

DIVERSITY OF STROPHOMENID, ORTHOTETID AND ORTHID BRACHIOPODS IN THE UPPERMOST FAMENNIAN (“STRUNIAN”; UPPER DEVONIAN) OF THE AVESNOIS (NORTHERN FRANCE)

Diversité des brachiopodes strophoménidés, orthotétidés et orthidés dans le Famennien terminal ('Strunien' ; Dévonien supérieur) de l'Avesnois (Nord, France)

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Abstract. – In order to contribute to assessment of the aftermath of the Hangenberg Biological Crisis that took place at the top of the Famennian (Upper Devonian), the strophomenid, orthotetid and orthid brachiopods from the ‘Strunian’-aged Etrœungt Limestone Formation (Avesnois, northern France) are described. The Avesnois is the historical type area of the ‘Strunian’, traditionally considered as the last Famennian substage. Although they are sometimes abundant in the studied sections, their generic and specific diversity is very low in the Etrœungt Limestone Formation. Moreover, the majority of the species belong to long-ranging genera (*Leptagonia*, *Schellwienella*?, *Schizophoria*, *Aulacella*).

Résumé. – Afin de préciser les conséquences de la Crise biologique de Hangenberg survenue au sommet du Famennien (Dévonien supérieur), les brachiopodes strophoménidés, orthotétidés et orthidés de la Formation du Calcaire d'Etrœungt d'âge 'strunien' (Avesnois, Nord de la France) sont décrits. L'Avesnois est la région-type historique du 'Strunien' qui est traditionnellement considéré comme le sous-étage terminal du Famennien. Bien qu'ils soient parfois abondants dans les coupes étudiées, leur diversité générique et spécifique est très faible au sein de la Formation du Calcaire d'Etrœungt. De plus, la majorité des espèces appartiennent à des genres caractérisés par de grandes extensions stratigraphiques (*Leptagonia*, *Schellwienella* ?, *Schizophoria*, *Aulacella*).

Keywords. – Brachiopoda, Upper Devonian, Etrœungt Limestone Formation, Hangenberg biological Crisis.

Mots clés. – Brachiopoda, Dévonien supérieur, Formation du Calcaire d'Etrœungt, crise biologique de Hangenberg.

I. — INTRODUCTION

The consequences of the Hangenberg Biological Crisis (e.g. Kaiser *et al.*, 2011) on brachiopods have been recently discussed by Mottequin *et al.* (in press). These authors stressed that revision of the uppermost Famennian brachiopod faunas from classical areas, such as Western Europe (Franco–Belgian Basin, Germany, United Kingdom), is urgently needed as these organisms are prime tools for research dedicated to biological crises, but also to the biostratigraphy in environments unfavorable to ammonoids and conodonts.

This paper is the first of a series dedicated to revision of the brachiopods from the historical type area of the ‘Strunian’ (uppermost Famennian) (Streel *et al.*, 2006), namely the Avesnois in northern France (Fig. 1), as most of the data, related to the brachiopod faunas from this significant area, dates back to Dehée (1929). Moreover, the bulk of the taxa has never been illustrated. This is also the case in southern Belgium, the historical type area of the Famennian Stage (Thorez *et al.*, 2006) and where ‘Strunian’ facies are relatively similar to those occurring in the Avesnois. There, the vast majority of the uppermost Famennian brachiopods is almost only known by lists of species (Demanet, 1958; Conil *et al.*, 1986).

We deal here with the systematics of representatives of the orders Strophomenida, Orthotetida and Orthida on the basis of material collected since 1970 in the Avesnois, notably in the disused Parcq quarry and the Avesnelles railway section. The Parcq quarry is the historical section of the Etrœungt Limestone (= Etrœungt Limestone Formation, Conil *et al.*, 1977) firstly described by Gosselet (1857). Both sections are revised by Mistiaen *et al.* (2013).

II. — GEOLOGICAL FRAMEWORK

The studied material comes from several sections (Fig. 1), located in the Avesnois (northern France) that expose the Etrœungt Limestone Formation (see Mistiaen *et al.* [2013] for more details on this lithostratigraphic unit): the Parcq and Jean-Pierre quarries (Fig. 2) in Etrœungt, the Avesnelles railway section (Fig. 3) and several temporary ones in the Godin quarry. The Avesnois is the western prolongation of the southern margin of the Dinant Synclinorium; it includes a series of WSW–ENE anticlines and synclines (Fig. 1) developed in Devonian–Carboniferous succession (Delattre *et al.*, 1967; Khatir, 1990).

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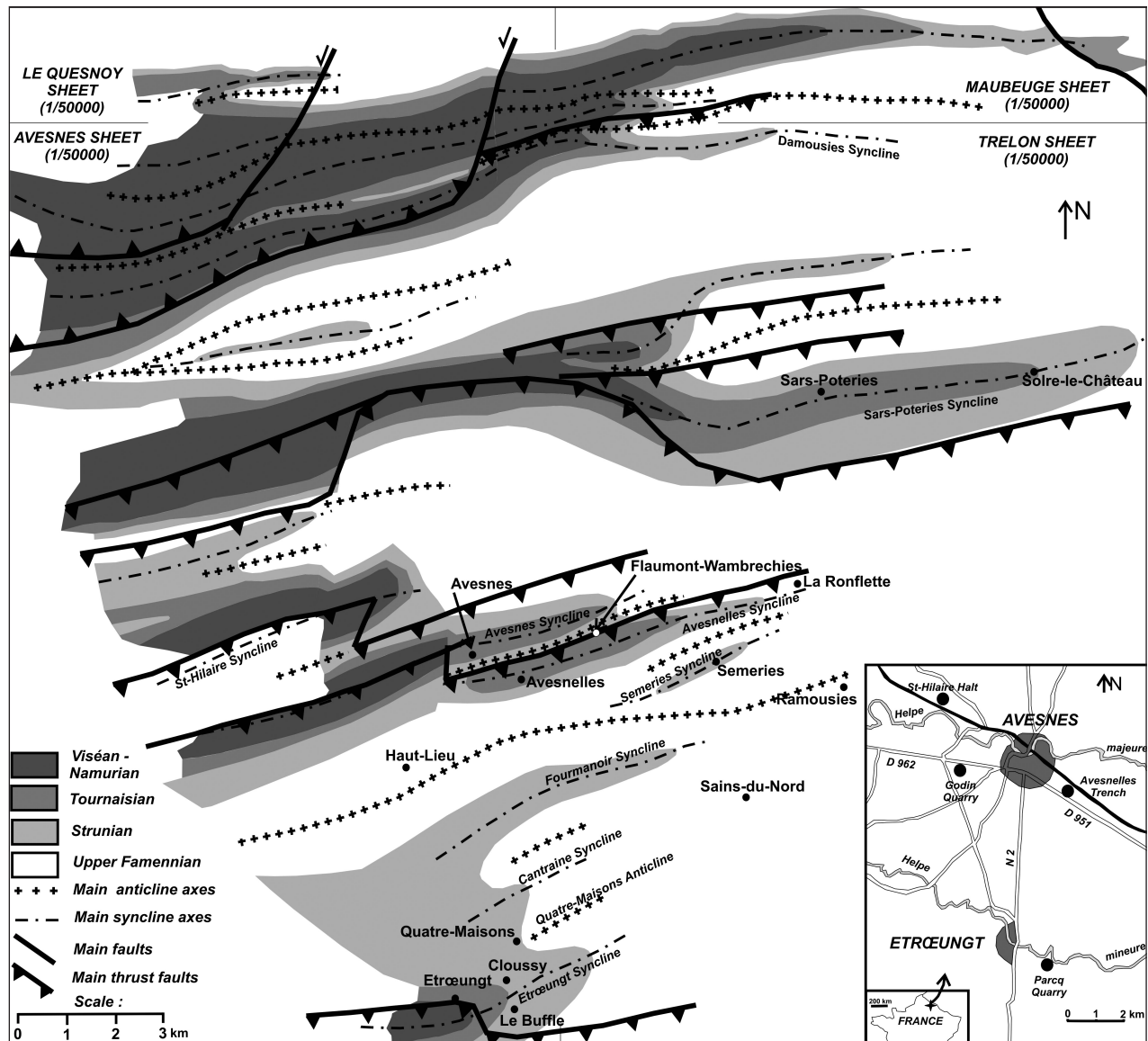


Fig. 1. — Schematic geological map of the Avesnois, Northern France (modified from Delattre *et al.*, 1967 according to A. Khatir data) and location of the main outcrops and sections in the Avesnes-sur-Helpe and Etrœungt areas.

Fig. 1. — Carte géologique schématique de l'Avesnois, Nord, France (d'après Delattre *et al.*, 1967 modifiée selon les indications d'A. Khatir) et localisation des principaux affleurements et coupes dans les régions d'Avesnes-sur-Helpe et d'Etrœungt.

III – SYSTEMATIC PALEONTOLOGY

Part of the investigated material belongs to Dehée's (1929) collection, curated at the Musée d'Histoire naturelle de Lille and prefixed MGL (Musée Géologique de Lille). Most of the studied material was collected between 1970 and 2013 by the members of the Faculté Libre des Sciences et Technologies de Lille (FLST) and is housed at the FLST with, for types and figured specimens, the prefix GFCL (= Géologie Faculté Catholique de Lille). The latter come from the Avesnelles railway section (AT), the Godin quarry in Avesnes-sur-Helpe (BO), the Parcq (EP) and Jean-Pierre (EJ) quarries in Etrœungt, and the Sains-du-Nord (SA) railway section; a number follows these prefixes and corresponds to the bed from which the brachiopods originate (see Mistiaen *et al.*, 2013). Additional material, with the prefix ULg, is curated at the Geology Department of the

Liège University. Only illustrated specimens are registered. The synonymy lists refer only to material from the Avesnois. The Figs. 2-3 give the range of the strophomenids, orthotetids and orthids described below.

Phylum Brachiopoda Duméril, 1805

Subphylum Rhynchonelliformea Williams *et al.*, 1996

Class Strophomenata Williams *et al.*, 1996

Order Strophomenida Öpik, 1934

Superfamily Strophomenoidea King, 1846

Family Rafinesquinidae Schuchert, 1893

Subfamily Leptaeninae Hall & Clarke, 1894

Genus *Leptagonia* M'Coy, 1844

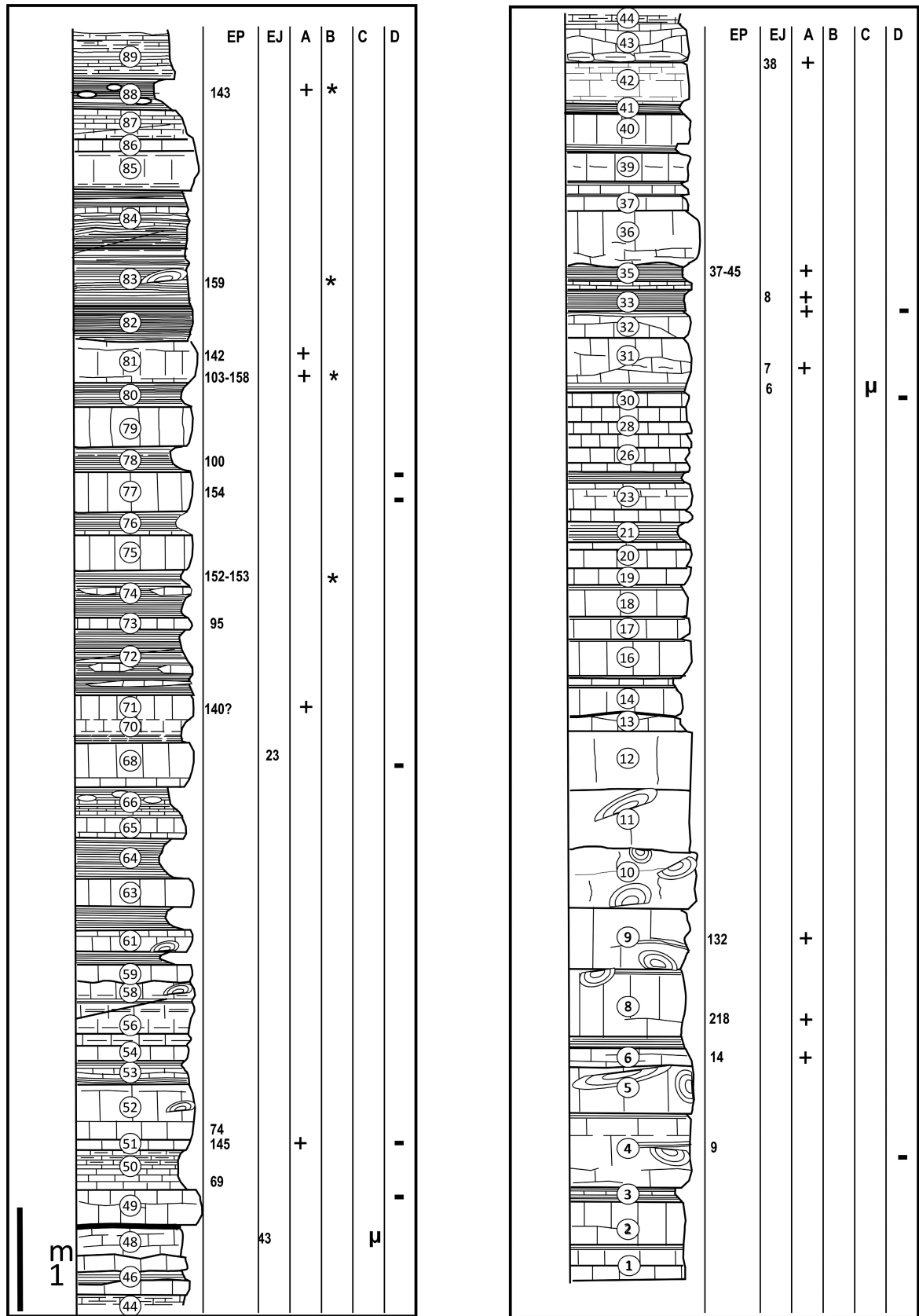


Fig. 2 – Distribution of *Schellwienella?* sp. (A,+), *Orthotetida* gen. et sp. indet. (B,*), *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809) (C,μ), and *Aulacella interlineata* (Sowerby, 1840) (D,°) in the sections and outcrops of the Parc (EP) and Jean-Pierre (EJ) quarries in Etrœungt.

Fig. 2. — Répartition de *Schellwienella?* sp. (A,+), d'*Orthotetida* gen. et sp. indet. (B,*), de *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809) (C,μ) et d'*Aulacella interlineata* (Sowerby, 1840) (D,°) dans les coupes et affleurements des carrières du Parc (EP) et Jean-Pierre (EJ) à Etrœungt.

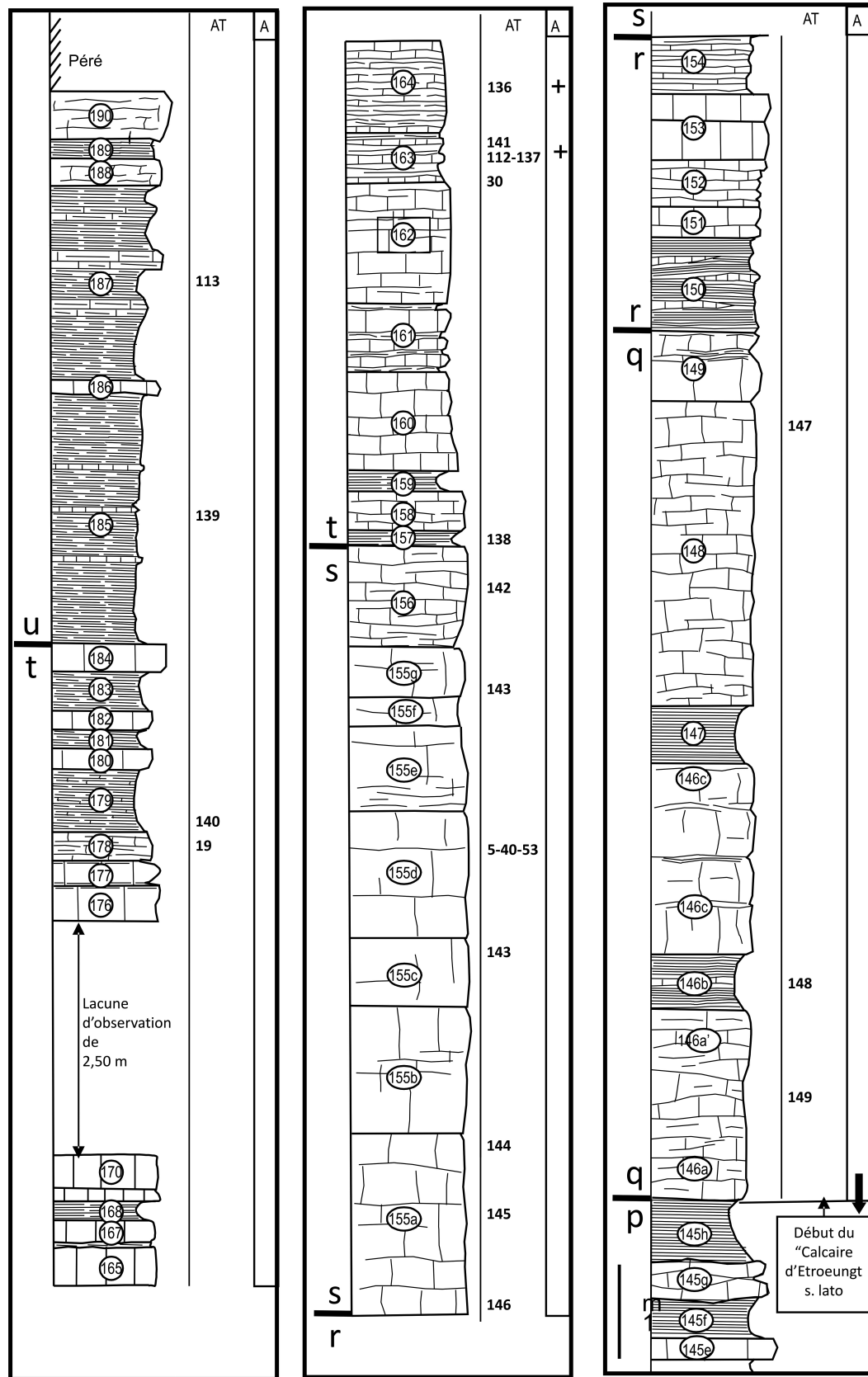


Fig. 3. — Distribution of *Schellwienella*? sp. (A,+), *Orthotetida* gen. et sp. indet. (B,*), *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809) (C, μ), and *Aulacella interlineata* (Sowerby, 1840) (D, $^{\circ}$) in the Avesnelles railway section.

Fig. 3. — Répartition de *Schellwienella*? sp. (A,+), d'*Orthotetida* gen. et sp. indet. (B,*), de *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809) (C, μ) et d'*Aulacella interlineata* (Sowerby, 1840) (D, $^{\circ}$) dans la coupe de la tranchée de voie ferrée d'Avesnelles.

Type species. Producta analoga Phillips, 1836, from the Visean Pendleside Limestone Group of Bowland, Yorkshire, England.

Leptagonia sp. cf. *L. analoga* (Phillips, 1836)

Fig. 4A–B

cf. 1836 *Producta analoga* Phillips, p. 215, pl. 7, fig. 10.

1860 *Leptaena rhomboidalis* Gosselet, p. 86.

1888 *Strophomena rhomboidalis* Gosselet, p. 548.

1913 *Leptaena rhomboidalis* var. *analoga* Phill., Carpentier, p. 31.

1929 *Leptaena rhomboidalis* Wilckens, Dehée, p. 36.

Material. One incomplete ventral valve (MGL 4564) and one incomplete internal mould (MGL 6541; Fig. 4A–B).

Discussion. These clearly wider than long ventral valves, reaching their maximum width at the hinge line, are tentatively assigned to *Leptagonia analoga* on the basis of their slightly resupinate lateral profile, their similar parvicostellate ornamentation with numerous rugae on the disc.

Distribution. *Leptagonia analoga* (Phillips, 1836) is well-known from the Mississippian of Western Europe (e.g. Brunton, 1968; Brand, 1972; Mottequin, 2010) and has been also reported in North America (Carter, 1999) and tentatively in other parts of the world, notably in Iran (Bahrammanesh *et al.*, 2011). As discussed by Bassett & Bryant (2006, p. 488), *L. analoga* was used as a ‘blanket’ to include numerous taxa that need to be revised thoroughly.

In the Famennian succession of the Avesnois, Gosselet (1860, p. 86) reported *Leptaena rhomboidalis* in the Etrœungt Limestone within the Avesnes-sur-Helpe syncline in the hamlets of Quatre-Maisons, Cloussy and Buffle. Moreover, Dehée (1929, p. 36) reported its presence in the Etrœungt Shale, which probably corresponds to the EpINETTE Shale (see Conil & Lys, 1980) at Sars-Poteries (Sars-Poteries syncline) and Avesnelles (Avesnelles syncline), but Carpentier (1913, p. 31) recognized *Leptaena rhomboidalis* var. *analoga* in the Fourmanoir syncline. In spite of our efforts, we have not found additional specimens in the Etrœungt Limestone Formation. Demanet (1958, p. 53) reported *Leptaena analoga* within the uppermost Famennian of southern Belgium (Namur–Dinant Basin).

Order Orthotetida Waagen, 1884

Suborder Orthotetidina Waagen, 1884

Superfamily Orthotetoidea Waagen, 1884

Family Pulsidae Cooper & Grant, 1974

Genus *Schellwienella* Thomas, 1910

Type species. Spirifera crenistria Phillips, 1836, from the Visean Pendleside Limestone Group of Bowland, Yorkshire, England.

Schellwienella? sp.

Figs 1, 2, 3, 4C–L, Table 1

1929 *Orthotetes* (*Schellwienella*) *crenistria* (Phillips), Dehée p. 34, pl. 5, figs 6–8.

? 1929 *Streptorhynchus* (*Schellwienella*) sp. cf. *S. (S.) umbraculum* Schlottheim, Dehée, p. 36, pl. 5, fig. 9.

Material. One articulated specimen, twenty ventral valves, three ventral valve interiors, three ventral internal moulds, thirty-six dorsal valves, seven dorsal valve interiors, three dorsal internal moulds (+ numerous fragments). MGL 29816-1:

one dorsal valve; MGL 29816-2: one dorsal valve; MGL 29816-3: nine dorsal valves (‘Assise d’Etrœungt à Etrœungt’); MGL 29815-1: one dorsal internal mould; MGL 29815-2, 3, 6, 7, 8: five incomplete dorsal valves; MGL 29815-4, 5, 9: three incomplete ventral valves (no specimen corresponds to those illustrated by Dehée [1929]); EP14: one incomplete ventral valve; EP37: one incomplete dorsal valve; EP45: one ventral internal mould; EP103: one incomplete ventral valve; EP132: one incomplete dorsal valve; EP140: one crushed dorsal valve; EP142: one dorsal valve; EP145: two dorsal valves; EP218: fragments; EJ7: one dorsal internal mould; EJ8: fragments; EJ38: one ventral interior; AT135: one ventral internal mould; AT136: one ventral valve; AT137: one incomplete ventral valve; BO38: one incomplete dorsal interior; BO41: one incomplete ventral valve; BO44: three ventral valves, two dorsal external moulds, three dorsal interiors, fragments; BO55: one ventral internal mould, one ventral interior; BO56: one incomplete dorsal valve, fragments; BO74: five ventral valves, five incomplete dorsal valves, fragments; BO143: one ventral valve, one ventral interior, one dorsal interior, fragments; BO145: two ventral interiors, one incomplete dorsal interior; BO146: two ventral valves; BO163: one incomplete dorsal interior; BO192: one dorsal internal mould; BO198: one crushed ventral valve; BO199: one crushed dorsal valve; BO211: fragments; BO202: one incomplete specimen.

Description. Shell middle- to large-sized (c. 50 mm in width), wider than long (approximate width/length ratio: 1.15–1.48), widest near midlength, semi-circular to subcircular in outline, dorsibiconvex; hinge line slightly shorter than maximum width; lateral margins slightly rounded; anterior commissure rectimarginate. Ornamentation parvicostellate; intercostal grooves flattened; filae numerous; strong growth varices observed on few dorsal valves; numerous pseudopunctations visible on decorticated valves. Ventral valve slightly convex close to the beak, sometimes almost flat or resupinate near the lateral margins; interarea observed in only one specimen (c. 5 mm in height), apsacline, horizontally striated, with vertical striae between the horizontal ones; delthyrium completely closed by a convex pseudodeltidium (without perideltidium). Interior poorly preserved, showing a small muscle field striated anteriorly and divided by a median ridge. Dorsal valve of variable convexity, but always more convex than ventral one, especially in posterior part; interarea not observed. Dorsal interior with strong, bilobed cardinal process; dental sockets deep, open laterally; muscle field bilobed, each lobe covered by numerous radial striae, especially in their anterior part.

Measurements. See Table 1.

	BO31 GFCL 2258	BO145 GFCL 2259	AT136 GFCL 2260	MGL 29816-2	MGL 29816-3	MGL 29816-1
Length	27.3	35	19	19	43.8	30.5
Width	35.3	43.5	27.5	28	50.5	45
W/L	1.29	1.24	1.45	1.47	1.15	1.48

Table 1. — Dimensions in mm of selected specimens of *Schellwienella?* sp. Abbreviations: L, length; W, width.

Tableau 1. — Dimensions en mm de spécimens sélectionnés de *Schellwienella?* sp. Abréviations : L, longueur ; W, largeur.

Discussion. The tentative generic assignment of this material that includes only disarticulated valves, to *Schellwienella* rather than to *Schuchertella* is primarily based on the presence of pseudopunctations. Furthermore, no specimen displays the high, anacline ventral interarea characteristic of representatives of the latter. The generic assignment remains doubtful due to lack of knowledge of the internal features and absence of a perideltidium, a diagnostic feature of pulsiid representatives (Williams & Brunton, 2000, p. 652). Externally, some of the smaller shells resemble specimens from the uppermost Famennian of the Holy Cross Mountains (Poland) that have been identified as *Schellwienella pauli* Gallwitz, 1932, by Halamski & Baliński (2009).

Distribution (Figs. 2-3). On the basis of our collections, as it was reported by Gosselet (1888, p. 549), Carpentier (1913, p. 17, 21, 25, 27, 28, 29, 30, 31, 33, 36, 38, 51) and Dehée (1929), these remains, which were assigned to Phillips' species, are very common in the Parcq and Jean-Pierre quarries in Etrœungt (Etrœungt syncline) and in the Godin quarry (Avesnes-sur-Helpe syncline). They are generally present, but less abundant, in the Avesnelles railway section close to the Godin quarry where we have collected similar specimens in the underlying Epinette Shale Formation.

Orthotetida gen. and sp. indet.

Figs. 1-2, 4M-O

Material. Two incomplete ventral valves (GFCL 2250 [EP143; Fig. 4N], GFCL 2249 [EP159, Fig. 4O]), and several fragments (GFCL 2251 [EP153, Fig. 4M], EP151-152, EP158, BO15, BO143, BO183).

Description. Ventral valve very slightly convex, subconical; ornamentation fascicostellate; three to five flat-topped costae and costellae per bundle; bundles separated by grooves slightly wider than intercostal ones.

Discussion. Lack of knowledge about the internal morphology and the poor preservation of the available material preclude a generic assignment. It differs from specimens identified as *Schellwienella*? sp. by its fasciculate ornamentation.

Distribution. This undetermined species is known from the upper part of the Etrœungt Limestone Formation in the Parcq and Godin quarries.

Class Rhynchonellata Williams *et al.*, 1996
Order Orthida Schuchert & Cooper, 1932
Suborder Dalmanellidina Moore, 1952
Superfamily Dalmanelloidea Schuchert, 1913
Family Rhipidomellidae Schuchert, 1913
Subfamily Rhipidomellinae Schuchert, 1913
Genus *Aulacella* Schuchert & Cooper, 1931

Type species. 'Orthis eifeliensis (= eifliensis) Schnur, 1853' (= *Orthis prisca* Schnur, 1851), from the Middle Devonian of the Eifel, Germany.

Aulacella interlineata (Sowerby, 1840)

Figs. 1-2-3, 5A-E

1840 *Orthis interlineata* Sowerby, pl. 53, fig. 11, pl. 54, fig. 14.

1860 *Orthis Eifeliensis* Gosselet, p. 86, 87.

e.p. 1879 *Orthis arcuata* Gosselet, p. 393, 394, 395.

e.p. 1888 *Orthis arcuata* Gosselet, p. 548.

1929 *Dalmanella interlineata* Sowerby, Dehée, p. 31-33, pl. 5, figs 1-5.

Material. Four whole specimens, eight ventral valves, seven ventral internal moulds, one ventral external mould, one ventral interior, four dorsal valves, three dorsal internal moulds, one dorsal interior. MGL 27667: one crushed specimen, two ventral and one dorsal valves (NW of the Sains-du-Nord station); MGL 30063: one specimen (Etrœungt); EP9: one ventral valve; EP69: one dorsal valve; EP74: one incomplete ventral valve; EP100: one dorsal internal mould; EP154: one ventral internal mould, one incomplete ventral interior, one dorsal valve, one dorsal internal mould; EJ6: one incomplete ventral valve; EJ8: one specimen; EJ 23: one incomplete ventral valve; AT21: one ventral valve; AT72: one ventral valve; BO158: five incomplete ventral internal moulds, one incomplete dorsal valve and one dorsal internal mould; ULg 2013-06-27: one ventral internal mould (Avesnelles, Epinette Shale).

Description. See Dehée (1929) for the external morphology. We focus here only on the internal features. Ventral interior with important, clearly delimited muscle field, divided anteriorly by a more or less wide, median ridge (fig. 5A-C); each lobe can bear several thin ridges (fig. 5A). Dorsal interior (fig. 5D) with strong cardinal process; dental sockets small, laterally open; muscle field extending to valve mid-length, divided by a ridge corresponding to the sulcus: posterior and anterior muscle scars poorly differentiated.

Discussion. Dehée's (1929) discussion related to the specific assignment of *Aulacella* representatives is still applicable to the new material. The external features established on the basis of relatively abundant material according to this author, are identical to those of the isolated, frequently incomplete valves of our collections with, however, some minor differences, most probably linked to their smaller size. Thus the dorsal valve of Dehée's specimen (fig. 5D) displays a median flattening instead of a sulcus whereas the small dorsal valve from the Godin quarry has a poorly defined sulcus, less numerous and wider costellae, with no thickened growth lamellae. On the other hand, the outline of the valves is also sub circular, with widening in the largest specimens, the hinge line is two times less wide than the maximum width; and the fascicostellate ornamentation includes costellae increasing by bifurcation and intercalation.

Distribution (Figs 2-3). *Aulacella interlineata* (Sowerby, 1840) has been reported in the Upper Famennian of Europe and North Africa, but could be present also in Armenia (see Halamski & Baliński, 2009 for more details). Sowerby's species needs to be revised on the basis of its type material. The specimens recently collected originate from outcrops in the Avesnes-sur-Helpe (Godin quarry), Avesnelles (Avesnelles railway trench, in the Epinette Shale [see Conil & Lys, 1980]), Etrœungt (Parcq and Jean-Pierre quarries) and Cantraine (outcrop NW of Sains-du-Nord) synclines. Due to paucity of specimens new collections, the stratigraphic distribution of *Aulacella interlineata* in the Avesnois remains poorly known.

Superfamily Enteletoidea Waagen, 1884

Family Schizophoriidae Schuchert, 1929

Genus *Schizophoria* King, 1850

Type species. *Conchyoliolithus (Anomites) resupinatus* Martin, 1809, from the Viséan of Dovedale, Derbyshire, England.

Schizophoria sp. cf. *S. resupinata* (Martin, 1809)

Figs. 1-2, Fig. 5F-H, Table 2

cf. 1809 *Conchyoliolithus (Anomites) resupinatus* Martin, pl. 49, figs 13-14.

e.p. 1879 *Orthis striatula*; Gosselet, p. 395.

e.p. 1888 *Orthis striatula*; Gosselet, p. 548.

1929 *Schizophoria striatula* Schlottheim; Dehée, p. 34.

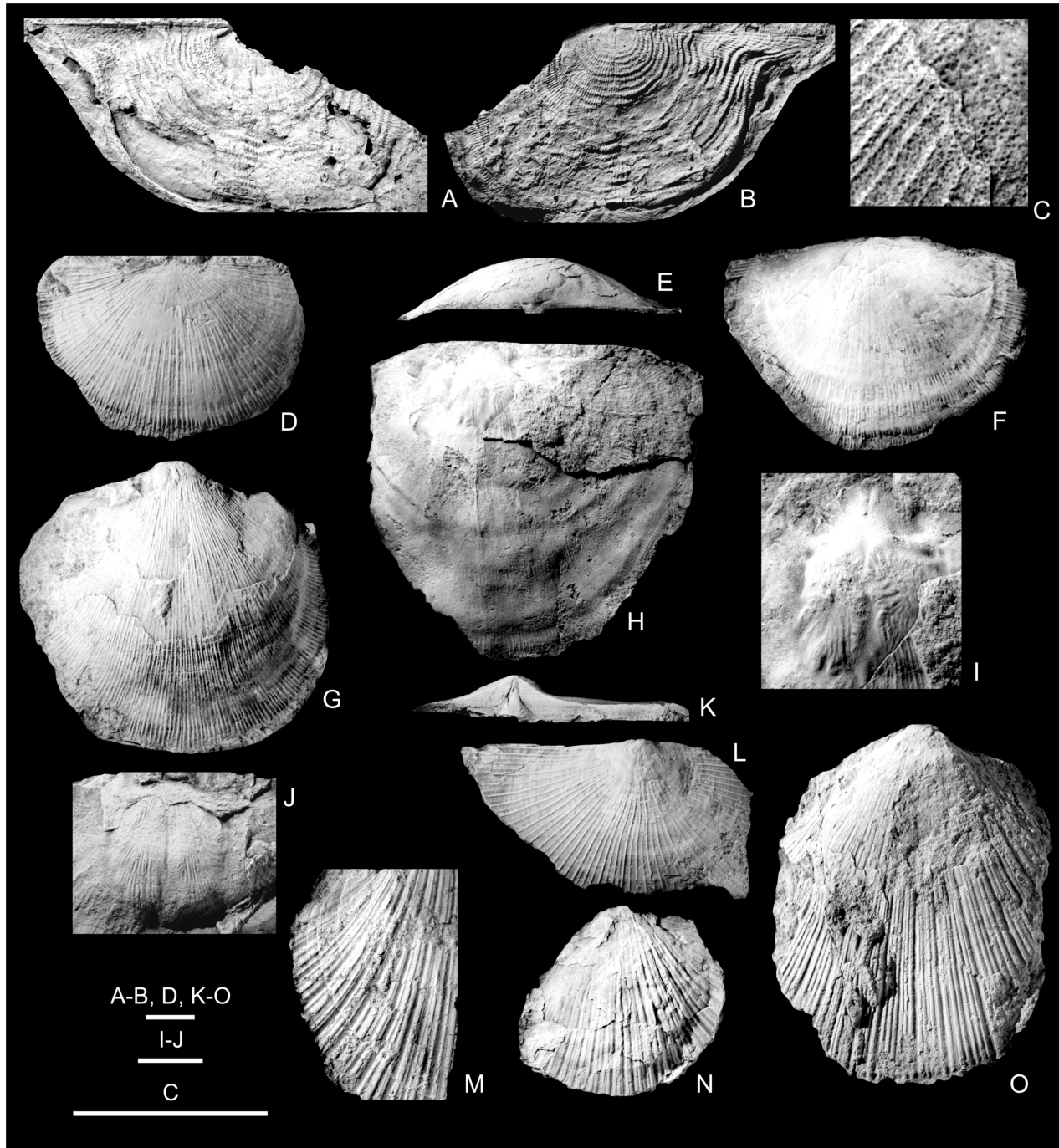


Fig. 4. — **A–B**, *Leptagonia* sp. cf. *L. analoga* (Phillips, 1836), MGL 6541 1B & 1A, internal and external moulds of an incomplete ventral valve ('Schistes et calcaires d'Etrœungt', Avesnelles railway section). **C–L**, *Schellwienella*? sp. (Assise d'Etrœungt à Etrœungt) **C**, MGL 29816.4 ('Assise d'Etrœungt', Etrœungt), external view of a dorsal valve showing pseudopunctuations. **D**, MGL 29816.2 ('Assise d'Etrœungt', Etrœungt), dorsal valve. **E–F**, MGL 29816.1 ('Assise d'Etrœungt', Etrœungt), dorsal valve in posterior and dorsal views. **G**, MGL 29816.3 ('Assise d'Etrœungt', Etrœungt), dorsal valve. **H–I**, GFCL 2254 (= EP 138), internal mould of a dorsal valve with shelly fragments and details of muscle field. **J**, GFCL 2253 (= BO 143), details of dorsal muscle field (internal mould). **K–L**, GFCL 2252 (= EP 103), incomplete ventral valve in posterior and ventral views. **M–O**, *Orthotetide* gen. et sp. indet. **M**, GFCL 2251 (= EP 153), details of ornamentation of a ventral valve. **N**, GFCL 2250 (= EP 143), incomplete ventral valve. **O**, GFCL 2249 (= EP 159), incomplete ventral valve. Scale bars = 5 mm.

Fig. 4. — **A–B**, *Leptagonia* sp. cf. *L. analoga* (Phillips, 1836), MGL 6541 1B & 1A, moules interne et externe d'une valve ventrale incomplète ('Schistes et calcaires d'Etrœungt', tranchée d'Avesnelles). **C–L**, *Schellwienella*? sp. **C**, MGL 29816.4, vue externe d'une valve dorsale montrant des pseudopunctuations ('Assise d'Etrœungt' à Etrœungt). **D**, MGL 29816.2, valve dorsale ('Assise d'Etrœungt' à Etrœungt). **E–F**, MGL 29816.1, valve dorsale en vue postérieure et dorsale ('Assise d'Etrœungt' à Etrœungt). **G**, MGL 29816.3, valve dorsale ('Assise d'Etrœungt' à Etrœungt). **H–I**, GFCL 2254 (= EP 138), moule interne d'une valve dorsale avec des fragments et détail du champ musculaire. **J**, GFCL 2253 (= BO 143), détail du champ musculaire dorsal (moule interne). **K–L**, GFCL 2252 (= EP 103), valve ventrale incomplète en vues postérieure et ventrale. **M–O**, *Orthotetide* gen. et sp. indet. **M**, GFCL 2251 (= EP 153), détail de l'ornementation d'une valve ventrale. **N**, GFCL 2250 (= EP 143), valve ventrale incomplète. **O**, GFCL 2249 (= EP 159), valve ventrale incomplète. Barres d'échelle = 5 mm.

Material. Two incomplete specimens, five ventral valves of which two are incomplete, one ventral external mould; one dorsal valve, one incomplete dorsal (?) valve. MGL 4567-1: one incomplete specimen; MGL 4567-2: one incomplete dorsal valve; MGL 4569: one incomplete specimen of unknown locality; MGL 4594: one undifferentiated valve; MGL 4594-2: two ventral valves (Etrœungt, Quatre-Maisons); EJ 6: one incomplete dorsal valve; EJ 43: one incomplete ventral valve; BO 44: one incomplete dorsal (?) valve; BO 154: one external mould of a ventral valve; BO 190: one ventral valve; BO 192: one ventral valve.

Description. Shell mid- to large-sized (up to 43 mm in width), dorsibiconvex, transversely elliptical in outline, wider than long; hinge line shorter than greatest width (hinge line width/width ratio: 0.53 [n=1!]), widest at mid-length; lateral margins rounded; anterior commissure uniplicate. Ornamentation muticostellate; costellae increasing by intercalation; about 10 costae and costellae per 2.5 mm at 5 mm of the beak. Ventral valve convex in umbonal area, almost flat or even slightly concave towards lateral commissures; interarea apsacline, clearly higher than dorsal interarea, slightly concave; delthyrium open; sulcus weak, poorly defined anteriorly. Interior not observed. Dorsal valve regularly inflated, with maximum convexity in umbonal area; beak overhanging hinge line; interarea low, almost orthocline. Interior not observed.

Measurements. See Table 2.

	MGL 4567	BO 154	BO 190
Length	36.5	18	13.3
Width	43	25	18
Thickness	20.3	13.3	/

Table 2. — Dimensions in mm of selected specimens of *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809).

Tableau 2. — Dimensions en mm de spécimens sélectionnés de *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809).

Discussion. According to Halamski (2012), the diameter and the density of punctae in *Schizophoria* species are of significant taxonomical value, but preservation of the few specimens available is too poor for providing detail. Our specimens are tentatively assigned to *Schizophoria resupinata*, well-known in the Tournaisian–Visean succession of Western and Eastern Europe, but also in China, Iran and Russia (see references in Bahrammanesh et al., 2011). This very long ranging, morphologically very variable species is badly in need of thorough revision despite recent studies (Brunton, 1968; Pocock, 1968; Żakowa, 1989); this is beyond the scope of this paper. This material was previously assigned to Frasnian-aged *Schizophoria striatula* (von Schlotheim, 1813), by various authors such as Gosselet (1888) and Dehée (1929) but this species is still poorly known (see Struve, 1965).

Distribution. This species is rare in the uppermost Famennian of the Avesnois. Dehée (1929, p. 34) reported, without precise location and illustration, some badly preserved specimens assigned to *Schizophoria striatula*. Gosselet (1879, p. 395) cited the latter in the Semeries railway section and Carpentier

(1913, p. 19) in the ‘Etrœungt strip’ at Cloussy and (Ibid. 1913, p. 29), in the ‘Avesnelles strip’ but mentioned *S. resupinata* only in the Flaumont section (Avesnelles syncline). Demanet (1934, p. 49) reported the occurrence of *Schizophoria resupinata* in the uppermost Famennian of the eastern part of the Dinant Synclinorium (southern Belgium).

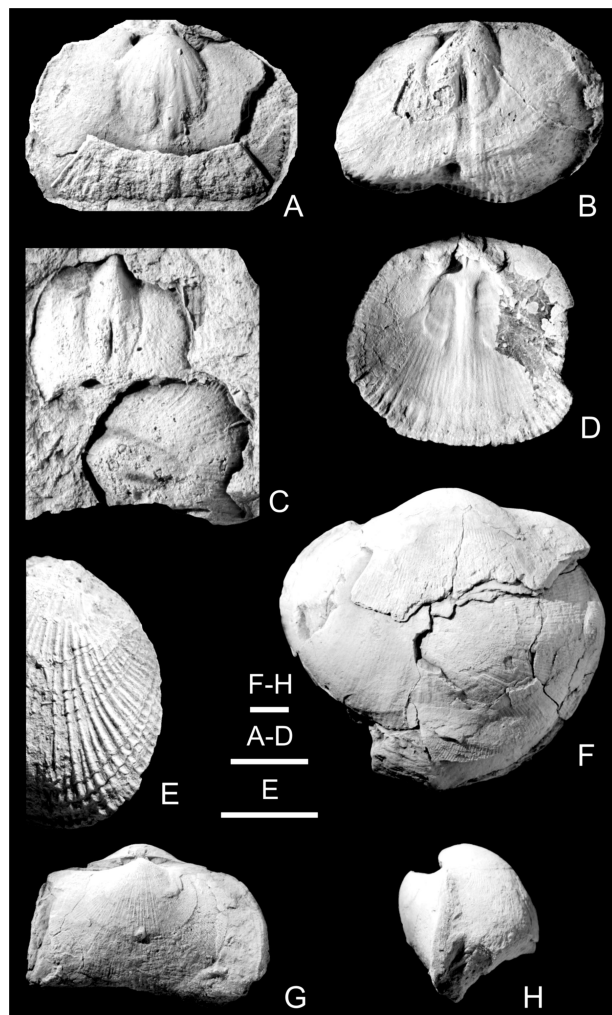


Fig. 5. — A–E, *Aulacella interlineata* (Sowerby, 1840). A, ULg 2013-06-27, ventral internal mould with shelly fragments, Avesnelles railway section, Epinette Shale (bed 124). B, GFCL 2255, ventral internal mould. C, GFCL 2256–2257 (= BO 158), two ventral internal moulds. D, MGL 27667.1, dorsal interior. E, MGL 27667.2, details of ornamentation on a ventral valve (Famennian, NW of Sains-du-Nord station.). F–H, *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809). F, MGL 4567.2, two incomplete dorsal valves (‘Schistes et Calcaires d’Etrœungt, Etrœungt [Quatre-Maisons]). G–H, MGL 4567.1, incomplete specimen in ventral and lateral views. Scale bars = 5 mm.

Fig. 5. — A–E, *Aulacella interlineata* (Sowerby, 1840). A, ULg 2013-06-27, moule interne ventral avec des fragments, tranchée de la voie ferrée à Avesnelles, Schistes de l’Epinette (banc 124). B, GFCL 2255, moule interne ventral. C, GFCL 2256–2257 (= BO 158), deux moules internes ventraux. D, MGL 27667.1, intérieur dorsal. E, MGL 27667.2, détails de l’ornementation d’une valve ventrale (Famennien, NW de la gare de Sains-du-Nord). F–H, *Schizophoria* sp. cf. *S. resupinata* (Martin, 1809). F, MGL 4567.2, deux valves dorsales incomplètes (‘Schistes et Calcaires d’Etrœungt’, Etrœungt [Quatre-Maisons]). G–H, MGL 4567.1, spécimen incomplet en vues ventrale et latérale. Barres d’échelle = 5 mm.

IV. — DISCUSSION

All the strophomenids, orthotetids and orthids, obtained from the uppermost Famennian- Etrœungt Limestone Formation in the Avesnois, belong to long-ranging genera; diversity is low. This is comparable with data from other ‘Strunian’ brachiopod faunas such as those from the Holy Cross Mountains in Poland (Halamski & Baliński, 2009). From the generic viewpoint, these three orders were poorly diversified worldwide during the Famennian (Curry & Brunton, 2007).

Reappearance of representatives of the Subfamily Leptaeninae (*Leptagonia*) within the uppermost Famennian, probably due to favourable facies, has to be emphasized as they seem to have been absent since the end of the Eifelian in adjacent areas such as the Namur–Dinant Basin in southern Belgium according to Maillieux (1941); this author doubtfully reported the presence of *Leptaena rhomboidalis* in the Lower Famennian, but this could not be confirmed by Mottequin (2008a). Maillieux (1933) also reported *Leptaena rhomboidalis*, but without illustration, in the Mid Famennian Condroz Group in southern Belgium. Brice (1988) did not encounter them in the Givetian–Frasnian succession of the Boulonnais. Leptaeninae (Rafinesquinidae) are the only strophomenids which crossed the Frasnian–Famennian and Devonian–Carboniferous boundaries (e.g. Rong & Cocks, 1994).

Orthotetids are common in the Etrœungt Formation, but their poor preservation precludes definitive identifications. At least two species can be distinguished. Demanet (1958, p. 51) reported five orthotetid taxa in the uppermost Famennian succession of the southern margin of the Dinant Synclinorium, but these data cannot be discussed further in the absence of illustrations. Just after the Hangenberg Biological Crisis, the

Suborder Orthotetidina was marked by a diversification phase on a global scale at the base of the Carboniferous according to Williams & Brunton (2000), with the inception of two new families (Orthotetidae, Derbyiidae) and a new subfamily (Streptorhynchinae). In the Avesnois, recent data related to Tournaisian orthotetids are lacking. Carpentier (1913) reported relatively frequent “*Orthotetes crenistria*”, but without illustration, within the Hastarian Pont d’Arcole Formation.

The orthids include representatives of *Aulacella* and *Schizophoria*, common brachiopods in Famennian shelf-ramp; they rank among the first to re-occur after the end-Frasnian Biological Crisis (Baliński, 2002; Stigall Rode, 2005; Mottequin, 2008b).

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