris* with very asymmetrical valves. Dorsal and anterior borders of the carapace regularly rounded. Posterior border of juveniles regularly rounded becoming slightly angular in adults. Ventral border of juveniles straight becoming slightly concave in adults. Great length at mid-height and great height generally before the mid-length. Right valve smaller comparatively to the left, with the dorsal and the antero-dorsal borders straight and forming a 145° angle. Anterior border of the right valve well rounded in the anterior and antero-ventral sectors. Posterior border of right valve well rounded, and ventral border slightly concave. In right lateral view, left valve of adult highly prominent in the postero-ventral sector. In dorsal view, elliptic with the great width at mid-length, and contact of valves sinuous. Carapace smooth.

Remarks

Bairdiacypris breuxensis nov. sp. is not so elongate compared to the majority of species belonging to this genera. *B. breuxensis* is distinguishable from all other species belonging to the genus by the character of the diagnosis.

Occurrence

Bairdiacypris breuxensis nov. sp. is known from the Frasnes railway section, in the upper part of the Moulin Liénaux Formation and in the Grands Breux Formation. The new species is also present in the Chalon Member of the Moulin Liénaux Formation in the Arche quarry located close to the Frasnes railway section. The study of ostracods present in the Arche quarry is in progress.

Discussion concerning the distribution of ostracods

The stratigraphic distribution of a series of species described by BECKER (1971) from a sample collected in the access path to the Lion quarry is stated more precisely within the Boussu-en-Fagne Member. In particular, the extension of the stratigraphic range of *Favulella lecomptei* (BECKER, 1971) and of *Plagionephrodes laqueus* (MATERN, 1929) to the top of the member, and consequently to the top of the Grands Breux Formation is of great interest because species belonging to the Thlipsuroidea are good biostratigraphic markers.

The stratigraphic distributions of *Scrobicula capsa* BECKER, 1971, *Bairdia* (*Rectobairdia*) sp. A in BECKER (1971), and of *Orthocypris* sp. A in BECKER (1971) are extended to the Bieumont Member of the Grands Breux Formation, and the stratigraphic distributions of *Plagionephrodes laqueus* (MATERN, 1929) and of *Healdianella* sp. A in BECKER (1971) are extended to the Ermitage Member of the Grands Breux Formation.

Moreover, the following 20 taxa have been recorded for the first time in the Middle Frasnian of the Dinant Synclinorium: *Acratia evlanensis* EGOROV, 1953, *Bairdia* (*Orthobairdia*) sp. A, *Bairdia* (*O.*) sp. B, *Bairdia* (*Rectobairdia*) sp. B, aff. *B. (R.) paffrathensis* KUMMEROW, 1953, *Bairdia* (*R.*) sp. C, *Bairdiacypris breuxensis* nov. sp., *Bairdiacypris* sp. A, *Bairdiacypris* sp. B, aff. *B. martinae* CASIER & LETHIERS, 1997, *Bairdiacypris* sp. A, *Bairdiacypris* sp. B, *Bairdiacypris* sp. 5 in MAGNE (1964), *Cytherellina* sp. A, *Cytherellina*? sp. B, *Microcheilinella* sp. A, *Paraparchites* sp. A, *Samarella* sp. B, *Tubulibairdia* sp. A, aff. *T. clava* (KEGEL, 1933), *Urftella*? sp. B, *Youngiella* sp. 5 in MAGNE (1964), and *Youngiella* sp.

Favulella lecomptei is relatively abundant and

regularly present in samples collected in the Ermitage, Bieumont and Boussu-en-Fagne Members. This species characterises a sub-zone established by LETHIERS (1974), but later elevated by CASIER (1979) to the rank of a zone in a biostratigraphic zonation established exclusively on Metacopina.

Discussion concerning the palaeoecology

Three mega-assemblages are recognised in the Devonian (CASIER, 2004): 1. The Myodocopida Mega-Assemblage characterised by entomozoid and (or) cyprinoid ostracods is indicative of poorly oxygenated marine environments; 2. The Thuringe Mega-Assemblage characterised by spiny ostracods is indicative of deep and (or) cold marine environments; 3. The Eifel Mega-Assemblage generally characterised by a rich and diversified ostracod fauna is indicative of shallow marine (neritic), semi-restricted or lagoonal environments. The Thuringe and Eifel Mega-Assemblages correspond to the Thuringe and Eifel ecotypes defined by Becker (in BANDEL & BECKER, 1975). In reality "ecotype" is improperly used in this case since the word indicates specimens belonging to one species but genetically adapted to a particular environment (CASIER, 2004; CASIER *et al.*, 2005).

The Thuringe Mega-Assemblage is absent in the Frasnes railway section. The sea was probably too warm during the Lower and Middle Frasnian in the Dinant Synclinorium, and the water conditions too poorly oxygenated during the late Frasnian for the spiny-ostracods belonging to the Thuringe Mega-Assemblage.

The Myodocopid Mega-Assemblage, which is indicative of poorly oxygenated water conditions (CASIER, 2004), is on the contrary well represented in the Late Frasnian Matagne Formation exposed in the Frasnes railway section (see CASIER, 1982).

The ostracods present in the upper part of the Moulin Liénaux Formation and in the Grands Breux Formation belong exclusively to the Eifelian Mega-Assemblage. Their abundance, diversity, and particularly the abundance of Podocopina, generally indicate a shallow marine environment.

In the Ermitage Member (Table 1), belonging to the Moulin Liénaux Formation, the ostracod fauna is indicative of a regressive trend: samples CF-1, CF-2 and CF-4 contain quasi exclusively ostracods belonging to the Metacopina. The environment was calm, poorly oxygenated, and below storm wave base. In sample CF-3, the ostracod fauna is more diverse: 4 species

Ermitage Member	1 0.2	2 0.5	3 1.1	4 2.1	5 3.1	6 3.6	7 4.2
<i>Punctomosea weyanti</i>	*	-	*	*	*	*	-
<i>Polyzygia neodevonica</i>	*	-	*	*	-	*	*
<i>Favulella lecomptei</i>	*	*	-	*	*	*	*
<i>Plagionephrodes laqueus</i>	-	*	-	-	-	-	-
<i>Adelphobolbina europaea</i>	-	*	-	-	-	-	-
<i>Cytherellina</i> sp. A	-	*	-	-	-	-	-
<i>Jenningsina lethiersi</i>	-	*	-	-	-	*	*
<i>Youngiella</i> sp.	-	-	?	-	-	-	-
<i>Bairdia</i> (R.) sp. B, aff. <i>B. (R.) paffrathensis</i>	-	-	*	-	-	-	-
<i>Hollinoidea</i> indet.	-	-	*	-	-	-	-
<i>Bairdiacypris breuxensis</i> nov. sp.	-	-	*	-	-	-	-
<i>Healdianella?</i> sp. indet.	-	-	*	-	-	*	-
<i>Asturiella blessi</i>	-	-	*	-	?	-	*
<i>Svantovites magnei</i>	-	-	*	-	-	*	*
<i>Healdianella</i> sp. A	-	-	-	?	?	*	-
<i>Bairdiocypris</i> sp. B	-	-	-	-	?	-	-
<i>Tubulibairdia</i> sp. A, aff. <i>T. clava</i>	-	-	-	-	*	-	-
<i>Bairdiocypris</i> sp. B, aff. <i>B. martinae</i>	-	-	-	-	-	*	-
<i>Amphissites</i> cf. <i>parvulus</i>	-	-	-	-	-	*	-
<i>Paraparchites?</i> sp. A	-	-	-	-	-	*	-
<i>Uchtovia materni</i>	-	-	-	-	-	*	*
<i>Acratia evlanensis</i>	-	-	-	-	-	-	?
<i>Cryptophyllus</i> sp. indet.	-	-	-	-	-	-	*

Table 1 — Distribution of ostracods in the Ermitage Member. In bold: sample numbers; in regular: location of samples, in meter above the base of the member.

belong to the Metacopina, 2 to the Palaeocopina, and 3 to the Podocopina. This composition is indicative of better oxygenated conditions, but the abnormally large number of instars in sample CF-3 indicates storm deposition. The greater number of species belonging to the Podocopina in samples CF-5 to CF-7, the entry of Platycopina in sample CF-6 and even of a Cryptophyllidae in sample CF-7 indicate better oxygenated water conditions, probably between fair weather and storm wave bases.

In the two first meters of the Bieumont Member (Table 2) belonging to the Grands Breux Formation (samples CF-8 to CF-11), and also between 5 and 8 m, the Podocopina dominate largely the ostracod fauna. Thick shelled *Tubulibairdia* and *Microcheilinella* are the most abundant species in this level. Moreover, in sample CF-9, dissociated and broken carapaces are very abundant. The environment was certainly well oxygenated, very shallow and sometimes strongly agitated, probably close to, and sometimes just above, fair weather wave base. Between 2 and 5 meters,

several Metacopina are also present, indicating a slight deepening. Above 8 m, the Metacopina are as much or more abundant than the Podocopina proving that the environment was below fair weather wave base. The rarity or even the absence of ostracods above 10 m is indicative of deep water conditions below storm wave base, especially between 12 m and 19 m.

In the Boussu-en-Fagne Member (Table 3), and particularly in the upper part of that member, ostracods are more abundant and diverse than in the upper part of the underlying member. The Podocopina and Metacopina are present together and the environment was presumably between fair weather and storm wave-base.

The Neuville Formation and the Matagne Formation have not been studied herein. In reality due probably to an increase in deepening, and (or?) to the increase in sedimentation rate, ostracods are extremely rare in the Neuville Formation. In the Matagne Formation, the environment became poorly oxygenated, as indicated by the entry of the Entomozoidea (CASIER, 1982). They belong to the Myodocopid Mega-Assemblage.

Bieumont Member	8	9	10	11	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	32	33	35	36	37	38	39	40	41	48	49	50	51	54	55	56	57	60	61		
	0.3	0.6	1.3	1.8	2.2	2.6	3.0	3.5	4.4	4.8	5.0	5.4	5.7	6.0	6.2	6.6	7.0	7.3	8.5	8.8	9.2	9.6	10.3	10.6	11.4	11.8	11.9	12.0	12.5	13.0	13.7	17.5	18.4	19.0	20.3	24.4	25.0	25.4	26.2	31.2	33.0		
<i>Tubulibairdia</i> sp. A, aff. <i>T. clava</i>	*	*	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*	*	*																						
<i>Plagionephrodes laqueus</i>	?				*			*	*		*								*	*	*				*																		
<i>Bairdia</i> (R.) <i>paffrathensis</i>	*	?	*											*	*	*	*		*	*	*										*												
<i>Uchtovia materni</i>		*	*	*																											*				?			*					
<i>Microcheilinella</i> sp. A		*		*						*				*																							*				*		
<i>Youngiella</i> sp. 5			*																																								
<i>Bairdia</i> (R.) sp. C			*																																								
<i>Samarella</i> sp. B			*														*																										
<i>Acratia evlanensis</i>			*														*																										
<i>Bairdiacypris</i> sp. B, aff. <i>B. martinae</i>			*											*		*	*																										
<i>Bairdiacypris breuxensis</i> nov. sp.			*	*																															?								
<i>Bairdiocypris</i> sp. B		*																																	*								
<i>Bairdia</i> (R.) sp. A			*										*	*		*																				?	*						
<i>Bairdia</i> (O.) sp. B			*		*							?		*	*	*	*																										
<i>Polyzygia neodevonica</i>					*	*				*									*	*	*		*					*									*						
<i>Favulella lecomptei</i>					*	*		*	*	*	*								*	*	*	*	*			*	*	*	*	*	*				*			*					
<i>Punctomosea weyanti</i>				*				*	*	*	*										*	*	*	*	*	*	*	*	*	*	*			*	*				*			*	
<i>Paraparchites</i> sp. A						*																																					
<i>Cytherellina?</i> sp. B						*																																					
<i>Hollinella</i> (Keslingella) <i>lionica</i>						*																																					
<i>Bairdiacypris</i> sp. indet.					*					*				*																													
<i>Orthocypris</i> sp. A							*																			*																	
<i>Asturiella blesi</i>								*	*	*									*	*	*				*							?	*	*	*	*		*	*				
<i>Healdianella</i> sp. A										*										*		*															*						
<i>Bairdiocypris</i> sp. A										*						*		*																			*						
<i>Balantoides</i> cf. <i>minima</i>													*																														
<i>Bairdia</i> (O.) sp. A													*				*																										
<i>Scrobicula capsae</i>														*										*																			
<i>Bairdiocypris</i> sp. 5															*				*		*																						
<i>Healdianella?</i> sp. indet.																*				*		*		*										*									
<i>Amphissites</i> cf. <i>parvulus</i>																							*		*																		
<i>Cavellina</i> ? sp. indet.																								*		*																	
<i>Svantovites magnei</i>																										?																	
<i>Hypotetragona tremula</i>																																		*									
<i>Refrathella?</i> sp. indet.																																			*								
Entomozoidea indet.																																						*					

Table 2 — Distribution of ostracods in the Bieumont Member. In bold: sample numbers; in regular: location of samples, in meter above the base of the member.

Boussu-en-Fagne Member	102 5.0	103 8.3	107 20.9	108 23.8	110 31.8	63 36.3	65 40.0	67 43.7	68 45.8	70 51.4	72 56.0	73 58.9	74 61.7	75 63.6	76 66.8	77 70.2	78 74.0
<i>Bairdiocypris</i> sp. indet.	*																*
<i>Refrathella?</i> sp. indet.		*															
<i>Bairdia</i> (R.) <i>paffrathensis</i>			?						?				*		*		
<i>Favulella lecomptei</i>			*				*			*		*	*			*	*
<i>Punctomosea weyanti</i>				*	*	*		*				*	*				
<i>Urtella?</i> sp. B							*										
<i>Bairdiocypris</i> sp. 5							*	*	*								
<i>Jenningsina lethiersi</i>							?								*		
<i>Uchtovia materni</i>							?			*		*	*		*	*	
<i>Asturiella blessi</i>							?		*	*		*	*		*		*
<i>Polyzygia neodevonica</i>							*		*				*		*	*	*
<i>Cryptophyllus</i> sp. indet.								*	*			*					
<i>Schneideria groosae</i>								?			*		?			?	
<i>Orthocypris</i> sp. A							*					?					*
<i>Bairdiocypris breuxensis</i>									*						*		*
<i>Healdianella</i> sp. A									*				*		*		*
<i>Plagionephrodes laqueus</i>										*					?	*	*
<i>Acratia evlanensis</i>														*		*	?
<i>Bairdiocypris</i> sp. A																?	
<i>Microcheilinella</i> sp. A																	*

Table 3 — Distribution of ostracods in the Boussu-en-Fagne Member. In bold: sample numbers; in regular: location of samples, in meter above the base of the member.

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Explanation of plates

The types are deposited in the collections of the Department of Paleontology of the Royal Belgian Institute of Natural Sciences (IRScNB n° b.....).

PLATE 1

- Fig. 1 — *Amphissites* cf. *parvulus* (PAECKELMANN, 1913), CFF-35, Bieumont Mbr., IRScNB n° b4867, right valve, x60.
- Fig. 2 — *Adelphobolbina europaea* BECKER & BLESS, 1971, CFF-2, Ermitage Mbr., IRScNB n° b4868, carapace, a. left lateral view, b. dorsal view, x50.
- Fig. 3 — *Hollinella* (*Keslingella*) *lionica* BECKER & BLESS, 1971?, CFF-13, Bieumont Mbr., IRScNB n° b4869, broken left valve, x70.
- Fig. 4 — *Scrobicula capsa* BECKER, 1971, CFF-22, Bieumont Mbr., IRScNB n° b4870, carapace, a. right lateral view, b. dorsal view, x105.
- Fig. 5 — *Hollinoidea* indet., CFF-3, Ermitage Mbr., IRScNB n° b4871, right valve, x95.
- Fig. 6 — *Yungiella* sp. F5 in MAGNE (1964), CFF-76, Boussu-en-Fagne Mbr., IRScNB n° b4872, carapace, a. right lateral view, b. dorsal view, x95.
- Fig. 7 — *Urftiella?* sp. B, CFF-65, Boussu-en-Fagne Mbr., IRScNB n° b4873, right lateral view of a carapace, x110.
- Fig. 8 — *Balantoides* cf. *minima* (LETHIERS, 1970), CFF-21, Bieumont Mbr., IRScNB n° b4874., left valve, x135.
- Fig. 9 — *Refrathella* sp. A, CFF-51, Bieumont Mbr., IRScNB n° b4875, carapace, a. left lateral view, b. dorsal view, x65.
- Fig. 10 — *Paraparchites* sp. A, CFF-6, Ermitage Mbr., IRScNB n° b4876, carapace, a. right lateral view, b. dorsal view, x80.
- Fig. 11 — *Samarella* sp. B, CFF-25, Bieumont Mbr., IRScNB n° b4877, right lateral view of a carapace, x45.
- Fig. 12 — *Uchtovia materni* BECKER, 1971, CFF-6, Ermitage Mbr., IRScNB n° b4878, carapace of a tecnomorph, a. left lateral view, b. dorsal view, x55.
- Fig. 13 — *Uchtovia materni* BECKER, 1971, CFF-11, Bieumont Mbr., IRScNB n° b4879, dorsal view of a heteromorph, x50.
- Fig. 14 — *Cavellina?* sp. indet., CFF-35, Bieumont Mbr., IRScNB n° b4880, left valve?, x115.
- Fig. 15 — *Hypotetragona tremula* BECKER, 1971, CFF-50, Bieumont Mbr., IRScNB n° b4881, carapace, a. right lateral view, b. dorsal view, x70.
- Fig. 16 — *Cytherellina* sp. A, CFF-2, Ermitage Mbr., IRScNB n° b4882, carapace, a. right lateral view, b. dorsal view, x60.
- Fig. 17 — *Cytherellina?* sp. B, CFF-13, Bieumont Mbr., IRScNB n° b4883, right lateral view of a carapace, x65.
- Figs 18-19 — *Polyzygia neodevonica* (MATERN, 1929). 18 = CFF-27, Bieumont Mbr., IRScNB n° b4884., left valve, x90; 19 = CFF-77, Boussu-en-Fagne Mbr., IRScNB n° b4885, left valve, x60.
- Fig. 20 — *Polyzygia neodevonica aragonensis* GOZALO & SANCHEZ DE POSADA, 1986, CFF-12, Bieumont Mbr., IRScNB n° b4886, right valve, x70.

PLATE 2

- Figs 1-2 — *Favulella lecomptei* BECKER, 1971. 1 = CFF-6, Ermitage Mbr., IRScNB n° b4887, carapace, a. left lateral view, b. dorsal view, x45; 2 = CFF-12, Bieumont Mbr., IRScNB n° b4888, right valve, x65.
- Fig. 3 — *Favulella lecomptei spissa* ŻBIKOWSKA, 1983, CFF-3, Ermitage Mbr., IRScNB n° b4889, right lateral view of a carapace, x70.
- Fig. 4 — *Asturiella blessi* BECKER, 1971, CFF-35, Bieumont Mbr., IRScNB n° b4890, carapace, a. right lateral view, b. dorsal view, x60.
- Fig. 5 — *Asturiella blessi* BECKER, 1971, spiny subsp., CFF-67, Boussu-en-Fagne Mbr., IRScNB n° b4891, right lateral view of a carapace, x50.
- Figs 6-7 — *Punctomosea weyanti* BECKER, 1971. 6 = CFF-6, Ermitage Mbr., IRScNB n° b4892, carapace, a. right lateral view, b. dorsal view, x60; 7 = CFF-51, Bieumont Mbr., IRScNB n° b4893, carapace, a. left lateral view, b. dorsal view, x55.
- Fig. 8 — *Punctomosea weyanti* BECKER, 1971, spiny subsp., CFF-38, Bieumont Mbr., IRScNB n° b4894, carapace, a. right lateral view, b. dorsal view, x55.

- Fig. 9 — *Jenningsina lethiersi* BECKER, 1971, CFF-76, Boussu-en-Fagne Mbr., IRScNB n° b4895, left valve, x75.
- Figs 10-11 — *Svantovites magnei* BECKER, 1971. 10 = CFF-6, Ermitage Mbr., IRScNB n° b4896, left valve, x65; 11 = CFF 7, Bieumont Mbr., IRScNB n° b4897, carapace, a. right lateral view, b. dorsal view, x50.
- Figs 12-13 — *Plagionephrodes laqueus* (MATERN, 1929). 12 = CFF-19, Bieumont Mbr., IRScNB n° b4898, left valve, x60; 13 = CFF-12, Bieumont Mbr., IRScNB n° b4899, carapace, a. right lateral view, b. dorsal view, x65.
- Fig. 14 — *Healdianella* sp. A BECKER, 1971, CFF-78, Boussu-en-Fagne Mbr., IRScNB n° b4900, carapace, a. right lateral view, b. dorsal view, x75.
- Fig. 15 — *Healdianella?* sp. indet., CFF-50, Bieumont Mbr., IRScNB n° b4901, carapace, a. right lateral view, b. dorsal view, x110.
- Fig. 16 — *Bairdiocypris* sp. 5 MAGNE, 1964, CFF-24, Bieumont Mbr., IRScNB n° b4902, broken carapace, a. right lateral view, b. dorsal view, x40.
- Fig. 17 — *Bairdiocypris* sp. A, CFF-23, Bieumont Mbr., IRScNB n° b4903, right lateral view of a carapace, x100.
- Fig. 18 — *Bairdiocypris* sp. B, CFF-23, Bieumont Mbr., IRScNB n° b4904, carapace, a. right lateral view, b. dorsal view, x50.

PLATE 3

- Figs 1-2 — *Bairdiocypris* sp. B, CFF-10, Bieumont Mbr., right lateral view of a carapace, 1 = IRScNB n° b4905, x60; 2 = IRScNB n° b4906, x95.
- Fig. 3 — *Orthocypris* sp. A BECKER, 1971, CFF-78, Boussu-en-Fagne Mbr., IRScNB n° b4907, carapace, a. right lateral view, b. dorsal view, x70.
- Figs 4-5 — *Tubulibairdia* sp. A, aff. *T. clava* (KEGEL, 1933), Bieumont Mbr. 4 = CFF-28, IRScNB n° b4908, carapace, a. right lateral view, b. dorsal view, x95; 5 = CFF-23, IRScNB n° b4909, right lateral view of a carapace, x30.
- Fig. 6 — *Microcheilinella* sp. A, CFF-19, Bieumont Mbr., IRScNB n° b4910, right lateral view of a carapace, x105.
- Fig. 7 — *Acratia evlanensis* EGOROV, 1953, CFF-10, Bieumont Mbr., IRScNB n° b4911, carapace, a. right lateral view, b. dorsal view, x85.
- Fig. 8 — *Bairdia* (*Rectobairdia*) *paffrathensis* (KUMMEROW, 1953), CFF-24, Bieumont Mbr., IRScNB n° b4912, carapace, a. right lateral view, b. dorsal view, x60.
- Fig. 9 — *Bairdia* (*R.*) sp. B, aff. *B. (R.) paffrathensis* (KUMMEROW, 1953), CFF-3, Ermitage Mbr., IRScNB n° b4913, carapace, a. right lateral view, b. dorsal view, x50.
- Fig. 10 — *Bairdia* (*R.*) sp. A in BECKER (1971), CFF-54, Bieumont Mbr., IRScNB n° b4914, carapace, a. right lateral view, b. dorsal view, x80.
- Fig. 11 — *Bairdia* (*R.*) sp. C, CFF-10, Bieumont Mbr., IRScNB n° b4915, broken carapace, a. right lateral view, b. dorsal view, x60.
- Fig. 12 — *Bairdia* (*Orthobairdia*) sp. B, CFF-23, Bieumont Mbr., IRScNB n° b4916, right lateral view of a broken carapace, x70.
- Fig. 13 — *Bairdia* (*O.*) sp. A, CFF-25, Bieumont Mbr., IRScNB n° b4917, carapace, a. right lateral view, b. dorsal view, x60.
- Figs 14-16 — *Bairdiocypris breuxensis* nov. sp. 14 = Holotype, CFF-10, Bieumont Mbr., IRScNB n° b4918, carapace, a. right lateral view, b. dorsal view, x50; 15 = Paratype A, CFF-76, Boussu-en-Fagne Mbr., IRScNB n° b4919, right lateral view of a carapace, x60; 16 = Paratype B, CFF-68, Boussu-en-Fagne Mbr., IRScNB n° b4920, right lateral view of a carapace, x55.
- Fig. 17 — *Bairdiocypris* sp. B, aff. *B. martiniae* CASIER & LETHIERS, 1997, CFF-24, Bieumont Mbr., IRScNB n° b4921, carapace, a. right lateral view, b. dorsal view, x55.
- Fig. 18 — *Schneideria groosae* BECKER, 1971, CFF-72, Boussu-en-Fagne Mbr., IRScNB n° b4922, right valve, x105.
- Fig. 19 — *Cryptophyllus* sp. indet., CFF-7, Ermitage Mbr., IRScNB n° b4923, right valve?, x70.

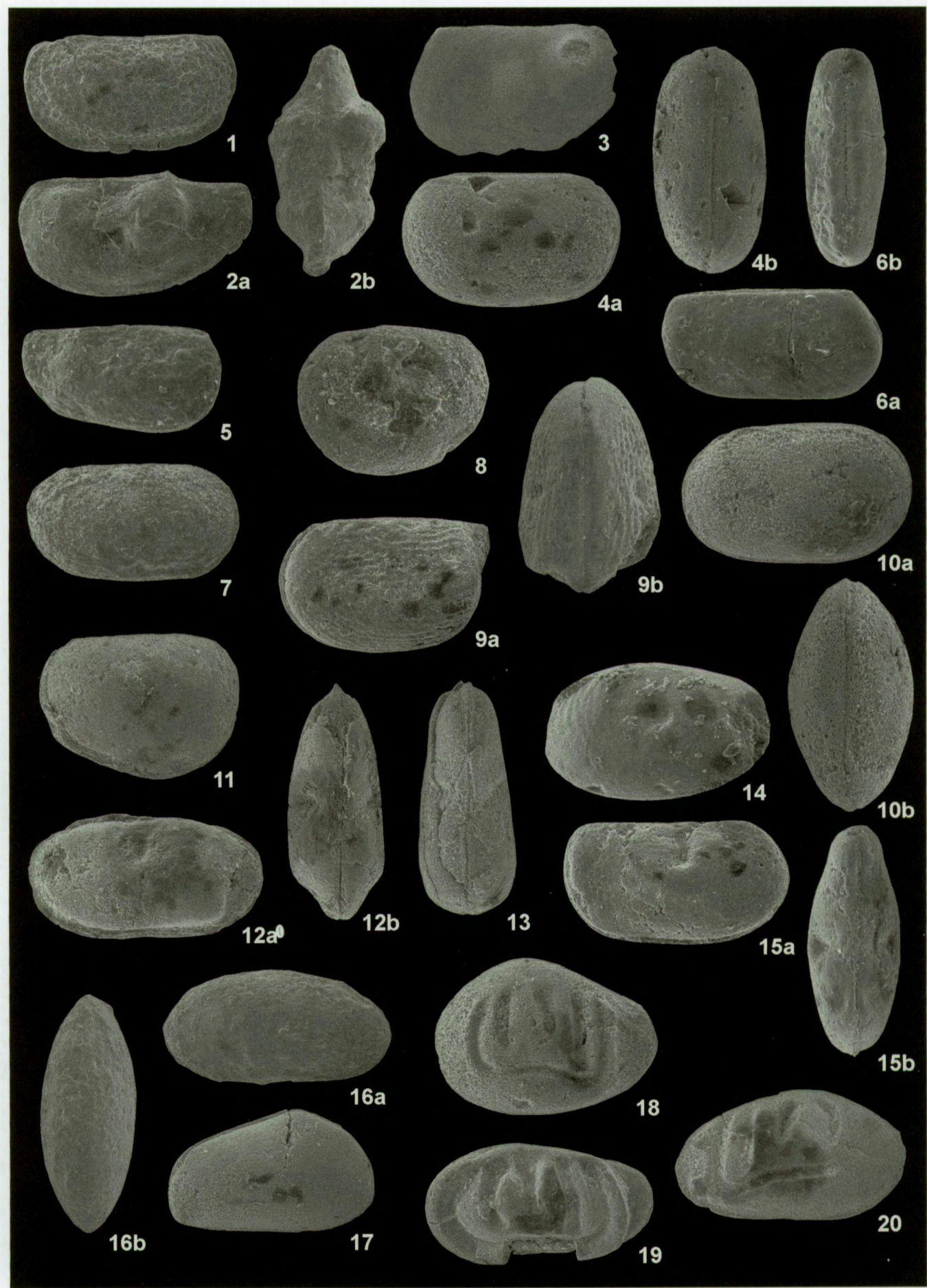


PLATE I

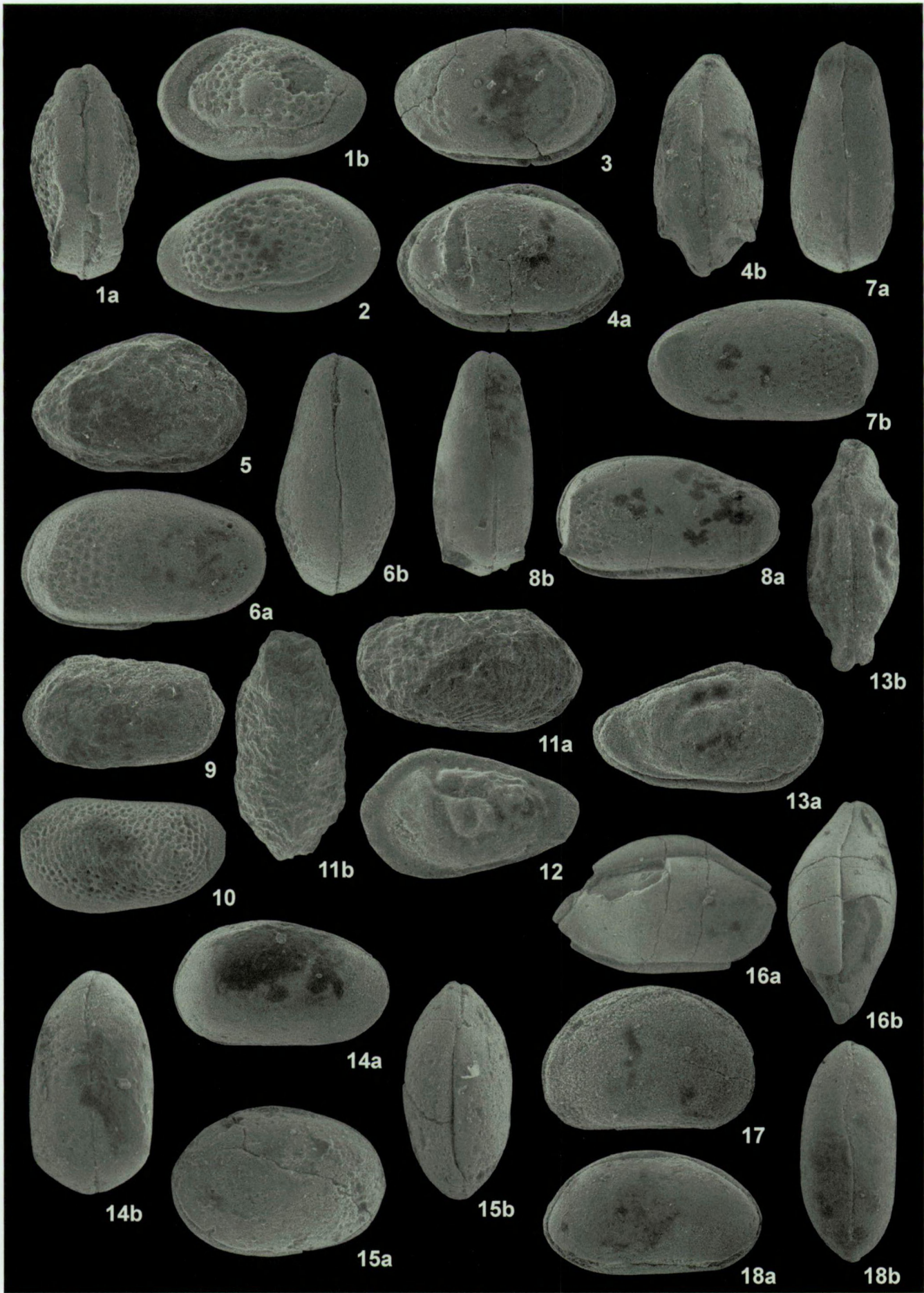


PLATE 2

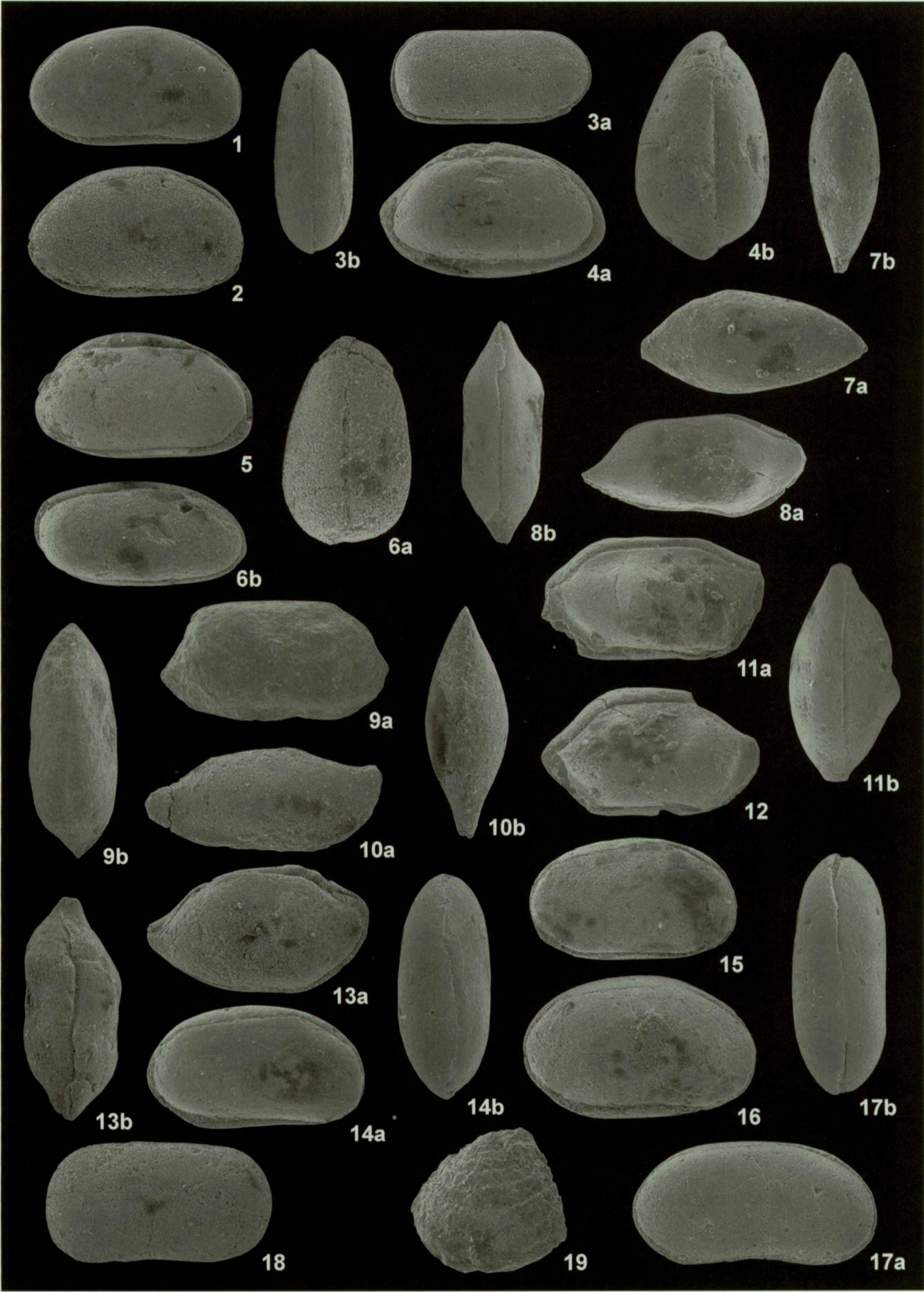


PLATE 3