

## Late Ordovician (Ashgillian) Brachiopods from the region of the Sambre and Meuse Rivers, Belgium

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### Abstract

A brachiopod fauna of 46 species is described from the Fosse Formation of Belgium. The Subfamily Furcitellinae is revised. A new genus, *Costistrophomena*, is erected as well as ten new species (*Spinorthis europa*, *Platystrophia leserancei*, *Dalmanella sambrensis*, *Portranella akymatata*, *Saukrodictya wrightii*, *Leangella namurensis*, *Anisopleurella sartenaeri*, *Christiania magna*, *Costistrophomena costata*, *Katastrophomena catalorni*), and a new subspecies (*Luhaia vardi roomusoksi*). The fauna establishes that the Fosse Formation is Ashgill in age and that the region was then a part of the North European Brachiopod Province.

Key-words: Ashgillian - Fosse Formation - Belgium - Taxonomy - Brachiopods.

### Résumé

L'auteur décrit 46 espèces d'une faune à Brachiopodes en provenance de la Formation de Fosse en Belgique et procède à la révision de la Sous-Famille des Furcitellinae. Un nouveau genre (*Costistrophomena*), dix nouvelles espèces (*Spinorthis europa*, *Platystrophia leserancei*, *Dalmanella sambrensis*, *Portranella akymatata*, *Saukrodictya wrightii*, *Leangella namurensis*, *Anisopleurella sartenaeri*, *Christiania magna*, *Costistrophomena costata*, *Katastrophomena catalorni*) et une nouvelle sous-espèce (*Luhaia vardi roomusoksi*) sont fondés. Cette faune permet d'établir que l'«Assise» de Fosse est d'âge ashgillien et qu'à cette époque la région faisait partie de la Province à Brachiopodes nord-européenne.

Mots-clés: Ashgillien - Formation de Fosse - Belgique - Taxonomie - Brachiopodes.

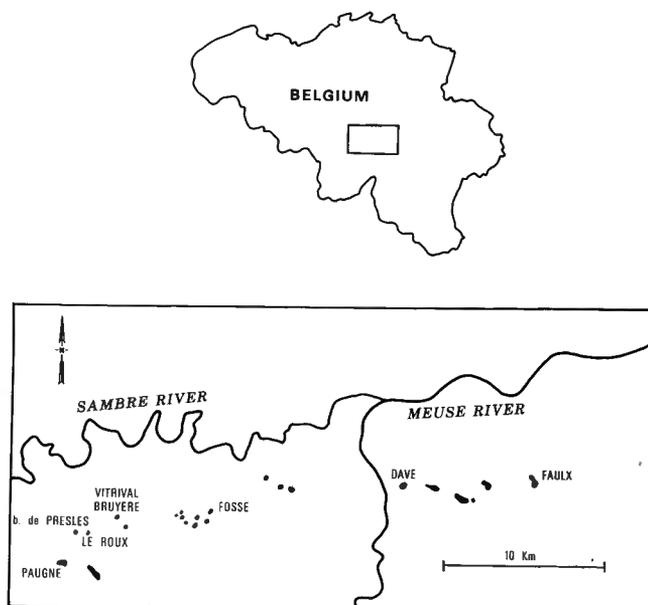
### Introduction

The late Ordovician Fosse Formation occurs in sporadic outcrops in the valleys of the Sambre and Meuse Rivers in Belgium (Fig. 1). The formation attains a thickness of about 100 to 110 m and is composed of shales and siltstones which are commonly calcareous in the lower part of the formation (MICHOT, in WATERLOT, 1957, p. 92). Structurally the region lies at the northern edge of the Hercynian Ardennes, just south of the Caledonian Brabant Massif (RUTTON, 1969).

Fossils occur as molds and preservation is good. Mild tectonic deformation of the shells is common. Brachiopods are diverse and abundant.

The Fosse Formation is very poorly exposed, but it received considerable attention during the late 19th and early 20th centuries (see summaries by MAILLIEUX, 1927; MICHOT, 1928, 1934, 1954, and in WATERLOT, 1957). The formation has generally been considered to be of Late Caradoc age with some Ashgill deposits at the top. However, the present study of the brachiopods from the Fosse Formation indicates that the entire formation is Ashgill in age. Earlier workers recognized a sequence of biostratigraphic zones within the formation, but the revision of the fauna carried out here brings the early biostratigraphic subdivisions into question, and it is suggested that future subdivision of the formation be restricted to lithologic characteristics.

Figure 1. - Location of Belgian Ordovician outcrops near the confluence of the Sambre and Meuse Rivers. The figure is after MARTIN (1968, Fig. 5). Only outcrop regions from which fossils were examined for this report are named.



The brachiopods indicate a close alliance with the late Ordovician North European Brachiopod Province. The formation was examined during a brief visit to Belgium by the author in 1971. Subsequently extensive collections were made by Pierre J. LESPÉRANCE during 1974.

### Age

The fauna from the localities collected during this study is listed on Table 1. The age of this assemblage is Ashgill. Thirteen genera of brachiopods (*Nicolella*, *Boreadorthis*, *Ptychopleurella* (*Glypterina*), *Reuschella*, *Laticrura*, *Vellamo*, *Kullervo*, *Diambonia*, *Sampo*, *Anisopleurella*, *Ptychoglyptus*, *Kiaeromena*, and *Cyclospira*?) are confined to the Ordovician. Four genera (*Dicoelosia*, *Fardenia*, *Ptychopleurella* (*Ptychopleurella*), and *Katastrophomena*) range from the Ashgill into the Silurian. Five genera (*Spinorthis*, *Saukrodictya*, *Portranella*, *Foliomena*, and *Luhaia*) are confined to the Ashgill. Although the assemblage as a whole is clearly Ashgill in age, no single locality contains all the genera listed above. Locality 74B21 (discussed below) has only *Foliomena folium* on which to base its age; but this monotypic genus is known elsewhere only from Ashgill age deposits. The overall homogeneity of the faunas from the remaining localities makes their Ashgill age assignment seem reasonable. All localities have a sufficient number of genera that are known only from the Ordovician to be confident of an Ordovician age. The rationale for an Ashgill age is discussed for each locality in the following section.

Of the genera confined to the Ashgill or younger, *Dicoelosia* is the most reliable to use in establishing an Ashgill age. *Dicoelosia* was examined by WRIGHT (1968) who determined that the genus is confined to the Ashgill or younger with the exception of one group of specimens from the F<sub>1a</sub> beds of Estonia. The latter specimens are probably late Caradoc in age; however, their primitive morphology is so distinctive that it is certain this group is not present in any of the collections under study.

The ranges of brachiopod species in the late Ordovician are very poorly known. Most of the well described species are known from only a few localities and their biozones are therefore very poorly understood. The species which have been confidently identified from Belgium will be discussed first, followed by species which are not certainly identified.

*Confidently identified:* *Boreadorthis recula* (ÕPIK) is based on specimens from the F<sub>1</sub> Lyckholm beds of Estonia. However the exact locality from which the specimens were obtained was not known. Subsequently the F<sub>1</sub> beds have been divided into four units (JAANUSSON, 1956). The F<sub>1</sub> beds now represent the lower part of the Harjuan Stage, equivalent to the Upper Caradoc and part of the Ashgill. *Kullervo com-*

*plectens* (WIMAN) *albida* (REED) is known from the Upper Caradoc to Ashgill Whitehouse beds at Shallock Mill, Girvan, Scotland, and from the Ashgill Portrane Limestone in Ireland. It is thus certainly Ashgill in age but may also occur in the Upper Caradoc. *Sampo ruralis* (REED) was originally described from the Starfish Beds of the Drummuck Group in Scotland; LAMONT (1935) subsequently reported its occurrence throughout the Drummuck Group. It has been widely reported in Ashgill strata in the British Isles. *Sowerbyella subcorrugatella* (REED) was originally described from the Whitehouse Group in Scotland, and has been subsequently reported from Tyrone, Ireland, (JONES, 1928); its range is poorly known. *Oxoplecia* cf. *O. plicata* (WIMAN) is the same species which occurs in the Portrane Limestone of Ireland and it is probably the same species that is found in the Boda Reefs of Sweden; in both areas it is of Ashgill age. *Luhaia vardi* RÖÖMUSOKS is known only from F<sub>1c</sub> beds of Estonia which are correlative with the Ashgill; a new subspecies is recognized in Belgium. *Anisopleurella quinquecostata* (JONES) is known from the Ashgill, but it is so widely reported and poorly understood that it is not useful in correlations. *Foliomena folium* is known from the Ashgill Králův Dvůr Formation of Bohemia and the Jerrestad Formation in southern Sweden.

Species which have tentatively been identified in Belgium have the following stratigraphic ranges: *Dicoelosia lata* WRIGHT and *Skenidioides paucicostatus* WRIGHT are known only from the Ashgill Portrane Limestone of Ireland. *Laticrura erecta* WRIGHT occurs in the Portrane Limestone and in zone 2 of INGHAM'S (1966) Ashgill in northern England. *Sowerbyella raegaverensis* RÖÖMUSOKS is known only from the E Beds (Basal Harjuan) of Estonia and the O<sub>2v</sub> beds of the Russian platform. However, the ranges of sowerbyellids have not been well established in the Baltic Harjuan, and in Belgium the species occurs with numerous other faunal elements which indicate an Ashgill age. *Spirigerina* (*Eospirigerina*) *sulevi* (JAANUSSON) was first described from the F<sub>1c</sub> beds of Estonia which are correlative with the Ashgill. RÖÖMUSOKS (1962) reported the species in the F<sub>1b</sub> beds of Estonia which are correlative with the Upper Caradoc. JAANUSSON (1963) reported the species in the Jonstorp Formation in the Smedsby Gård boring of Östergötland, Sweden, and from the same formation in the Siljan region of Sweden (JAANUSSON, 1958); the Jonstorp Formation is correlative with the Ashgill. JAANUSSON (1956) reported the species in the Ashgill Boda Reefs of Sweden.

### Age Assignments of Localities

The age of each locality, determined by their contained brachiopod fauna, is Ashgill, and the basis for these assignments is discussed below. The localities are divided into two groups — localities containing

	74B 4	74B 7	74B 8	74B 9	74B 10	74B 11	74B 12	74B 13	74B 14	74B 15	74B 16	74B 17	74B 19	74B 20	PS 57	PS 58	74B 21
<i>Nicolella</i> sp. A	X																
<i>Nicolella</i> sp. B			X					?			X		X				
<i>Boreadorthis recula</i>		?	?	X	X	?		?	?	X	X	X	X	X	X		
<i>Glyptorthis</i> sp. A			X														
<i>Glyptorthis</i> sp. B								X			X						
<i>Ptychopleurella</i> ( <i>Ptychopleurella</i> ) sp.	X																
<i>Ptychopleurella</i> ( <i>Glypterina</i> ) sp.													X				
<i>Spinorthis europa</i>	?	X	X				X	?		X	X	X		X			
<i>Platystrophia leperancei</i>				X			X			X	?	X	X	X	X	X	
<i>Skenidioides</i> cf. <i>S. paucicostatus</i>	X											X					
<i>Skenidioides</i> sp.	X						X	X	X	X	X		X	X			
<i>Dalmanella sambrensis</i>	X	X	?		X	?	X	X	X	X		X	X	X	X	X	
<i>Portranella akymatata</i>				X	X	X	X	X		X	X	X	X	X			X
<i>Dicoelosia</i> cf. <i>D. lata</i>	X				X				X		X	X			X	X	
<i>Dicoelosia</i> sp.									X	X	X	X			X	X	
<i>Reuschella</i> sp.											X						
<i>Laticurra</i> cf. <i>L. erecta</i>	X						X				X	X	X		X	X	
<i>Saukrodictya wrighti</i>			X							X	X		X				
<i>Saukrodictya</i> sp.	X																
<i>Vellamo</i> sp.														X			
<i>Kullervo complectens albida</i>	X		X			?				X	X				X	X	
<i>Triplesia</i> sp.	X	X						?			X	X	X	X	X		X
<i>Oxoplesia</i> cf. <i>O. plicata</i>	X								X		X	X	X	X	X	X	
<i>Diambonia</i> sp.					X			X									
<i>Leangella namurensis</i>			?		?					X							?
<i>Leangella?</i> sp.								X									
<i>Sampo ruralis</i>		X	X	X	?			X			X	X			X	X	
<i>Sowerbyella</i> cf. <i>S. raegaverensis</i>								?	X	X	?		X	?			?
<i>Sowerbyella</i> ( <i>Rugosowerbyella</i> ) <i>subcorrugatella</i>														X			
<i>Anisopleurella quinquecostata</i>	X									X							
<i>Anisopleurella</i> sp.			X						X								
<i>Anisopleurella?</i> <i>sartenaeri</i>								X				X	X				
<i>Ptychoglyptus</i> sp.		X											X				
<i>Chonetoides</i> sp.										X							
<i>Christiania magna</i>		?			X	X	X			X			X	X	X		
<i>Foliomena folium</i>																	X
<i>Strophomena</i> sp.				X			X	X		X			X	X			
<i>Luhaia vardi roomusoksi</i>				X				X									
<i>Costistrophomena costata</i>	X		X						X			X	X	X	X	X	
<i>Katastrophomena catalorni</i>								?					X	X			
<i>Leptaena</i> sp.	X	X				X	X		X		X	X	X		X	X	
<i>Kiaeromena</i> sp.					X	X	X	X									
<i>Fardenia</i> sp.															X	X	
<i>Spirigerina</i> ( <i>Eospirigerina</i> ) cf. <i>S. (E.) sulevi</i>	?	X			X	X			X			X				X	
<i>Catazyga?</i> sp.	X														X		
<i>Cyclospira?</i> sp.			X				X	X					X	X			
NUMBER OF SPECIES FROM LOCALITY	17	9	12	5	11	8	12	18	11	16	19	16	21	17	14	12	4

Table 1. - Brachiopods of the Fosse Formation.

specimens of *Dicoelosia* and localities from which *Dicoelosia* has not been recovered. Both species of *Dicoelosia* found in these collections resemble Ashgill species and are unlike any Silurian species. The presence of *Dicoelosia* (range — Ashgill to Devonian) together with a large number of Ordovician genera makes assignment to the Ashgill certain, but supportive evidence is presented. All localities which do not contain *Dicoelosia* are also considered to be Ashgill and the evidence for these age assignments is presented in the second section below. New species erected in this report are not included in the discussion, but since the presence of these species in association with *Dicoelosia* establishes their Ashgill age; their presence in the second set of localities can also be used to support the Ashgill age assignments. The total fauna for each locality is presented in Table 1.

#### Localities with Ashgill *Dicoelosia*:

##### 74B4

Five genera identified from this locality are confined to the Ordovician and of these *Spinorthis* and *Saukrodictya* are known only from the Ashgill. *Ptychopleurella* (*Ptychopleurella*) ranges from the Ashgill into the Silurian. *Kullervo complectens albida* and *Oxoplecia* cf. *O. plicata* are known only from the Ashgill. Species confined to the Ashgill but only tentatively identified here are *Laticrura erecta* and *Skenidioides pauciplicatus*. *Spirigerina* (*Eospirigerina*) *sulevi* ranges from Late Caradoc to Ashgill. An Ashgill age is established.

##### 74B10

Five genera identified from this locality are confined to the Ordovician and of these *Luhaia* is confined to the Ashgill. *Sampo ruralis* is confined to the Ashgill but has been only tentatively identified in this locality. *Spirigerina* (*Eospirigerina*) *sulevi* ranges from Late Caradoc to Ashgill. An Ashgill age is established.

##### 74B14

Two genera identified from this locality are confined to the Ordovician. *Oxoplecia* cf. *O. plicata* is confined to the Ashgill. *Spirigerina* (*Eospirigerina*) *sulevi* is known from the Late Caradoc and Ashgill. *Sowerbyella raegaverensis* (tentatively identified here) is known only from Pre-Ashgill beds in Estonia. However the presence of both *Dicoelosia* sp. and *Dicoelosia* cf. *D. lata* clearly establish an Ashgill age and the range of *S. raegaverensis* must be extended tentatively into the Ashgill. An Ashgill age is established.

##### 74B15

Eight genera identified from this locality are confined to the Ordovician, and of these *Spinorthis*, *Portranella* and *Saukrodictya* are known only from the Ashgill. *Kullervo complectens albida* is known only from the Ashgill. See discussion of locality 74B14 (above) for the range of *Sowerbyella raegaverensis*. An Ashgill age is established.

##### 74B16

Ten genera identified from this locality are confined to the Ordovician and of these *Spinorthis*, *Portranella* and *Saukrodictya* are known only from the Ashgill, *Sampo ruralis*, *Oxoplecia* cf. *O. plicata*, and *Kullervo complectens albida* are confined to the Ashgill. *Laticrura erecta* is known only from the Ashgill but is tentatively identified. See discussion of locality 74B14 (above) for the range of *Sowerbyella raegaverensis*. An Ashgill age is established.

##### 74B17

Six genera identified from this locality are confined to the Ordovician, and of these *Spinorthis* and *Portranella* are confined to the Ashgill, *Sampo ruralis* and *Oxoplecia* cf. *O. plicata* are known only from the Ashgill. Species confined to the Ashgill but only tentatively identified are *Laticrura erecta* and *Skenidioides pauciplicatus*. *Spirigerina* (*Eospirigerina*) *sulevi* ranges from Late Caradoc to Ashgill. An Ashgill age is established.

##### PS 57

Four genera identified from this locality are confined to the Ordovician. *Fardenia* ranges from the Ashgill into the Silurian. *Oxoplecia* cf. *O. plicata* is an Ashgill species. *Laticrura erecta* is an Ashgill species but has been only tentatively identified. An Ashgill age is established.

##### PS 58

Three genera identified from this locality are confined to the Ordovician. *Fardenia* ranges from the Ordovician to the Silurian. *Kullervo complectens albida* and *Oxoplecia* cf. *O. plicata* are confined to the Ashgill. The Ashgill species *Laticrura erecta* has been tentatively identified. *Spirigerina* (*Eospirigerina*) *sulevi* ranges from Late Caradoc to Ashgill. An Ashgill age is established.

#### Localities which lack *Dicoelosia*:

##### 74B7

Three genera identified from this locality are confined to the Ordovician and of these *Spinorthis* is known only from the Ashgill. *Sampo ruralis* is confined to the Ashgill. *Spirigerina* (*Eospirigerina*) *sulevi* is known from the Late Caradoc and Ashgill, but it is only tentatively identified here. Although the fauna from this locality is small it is definitive enough to allow an Ashgill assignment. The age assignment is strengthened by the similarity of this fauna to that from the other Ashgill localities.

##### 74B8

Eight genera identified from this locality are confined to the Ordovician, and of these *Saukrodictya* and *Spinorthis* are confined to the Ashgill. *Kullervo complectens albida* and *Sampo ruralis* are known only from the Ashgill; and an Ashgill age is indicated.

##### 74B9

Three genera identified from this locality are confined to the Ordovician and of these *Portranella* is confined to the Ashgill. *Sampo ruralis* is known only from the Ashgill. An

Ashgill age is indicated and the similarity of the fauna to that of other localities studied strengthens the age assignment.

#### 74B11

Four genera identified from this locality are confined to the Ordovician, and of these *Portranella* is known only from the Ashgill. *Kullervo complectens albida* is confined to the Ashgill but only tentatively identified from this locality. The tentatively identified *Spirigerina* (*Eospirigerina*) *sulevi* is known from the Late Caradoc and Ashgill. Based primarily upon the similarity of this fauna to others of this study an Ashgill age seems likely.

#### 74B12

Five genera identified from this locality are confined to the Ordovician, and of these *Portranella* and *Spinorthis* are known only from the Ashgill, *Laticrura erecta* is confined to the Ashgill, but the species is only tentatively identified from this locality. These limited data plus the similarity of this fauna to others from the region support an Ashgill age assignment.

#### 74B13

Ten genera identified from this locality are confined to the Ordovician and of these *Luhaia* and *Portranella* are confined to the Ashgill. Prior to its identification in Belgium *Katastrophenomena* was known only from the Lower Silurian. *Sampo ruralis* and *Luhaia vardi* are confined to the Ashgill. Finally, a single specimen tentatively assigned to *Dicoelosia* has been recovered. An Ashgill age is established.

#### 74B19

Ten genera identified from this locality are confined to the Ordovician and of these *Saukrodictya* and *Portranella* are known only from the Ashgill. Prior to this study *Katastrophenomena* was known only from the Lower Silurian. *Sampo ruralis* and *Oxoplecia* cf. *O. plicata* are confined to the Ashgill. The Ashgill *Laticrura erecta* has been tentatively identified. See discussion of locality 74B14 for the range of *Sowerbyella raegaverensis*. The evidence clearly supports assignment of this locality to the Ashgill.

#### 74B20

Six genera identified from this locality are confined to the Ordovician, and of these *Spinorthis* and *Portranella* are confined to the Ashgill. Prior to the present study *Katastrophenomena* was known only from the Lower Silurian. *Sampo ruralis* and *Oxoplecia* cf. *O. plicata* are known only from the Ashgill. An Ashgill age is indicated.

#### 74B21

*Foliomena folium* has been reported only from the Ashgill and an Ashgill age is indicated.

The Ashgill Series was subdivided into stages by INGHAM and WRIGHT (1970). The new stages were based merely on local fossil assemblage zones. A rigorous faunal basis of the stages is lacking and they are unrecognizable outside of a small area in northern England, with the exception of the uppermost stage (the Hirnantian Stage) which may be represented by

a unique fauna with time significance. No attempt is made to assign the Belgian faunas to these stages.

Earlier reports of brachiopods from the Fosse Shale (summarized by MAILLIEUX, 1967, MICHOT, 1934, 1954) listed numerous species in these beds. Since most of the collections were not made in restricted stratigraphic intervals, the earlier collections have not been included in the present study. However, an attempt has been made to link the earlier identifications with the species described in this report.

One drawer of fossils which are labeled as having been identified by MAILLIEUX in 1925 (presumably in the preparation of his 1927 paper) was examined carefully and the species identified. All are from the "schistes de Le Roux" at Fosse. The original identification and revised identifications are given below:

<i>Orthis insularis</i>	<i>Triplesia</i> sp.
<i>Platystrophia biforata</i>	<i>Platystrophia lespancei</i>
<i>Leptella? tenuicincta</i>	<i>Christiania magna</i>
<i>Rafinequina corrugatella</i>	<i>Ptychoglyptus</i> sp.
<i>Strophomena pecten</i>	<i>Fardenia</i> sp.
<i>Atrypa reticularis</i>	<i>Costistrophomena costata</i>
	and <i>Spinorthis europa</i>
<i>Atrypa marginalis</i>	<i>Spirigerina</i> ( <i>Eospirigerina</i> )
	<i>sulevi</i> and <i>Oxoplecia</i> cf.
	<i>O. plicata</i>
<i>Athyris</i> sp.	<i>Triplesia</i> sp.

Other species such as *Dalmanella testudinaria*, *Orthis plicata*, *Plectambonites sericeus*, and *Plectambonites transversalis* include several species or the material available is too poorly preserved to allow identification.

Comparison of species lists for the localities under study with earlier lists from the same or near-by localities suggests the following revised identifications:

<i>Orthis actioniae</i>	<i>Nicolella</i> sp.
<i>Orthis calligramma</i>	<i>Portranella akymatata</i>
<i>Orthis porcata</i>	<i>Boreadorthis recula</i>
<i>Orthis vespertilio</i>	<i>Reuschella</i> sp.
<i>Dalmanella testudinaria</i>	<i>Dalmanella sambrensis</i>
<i>Dalmanella turgida</i>	<i>Laticrura</i> cf. <i>L. erecta</i>
<i>Strophomena pecten</i>	<i>Costistrophomena costata</i>
<i>Leptaena rhomboidalis</i>	<i>Leptaena</i> sp.
<i>Leptaena undata</i>	<i>Katastrophenomena catalorni</i>
<i>Plectambonites youngianus</i>	<i>Christiania magna</i>
<i>Retzia bouchardi</i>	<i>Catazyga?</i> sp.

### The Fosse Formation

The Fosse Formation has traditionally been subdivided by a combination of lithologic and faunal criteria (see MAILLIEUX, 1927; MICHOT, 1928, 1934, 1954, and in WATERLOT, 1957). MICHOT (in WATERLOT, 1957, pp. 187-189) recognized two lithologic units and characterized the Fosse Formation by repeating his earlier description of the formation in the region (MICHOT, 1934, p. 92):

- (I) Schistes verts et vert noirâtre, finement gréseux à *Tretaspis seticornis* et *Christiania tenuicincta* (Ashgillien).
- (II) Grauwackes, schistes calcareux et calcschistes avec localement quelques bancs calcaires, à *Plaesiomys porcata* et *Nicolella actoniae*, subdivisé en deux niveaux;
- b) niveau de grauwackes et calcschistes noduleux à *Strophomena pecten*;
- a) niveau de calcschistes et schistes calcareux, parfois avec bancs calcaires.

Since the two lithologic units can be recognized over this region and are mappable (see MICHOT, 1934, figs. 3, 4, and 5 and Pl. 1) they will be referred to informally as lower and upper members of the Fosse Formation. The formation is underlain by the Vitruvian-Bruyère Formation of Llandeilo to Early Caradoc age, and it is overlain by Llandovery strata (MICHOT, 1954).

The biostratigraphic subdivision of the formation based on brachiopods is not valid. The previously recognized biostratigraphic subdivisions of the Fosse Formation were expressed by MICHOT (1954, p. 52) as follows:

Ashgillien:

à *Tretaspis seticornis* et *Christiania tenuicincta*.

Caradocien (s.s.):

- b) Zone à *Plaesiomys* (sic) *porcata* et *Nicolella actoniae* comportant deux sous-zones:
- 1) Sous-zone à *Strophomena pecten*.
  - 2) Sous-zone sans *Strophomena pecten*.

In the above scheme the Ashgill fauna was contained in the upper member and the Caradoc fauna came from the lower member. In the previous section of this memoir the fauna of the Fosse Formation was shown to be of Ashgill age. Collections from each of the three biostratigraphic subdivisions outlined above have provided faunas of demonstrable Ashgill age, as have collections from both the top and base of the formation.

The biostratigraphic units were based on minor differences in the fauna. The *Nicolella actoniae* (= *Nicolella* sp.) – *Plaesiomys porcata* (= *Boreadorthis recula*) fauna which characterizes the lower member actually ranges through the upper member (e.g. MICHOT, 1934, pp. 14, 19, 22, 35). Among the brachiopods only *Christiania tenuicincta* and *Strophomena pecten* were used in the subdivision. The species *Christiania tenuicincta* of earlier reports is the new species *Christiania magna*. It has been found throughout the formation and occurs at the base of the formation. The name *Strophomena pecten* of earlier workers has been applied to both *Costistrophomena costata* n. sp. and *Fardenia* sp. Some specimens identified by MAILLIEUX as being *S. pecten* were examined by the author and found to be *Fardenia* sp. *S. pecten* was reported in earlier collections at localities 74B4, 74B19, and 74B20 of this report. While *Fardenia* sp. was not present in collections from these localities the grossly

similar, coarsely ribbed *Costistrophomena costata* does occur. *Costistrophomena costata* also ranges well into the upper member (localities 74B19 and 74B20). *Fardenia* sp. occurs at the base formation at localities PS57 and PS58. *Costistrophomena costata* occurs at the base of the formation in localities 74B16, 74B17, PS57 and PS58. Clearly the recognition of a lower zone or subzone based on the absence of this species is unwarranted. All the zones of earlier workers based on brachiopods are invalid.

An attempt was made to recognize biostratigraphic subdivisions within the formation. The collections placed in their relative stratigraphic order are as follows:

Upper Member:

Top of formation: 74B9, 74B10

Middle of upper member: 74B7, 74B8, 74B21

Lower part of upper member: 74B11, 74B12, 74B13, 74B19, 74B20

Lower Member:

Middle or upper part of lower member: 74B4, 74B15

Near base of lower member: 74B16, 74B17, PS57, PS58

Position in formation uncertain, probably in lower member: 74B14.

As can be seen by comparing the faunas from these localities with each other (see Table 1) the overall faunal composition is quite homogeneous. Faunas from the base of the formation are very similar to those at the top. Of 13 species recorded from the uppermost two localities 8 are present among the 27 species recorded from the four localities at the base of the formation. The five species recorded from the top but not the base of the formation are *Diambonia* sp., *Leangella* cf. *L. namurensis*, *Strophomena* sp., *Luhaia vardi roomusoksi*, and *Kiaeromena* sp. However, of these five species none are found in both of the uppermost collections. None of the species from the basal localities are confined to the base of the formation.

Of species recorded in more than one collection only four are found only in the lower member, and these species are each recorded in only two localities. Of species recorded from more than one locality seven occur in only the upper member. Of the seven species confined to the upper member, five are recorded in only two localities. Only two species, *Kiaeromena* sp. and *Strophomena* sp., that are well represented in the upper member have not been found in the lower member. Note that *Strophomena* sp. is a fine ribbed species which could not be misidentified with *Strophomena pecten*, a coarsely ribbed species used by earlier workers to characterize a subzone in the lower member.

Clearly, distinct faunas do not characterize the two members. No meaningful zonation can be extracted from the minor faunal differences which are present. Therefore, in the future subdivision of the Fosse

Formation should be made on lithologic grounds, and prior biostratigraphic subdivisions should be abandoned.

### Community Ecology

The Belgian brachiopods are from a relatively deep water benthic assemblage in the sense of BOUCOT (1975). The fine grained sediments in which the brachiopods were found are consistent with the interpretation that they were deposited in relatively deep, quiet water. Two communities are represented. The fauna from locality 74B21 is representative of the *Foliomena* Community and the faunas from the remaining localities can be accommodated in the *Dicoelosia-Skenidioides* Community.

#### *Foliomena* Community:

The fauna from Locality 74B21 contains the brachiopod *Foliomena folium* which in other regions (Bohemia, Sweden, Poland, Québec) is from a relatively deep water community (benthic Assemblage 5-6) that is commonly developed adjacent to the graptolite facies (SHEEHAN, 1973, 1977). In Belgium *Foliomena folium* occurs in a community having about equal numbers of brachiopods and trilobites. The brachiopod fauna is composed of extremely small individuals which closely resemble small specimens of species found in the other localities. Clearly the associated species were not living in their environmental optima. The *Foliomena* Community is an Ashgill community which commonly occurs in both the Mediterranean and North European Provinces. SHEEHAN (1977) suggests that the *Foliomena* Community lived in a deep, cold water mass which developed in association with glaciation in North Africa, much as deep, cold water masses occur in the present oceans. The minute specimens of species which are common in the other Belgian community may represent individuals developed from larva which penetrated into deeper, possibly colder water. The individuals may have been unable to reach normal adult size in an environment which, for them, was hostile. Locality 74B21 is located southeast of Locality 74B4. This is in the most likely directions of deep water, off shore from the Brabant Massif. In addition the specimens in the adjacent locality 74B4 are generally smaller than those from the other localities, and locality 74B4 may be a relatively deep water development of the *Dicoelosia-Skenidioides* Community.

#### *Dicoelosia-Skenidioides* Community:

The fauna from localities other than locality 74B21 can be assigned to the broadly conceived *Dicoelosia-Skenidioides* Community of BOUCOT (1975). The taxonomic composition is compatible with this assign-

ment as is the generally small size attained by individuals and the diverse nature of the fauna. Diversity of brachiopods is extremely high (up to 21 species) in these modest sized collections. Such high brachiopod diversities are unusual in the Ordovician and are commonly found only in reefs and in Benthic Assemblage 4-5 position. The *Dicoelosia-Skenidioides* Community of BOUCOT (1975) ranges in age from Ashgill to Lower Devonian. During this period its taxonomic composition changed greatly. Thus it actually represents a series of communities through time. A separate community in the *Dicoelosia-Skenidioides* Community continuum is present in Belgium since the fauna is taxonomically distinct from the typical Silurian example given by BOUCOT (1975). However, a new community is not named at this time because it is the author's belief that new communities should only be recognized when their position relative to other communities can be established. Since no shallow water Ashgill communities are known from this region, a new name would do little to clarify the community ecology of the North European Province in the Late Ordovician.

### Biogeography

The biogeographic affinities of this fauna are clearly with northern Europe and parts of the British Isles, especially Ireland. Unfortunately the biogeography of Late Ordovician brachiopods is not well understood. To date WILLIAMS (1969, 1973, 1976) has presented the most rigorous treatment of the distribution of Late Ordovician brachiopods. However, he confined his examination to faunas which he considered to belong to only two distinct intervals, Late Caradoc and Middle Ashgill. He also restricted himself to well described faunas. His limited approach was necessitated by the space available to him in the symposium volumes in which his studies were presented. Of necessity much material was omitted in his treatment, and the geographic distributions of individual genera were not presented. WILLIAMS (1973) recognized separate North American and North European Provinces with a possible Bohemian Province based on one assemblage. Many of his faunal lists are based on his personal work and work in progress by others so the areal distribution of individual genera can not be reconstructed from the literature which he cited. Since WILLIAMS' work was completed, the brachiopods of southern Europe and North Africa have been restudied, and the presence of a distinctive Mediterranean Province has been established, primarily through the work of HAVLÍČEK. HAVLÍČEK began his studies of the Mediterranean Province brachiopods in Bohemia and subsequently described faunas from North Africa (HAVLÍČEK, 1951, 1967, 1970, 1971, 1974, 1976, a.o.; HAVLÍČEK & VANEK, 1966; HAVLÍČEK & MESSA, 1973; HAVLÍČEK & MAREK, 1973).

HAVLÍČEK's work substantiated the suggestion by SPJELDNAES (1961, 1967) that there was a South European-North African Province which owed its existence to a temperature gradient. Such a temperature gradient is reasonable since a Late Ordovician glaciation in North Africa is now well established (See BEUF, *et al.*, 1971). HAVLÍČEK, in the studies cited above, outlined the faunal composition of the Mediterranean Province and recently (HAVLÍČEK, 1976) discussed the incursion of several North European Province brachiopods into the Mediterranean region.

JAANUSSON (1971) also discussed the geographic distribution of several brachiopods in the Late Ordovician. His paper also preceded most of the work on the Mediterranean Province and was concerned primarily with the North European and North American Provinces. In the Late Ordovician, JAANUSSON (1971) recognized (1) an American Mid-Continent fauna, (2) a Hiberno-Salairian Province, including parts of the British Isles, Scandinavia, the Baltic region and the margins of North America, and (3) the Kolymo-Alaskan Belt, including Siberia and Alaska, which may be a part of the Hiberno-Salairian Province.

In summary although a rigorous provincial analysis has yet to be undertaken there does seem to be general agreement that in the Late Ordovician there were three faunal provinces in the present African, North American, and European regions. First is a North European Province including the Baltic region the Russian platform, Poland and parts of the British Isles, and the present Belgian faunas. North European Province faunas also occurred around the margins on North America in Gaspé, Québec (COOPER, 1930; COOPER & KINDLE, 1936; LESPÉRANCE & SHEEHAN, 1976), parts of Maine (NEUMAN, 1968), in Alaska (ROSS & DUTRO, 1966) and in north-west California (POTTER & BOUCOT, 1971).

Second, the North American Platform and possibly parts of Siberia were inhabited by a strongly endemic fauna which need not be discussed further in the present context, since none of the characteristic genera (e.g. *Lepidocyclus*, *Diceromyonia*, *Thaerodonta*) are recorded in Belgium. And finally a Mediterranean Province included North Africa and southern Europe including Brittany, the Carnic Alps, Bohemia, Spain and Portugal.

Since there has been no synthesis of Late Ordovician Brachiopod biogeography which presents taxonomic compositions and detailed geographic ranges of individual genera within the provinces, the discussion of the biogeographic affinities of the Belgian fauna must rely largely on comparisons with specific faunas from other areas. Using this approach similarities between faunas are informative. But it is difficult to assess the importance of differences between two assemblages, since the community relationships of the faunas have not been studied. Collections from communities living in different physical settings within one province often differ as much as do collections from communities

living in similar habitats in separate faunal provinces. In the same way, computation of various coefficients of association between two faunas (see for example WILLIAMS, 1973) may have only local ecologic significance, rather than biogeographic relevance.

#### *North European Province:*

The overall assemblage clearly has North European Province affinities. WILLIAMS (1974) listed 14 genera that were endemic to this North European Province and were present in at least 4 of the collections on which he based his study. Of these 14 genera 10 are found in Belgium. However, some of these genera (such as *Nicollella*, *Anisopleurella*, *Christiania*, and *Sampo*) are suspect because they are known from Caradoc equivalents in the Mediterranean Province, (HAVLÍČEK, 1976; HAVLÍČEK & MAREK, 1973; VAL, 1971; HARTVELT, 1970) and may have escaped detection in the Ashgill if communities in which they lived have not been adequately sampled.

All genera (aside from the new genus *Costistrophomena* and the genus *Katastrophomena*, which is recorded here for the first time in the Ordovician) have previously been reported from the North European Province. Genera which apparently are restricted to the North European Province include: *Boreadorthis*, *Diambonia*, *Dicoelosia*, *Kullervo*, *Leangella*, *Ptychoglyptus*, *Laticrura*, *Spirigerina* (*Eospirigerina*), *Ptychopleurella* (*Ptychopleurella*), and *Spinorthis*.

#### *Ireland:*

Of all well described Late Ordovician faunas, that of the Portrane Limestone of Ireland described by WRIGHT (1964) is by far the most similar to the Belgian fauna. Of the articulate brachiopods only the Orthida have been monographed recently (WRIGHT, 1964). Of 18 orthid genera and subgenera in the Belgian collections 16 are recorded from the Portrane Limestone. The similarity is strengthened by a comparison of the orthid species in common which include *Kullervo complectens albida* and *Oxoplecia* cf. *O. plicata*. In addition 3 species (*Skenidioides pauciplicatus*, *Dicoelosia lata*, and *Laticrura erecta*) from the Portrane Limestone have been identified tentatively in the collections under study. Since the Irish faunas occur in limestone, and the Belgian fauna is from a mudstone, the faunal similarities are even more striking.

Of the 38 genera identified in Belgium 24 are found among the 61 genera of articulate brachiopods recorded in the Killeen Bridge Formation of Pomeroy, Ireland, by MITCHELL (1977). Although the generic similarity indicates an affinity between the two regions, only one species, *Sampo ruralis*, is common to the two areas. In general the Portrane and Belgian faunas are more similar to each other than either is to the Pomeroy fauna. Whether the distinctiveness of the

Pomeroy brachiopods is due to their occupying a different community, having lived at different times, or having been parts of separate biogeographic entities can not be determined with the current state of our knowledge.

#### England:

In the Cautley and Dent regions of north England the fauna listed by INGHAM (1966) is reasonably up to date. Nineteen of the 36 genera recorded in Belgium are also recorded by INGHAM. Here and in the following section the new genus *Costistrophomena* is excluded from comparisons with other regions.

Ashgill faunas from elsewhere in the British Isles are in need of revision and, because of this, comparisons with Belgium are difficult to make.

#### Baltic:

The fauna of the Harju Series of the Baltic region is known through the work of numerous authors and this information has yet to be adequately compiled. However, a composite faunal list was assembled from the following publications: *Estonia* — RÕÕMUSOKS, (1962, 1964, 1959, 1956); ÕPIK (1934), MANNIL (1966), HINTS (1975). *Sweden* — SHEEHAN (1977) summarized previous records of Late Ordovician brachiopods that appeared in the literature through 1975, and supplemented this list with a few personal collections. Twenty four of the 36 genera recorded in Belgium have been reported in the Baltic region. Genera missing from the Baltic are *Ptychopleurella* (*Glypterina*)\*, *Spinorthis*\*, *Skenidioides*, *Protranella*\*, *Saukrodictya*\*, *Diambonia*, *Anisopleurella*, *Chonetoidea*, *Katastrophomena*\*, *Kiaeromena*, *Fardenia*, and *Catazyga*. The five genera marked with an asterisk (\*) were erected too recently to have been recorded in most of the faunal lists from which the Baltic fauna was compiled. So in fact 24 of 31 possible genera were recorded in the Baltic. For the most part the 7 genera not recorded from the Baltic region (lacking an asterisk in the preceding list) are common elsewhere in the North European Province.

Comparison with only northern Estonia reveals the kinds of differences which are probably due to the presence of different communities. Some of the typical North European Province genera (e.g. *Chrsittiania*, *Ptychoglyptus*) do not occur in northern Estonia (JAANUSSON, 1971). In addition three genera (*Bekkeromena*, *Porambonites*, and *Ilmarinia*) which JAANUSSON (1971) regarded as endemic to northern Estonia are not known from Belgium. The Belgian fauna is thus probably from the same faunal province as the Estonian fauna but differences between the faunas do exist. Most likely these differences are due to community ecology as most of the Estonian faunas are from limestones deposited in relatively shallow water (see MANNIL, 1966) whereas the Belgian fauna is from relatively deep water, non-carbonate mudstones.

The fauna from the Russian platform (ALICHOVA, 1960) is similar to that of the Baltic.

#### Alaska:

Species of 12 genera were recorded from probable Ashgill strata in Alaska by ROSS & DUTRO (1966); of these genera seven (*Dicoelosia*, *Ptychoglyptus*, *Cyclospira*?, *Platystrophia*, *Diambonia*, *Christiania*, *Catazyga*) are also known from the Belgian collections.

#### Gaspé, Québec:

COOPER & KINDLE (1936) recorded 23 genera from the White Head Formation in the vicinity of Percé, Québec, Canada, and of those, 16 occur in Belgium. Preliminary work on White Head Formation faunas has resulted in identification of two additional genera known from Belgium — *Chonetoidea* and *Foliomena* although other genera newly recorded in the White Head Formation do not occur in Belgium (e.g. *Epitomyonia*). A more detailed comparison of these faunas with the Belgium fauna must await completion of the study of the White Head Formation brachiopods.

#### Mediterranean Province:

Recent work on brachiopods from the Mediterranean Province makes it possible to compile a list of genera which have been found in the region. Although a community analysis of the faunas of the province will be needed before detailed comparisons can be attempted, tentative comparisons with other faunas can be made. A list of brachiopod genera known from the province was compiled from the following sources: *Bohemia* — HAVLÍČEK (1951, 1970, 1967), HAVLÍČEK & MAREK (1973), HAVLÍČEK & VANEK (1966). *Iberian Peninsula* — MITCHELL (1974), HAMMANN (1976), CHAUVAL *et al.* (1969). *France* — MELOU (1971, 1973), BABIN *et al.* (1976). *Carnic Alps* — VAI (1971), SCHÖNLAUB (1971). *North Africa* — HAVLÍČEK (1971), HAVLÍČEK & MASSA (1973). HAVLÍČEK & MAREK (1973) proposed a new sequence of chronologic units for the Ordovician of the Mediterranean Province. The Beroun Series is correlated with the uppermost Llandeilo, Caradoc, and lowermost Ashgill in the British sequence. The Králův Dvůr Series correlates with the middle Ashgill of Britain and the Kosov Series with the uppermost Ashgill, presumably the Hirnantian Stage. In compiling the faunal list, faunas assigned by authors to the Upper Caradoc are included in the list. It is difficult to correlate accurately between provinces, and faunas which were assigned to the Upper Caradoc are now included within the Beroun Series. From the correlations of HAVLÍČEK & MAREK (1973) the Upper Beroun (pre-Králův Dvůr) is correlative with the Lower Ashgill, raising the possibility that faunas once correlated with the

upper Caradoc could be correlative with the Lower Ashgill. Thus in the following comparisons faunas from the Upper Beroun and Králův Dvůr Series were included in the list of Mediterranean Province genera. This procedure is warranted since it is concluded that the Belgian fauna was not part of the Mediterranean Province and expanding the list to include possible Caradoc age faunas could only bias the data against confirmation of the conclusions. Of the 34 genera recorded from Belgium, 19 have also been recorded in the Mediterranean Province. Genera recorded from both areas are: *Nicolella*, *Glyptorthis*, *Dalmanella*, *Reuschella*, *Saukrodictya*, *Triplesia*, *Sampo*, *Anisopleurella*, *Chonetoidea*, *Christiania*, *Foliomena*, *Strophomena*, *Luhaia*, *Leptaena*, *Kiaeromena*, *Fardenia*, *Catazyga*, *Cyclospira?*, and possibly *Portranella* which has been tentatively identified in Portugal (MITCHELL, 1974). Although there are a large number of genera common to the two regions the genera which characterize the Mediterranean Province (e.g. *Svobodiana*, *Hirnantia* (in pre-Kosov-rocks), *Tafilaltia*, *Destombesium*, *Tazzarinia*, *Gelidorthis*, *Drabovinella*) have not been found in Belgium. The absence of distinctive Mediterranean Province genera in Belgium, together with the presence of numerous North European Province endemics clearly indicates that the Belgian fauna can not be allied with the Mediterranean Province. Of the genera common to both areas HAVLÍČEK noted that *Nicolella*, *Christiania*, and *Strophomena* «are more characteristic of the warm water seas of the Baltic regions and the North European Province. These genera are not common in the Mediterranean Province but are known, chiefly from the central parts of the proto-Tethyan sea (Spain, Sardinia, Austria).» (HAVLÍČEK, 1976, p. 355).

#### Asia:

The biogeographic affinities of Asian Late Ordovician brachiopod faunas are still uncertain. Interpretive studies (HAMILTON, 1970; CHURKIN, 1973; BURRET, 1974; ZONENSHAIN, 1973) indicate that the present Asian continent is composed of several lithospheric plates that may have been widely separated in the Late Ordovician. Upper Ordovician brachiopods in Asia are being intensively studied in the Soviet Union and analytical studies of the provincial affinities of the faunas by Soviet workers would rapidly outdate any summary presented here. Therefore no attempt has been made to synthesize the vast literature which bears on the biogeographic distribution of individual taxa in the Asian region. The Belgian fauna is compared to a few faunas that have been described recently and whose taxonomy is reasonably up to date.

#### NORTHWESTERN SIBERIA:

In their classic monograph NIKIFOROVA & ANDREEVA (1961) described the Ordovician and

Silurian brachiopods of northwestern Siberia. The generic identifications need to be updated in light of more recent work, but the monograph remains as the starting point for any examination of Asian faunas. Of 13 genera recorded from the Late Ordovician of this region only five (*Glyptorthis*, *Boreadorthis*, *Strophomena*, *Oxoplecia* and *Triplesia*) are present in Belgium. The Siberian fauna is quite distinctive especially in the presence of several rhynchonellids (see also SOKOLOV & TESAKOV, 1975). It will not be possible to understand the significance of the differences between the faunas of the two regions until more is known about the community relationships of the Siberian fauna.

#### NOVYA ZEMLIA:

BONDAREV (1968) records a Late Ordovician fauna from Novya Zemlia that has similarities with the fauna described by NIKIFOROVA & ANDREEVA (1961) in the presence of several of the same species. However, of 9 Ashgill genera 6 are found in Belgium, and if the Late Caradoc genera are added 20 genera are present of which 11 are recorded in the Ashgill faunas of Belgium.

#### SEVERO-VOSTOKA (CENTRAL SIBERIA):

ROZMAN (1970) described brachiopods from the Upper Ordovician in the area around Verkhoyansk in central Siberia. Of a total of 19 genera found by ROZMAN, 9 are present in Belgium. Of the genera in common between the regions, three (*Diambonia*, *Spirigerina* (*Eospirigerina*), and *Ptychoglyptus*) are thought to be restricted to the North European Province. However other genera such as *Paucicrura* and *Zygospira* have North American Province affinity.

#### KAZAKHSTAN:

NIKITIN (1972) summarized the known records of Late Ordovician brachiopods in Kazakhstan. In the Ashgill, 17 genera were recorded, and of these 9 are known in Belgium. Combining NIKITIN's (1972) lists of Late Caradoc and Ashgill brachiopods reveals 39 genera in Kazakhstan of which 16 are known from Belgium. Of the genera recorded in both regions *Leangella*, *Ptychopleurella*, *Spirigerina* (*Eospirigerina*), and *Diambonia* are considered to be characteristic of the North European Province. Other genera such as *Lepidocyclus*, *Austinella*, and *Zygospira* have North American Province affinity.

#### Position of Belgium on the North European Plate

Current plate tectonic reconstructions for the Ordovician divide Europe into northern and southern segments separated by a Mid-European Ocean (ANDERSON, 1975; BADHAM & HALLS, 1975; BURRET,

1972, 1973; BURRETT & GRIFFITHS; DEAN, 1976; DEWEY & BURKE, 1973; HAVLÍČEK, 1974, 1976; JOHNSON, 1974; LAURENT, 1972; LORENZ, 1976; MCKERROW & ZIEGLER, 1972; SMITH *et al.*, 1973; WHITTINGTON & HUGHES, 1972). Some disagree (e.g. AGER, 1975; KREBS & WACHENDORF, 1973; SPJELDNAES, 1976), but evidence for a Mid-European Ocean is impressive. The Mid-European Ocean closed during the Late Paleozoic, juxtaposing areas that in the Ordovician were widely separated.

Most studies place Belgium in the North European Plate, but some (HAVLÍČEK, 1976; DEAN, 1976; SMITH *et al.*, 1973) have placed Belgium in the South European Plate. The inclusion of the Belgian brachiopods in the North European Province strongly supports the positioning of Belgium in the North European Plate during the Ordovician. Since the faunal communities sampled are from relatively deep Benthic Assemblages and since no North European Province faunas are known south (present direction) of this area it is reasonable to conclude that the Sambre-Meuse Region bordered the Mid-European Ocean. The presence of an oceanic barrier to faunal communication is one of the reasons why the Late Ordovician faunas of Belgium are so different from those of south Europe. The suture line between the North European and South European-North African plates must lie between the Sambre-Meuse region and the Armorican Massif which has marine faunas of the Mediterranean Province (see summary by BABIN *et al.*, 1976).

COOK & TAYLOR (1975) and TAYLOR & COOK (1976) caution that during times of strong latitudinal temperature gradients, faunal resemblance data should be used for plate tectonic reconstructions only when the habitat and climatic preferences of the faunas are known. This is because, when a thermocline is present, faunas living in cold water below the thermocline may be as different from faunas living in water above the thermocline as are faunas from separate faunal provinces. In fact the thermocline acts as a provincial boundary (See COOK & TAYLOR, 1975, for recent and Cambrian examples; SHEEHAN, 1977, for the Ordovician). The Mediterranean Province was developed in high latitudes and must have been a relatively cool water province, whereas the North European Province was in much lower latitudes with relatively warmer water. A wide suite of shallow to deep water communities are known from the Mediterranean Province (HAVLÍČEK, 1976) and communities from all depths are easily distinguished from North European Province faunas. The *Dicoelosia-Skenidioides* Community (found in Belgium) belonged to the North European Province, and if a thermocline was present, this community lived above any faunal discontinuity. The *Foliomena* Community might represent a cold, deep water community living below the thermocline (SHEEHAN, 1977). In any case the habitat and climatic preferences of faunas from both provinces are reliable enough to be confident of the provincial affinities,

and the interpretation that Belgium was part of the North European Province is strongly supported by the faunal data.

### Taxonomy

Phylum BRACHIOPODA  
 Class ARTICULATA  
 Order ORTHIDA  
 Suborder ORTHOIDEA  
 Superfamily ORTHACEA WOODWARD, 1852  
 Family ORTHIDAE WOODWARD, 1852  
 Subfamily PRODUCTORTHINAE  
 SCHUCHERT & COOPER, 1932  
 Genus NICOLELLA REED, 1917  
*Nicolella* sp. A  
 (Pl. 1, figs. 1-3)

#### *Exterior:*

The lateral profile is concavo-convex; the ventral valve is very strongly curved posteriorly. The shells are transverse; maximum width is at the hinge line. The ventral interarea is short but distinct. Costae are strong and angular in cross section. Costae do not branch on the specimens available for study. There are 11 ventral and 10 dorsal costae. Growth lines increase in strength anteriorly. The largest shell is about 15 mm long.

#### *Ventral interior:*

Teeth are supported by very short dental plates. Muscle scars are not visible. The external ornament is deeply impressed on the interior.

#### *Dorsal interior:*

No dorsal interiors were recovered.

#### *Discussion:*

The material is too limited and poorly preserved to attempt a specific identification.

#### *Material:*

74B4 — 2 ventral and 3 dorsal valves.

*Nicolella* sp. B  
 (Pl. 1, figs. 4-6)

#### *Exterior:*

Shells are concavo-convex, though small individuals are ventribiconvex. The ventral interarea is short but distinct. Shells are transverse. Costae are strong, and angular in cross section. There are 15 to 18 costae on ventral valves. Growth lines are well developed. The largest shell is about 20 mm long.

#### *Ventral interior:*

Teeth are supported by short dental plates. The muscle field is weakly impressed. Diductor muscle

scars do not surround the adductor muscle scars anteriorly. The external ornament is very weakly impressed on the interior.

*Dorsal interior:*

The cardinal process is strong and ridgelike. Brachio-phores are widely divergent anteriorly. The muscle field was not preserved in any of the specimens examined.

*Comparison:*

*Nicolella* sp. B differs from *Nicolella* sp. A in having more numerous costae and having the external ornament weakly rather than strongly impressed on the interior.

*Material:*

74B8 — 4 ventral and 2 dorsal valves; 74B16 — 7 ventral and 3 dorsal valves; 74B19 — 3 ventral and 2 dorsal valves. Identified as *Nicolella* sp. B?: 74B13 — 1 dorsal and 2 ventral valves.

Family HESPERORTHIDAE  
SCHUCHERT & COOPER, 1931  
Subfamily HESPERORTHINAE  
SCHUCHERT & COOPER, 1931  
Genus BOREADORTHIS ÖPIK, 1934  
*Boreadorthis recula* ÖPIK, 1934  
(Pl. 1, figs. 7-16)

*Boreadorthis recula* ÖPIK, 1934, pp. 189-180, text figs. 42III, 47.

*Boreadorthis recula* var. *aequivalvata* ÖPIK, 1934, p. 190, text fig. 46 (lower).

*Boreadorthis recula aequivalvata* ÖPIK. ALICHOVA, 1953, pp. 42-43, Tab. 3, fig. 16a-e.

*Boreadorthis recula* ÖPIK. ORASPOOLD, 1959, pp. 66-68, Tab. 3, fig. 6.

*Exterior:*

The lateral profile is dorsibiconvex with the dorsal valve strongly curved. The outline is transverse; maximum width is in the posterior third of the valve. The largest shell, a ventral valve, is 33 mm wide and 23 mm long. The delthyrium is poorly preserved in the available specimens, and the presence of a deltidium could not be established. Both interareas are well developed. The surface is coarsely costellate; the largest shell has 44 costellae. Most new costellae arise by insertion. The steep sided costellae are flat-topped and are separated by interspaces that are wider than the costellae. From three to five fine parvicostellae are in the flat interspaces along the median 3/4 of the shell. Interspaces along the shell margins are narrow and do not contain parvicostellae. Concentric ornament consists of strong, irregularly spaced growth lines that cover the entire shell. Six to eight growth lines occupy a space of one mm along the midline near the anterior margin of large shells.

*Ventral interior:*

The teeth are supported by dental plates and have crural fossettes. Strong ridges extend forward from the dental plates and surround the muscle field which is confined to the posterior third of the valve. The adductor muscle scars are bounded laterally by low, parallel ridges. The adductor muscle scars are large, occupying the median third of the muscle field, and they extend nearly as far anteriorly as do the diductor muscle scars. The antero-lateral margins of the diductor muscle scars of specimens from locality 74B16 are more angular than on the specimen from locality 74B19 (compare Pl. 1, figs. 9 & 14).

*Dorsal interior:*

The notothyrial platform is well developed. The cardinal process is strong and platelike. The bladelike brachio-phores are basally convergent and anteriorly flaring. The medial surface of each brachio-phore bears a strong groove. The median ridge is broad and poorly defined. The dorsal muscle field is very weakly impressed.

*Comparison:*

This species is distinguished by having more numerous costellae than specimens of *Boreadorthis crassa* ÖPIK, *B. sadewitziensis* RÖMER (see ALICHOVA, 1953, and ORASPOOLD, 1959), *B. asiatica* NIKIFOROVA, and *B. toganensis* SEVERGINA.

*Orthis scotica* M'COY which was tentatively placed in *Boreadorthis* by NIKIFOROVA & ANDREEVA (1961, p. 85) has been shown to be a species of *Plectorthis* by WILLIAMS (1962).

*B. recula* is known elsewhere only from the Lyckholm Beds (F<sub>1</sub> Stage) of Estonia.

The genus *Boreadorthis* is unique among members of the Hesperorthinae in possessing pronounced concentric ornament, approaching that found on individuals of the Glyptorthinae. However, the shape of the brachio-phores, the presence of broad, flat-topped costellae, fine parvicostellae in the interspaces, and a deltidium are characteristic of members of the Hesperorthinae.

*Boreadorthis recula* is the species which has commonly been referred to *Plaesiomys porcata* by previous students of the Belgian fauna (e.g. MICHOT, 1934). *Orthis porcata* M'COY was referred to *Plaesiomys* by HALL & CLARKE (1892) when they erected the genus. They based the assignment on a description of the species by DAVIDSON (1869). However, the redescription of topotypic material of the species by WRIGHT (1965) reveals that the species has several morphological features which do not agree with *Plaesiomys*. *Plaesiomys* has a much more bulbous myophore on the cardinal process, and finer ribbing than *Orthis porcata*. In addition *Plaesiomys* has rod-like rather than flattened brachio-phores and oval ventral adductor muscle scars enclosed by the diductor muscle scars, rather than the elongate adductor muscle scars

which are not entirely surrounded anteriorly by the diductor muscle scars in *O. porcata* (see WRIGHT, 1965). *B. recula* differs from «*P.*» *porcata* in having coarser ribbing, much wider interspaces (with parvicostellae), and a bladelike cardinal process lacking a well developed myophore.

*Material:*

74B9 — 2 dorsal and 2 ventral valves; 74B10 — 1 dorsal and 4 ventral valves; 74B15 — 7 ventral valves; 74B16 — 10 ventral and 2 dorsal valves; 74B17 — 1 dorsal valve; 74B19 — 1 ventral and 2 dorsal valves; 74B20 — 6 ventral and 7 dorsal valves; PS57 — 1 ventral and 5 dorsal valves. Identified as ?*Boreadorthis recula*: 74B7 — 1 dorsal valve; 74B8 — 2 ventral and 2 dorsal valves; 74B11 — 2 exteriors; 74B13 — 1 dorsal and 1 ventral valve; 74B14 — 1 dorsal and 4 ventral valves.

Subfamily GLYPTORTHINAE  
SCHUCHERT & COOPER, 1931  
Genus GLYPTORTHIS FOERSTE, 1914  
*Glyptorthis* sp. A  
(Pl. 1, figs. 18-21)

*Ventral exterior:*

The transverse shells are small, the largest being 3 mm long and 5 mm wide. The ventral valve is pyramidal. The ventral interarea is long for the genus. The shells are bisulcate. Seven costellae occupy a space of 2 mm measured 2 mm from the beak. New costellae arise through bifurcation. Frilled growth lamellae are strong and closely spaced.

*Interior:*

The ventral muscle scar is confined to the posterior 1/3 of the valve and is surrounded by a strong ridge. The cardinal process is platelike and brachiophores are well developed for the genus. A low dorsal median ridge is confined to the posterior 1/3 of the valve.

*Discussion:*

The dorsal cardinalia resembles that of *Boreadorthis recula*, but this species is easily distinguished by its much finer costellation.

*Material:*

74B8 — 2 dorsal and 2 ventral valves.

*Glyptorthis* sp. B  
(Pl. 1, figs. 25-27)

*Discussion:*

Several glyptorthid shells with widely spaced growth lamellae were recovered. The shells from the two localities may not be conspecific, although the ridging and concentric ornament are similar.

*Material:*

74B13 — 1 ventral valve; 74B16 — 3 ventral and 1 dorsal valve.

Genus PTYCHOPLEURELLA  
SCHUCHERT & COOPER, 1931

*Discussion:*

The genus *Glypterina* was proposed by BOUCOT (1970) for small *Ptychopleurella* like species with unbranching costae. BOUCOT (1970, 1973) suggested that the genus is useful in differentiating Ordovician and Silurian species of ptychopleurellids. WRIGHT (1972, 1973) questioned the validity of the genus since it was based only on size and absence of bifurcating costae; in typical representatives of *Ptychopleurella* costellae do not bifurcate until the shell size is greater than individuals of *Glypterina* ever attain.

WRIGHT (1973) also called attention to some Ordovician ptychopleurellid species which have branching costae. BOUCOT (1973) suggested that these species were transitional between the genera, but included them in *Glypterina* because of their small size and only incipient development of branching costae.

To this authors' mind, the point raised by WRIGHT is valid — that is the morphologic basis for separating the two genera is relatively minor and a new genus is not clearly warranted. Another way of looking at this problem is that all species involved are closely related as evidenced by the minor morphologic characters which distinguish them. It seems unfortunate to obscure the close phylogenetic relationship of these species by placing them in two genera. On the other hand WRIGHT (1973, p. 138) recognizes that the species do fall into two related but morphologically distinguishable groups. I therefore propose that *Glypterina* be made a subgenus of *Ptychopleurella*. This allows the close phylogenetic relationship between the species to be expressed in the systematic nomenclature, while also expressing the distinctions between the two species groups.

For the present, and until the phylogenetic relationships of the species are established, I suggest that species with bifurcating costae on most individuals be included in *P. (Ptychopleurella)*. This establishes a classification based on grade, and the classification may need revision when cladistic relationships are better understood. Using these criteria, the small, Ordovician species *P. separata*, *P. pirguensis*, and *Ptychopleurella* sp. (described below) are included in *P. (Ptychopleurella)*.

The utility of these brachiopods for differentiation between the Ordovician and Silurian is uncertain. At present no species referable to *P. (Glypterina)* has been found in the Silurian, but as WRIGHT (1973) pointed out, Early Silurian ptychopleurellids are still poorly known.

*Ptychopleurella* (*Ptychopleurella*) sp.  
(Pl. 1, figs. 22-24)

*Exterior:*

The shells are ventribiconvex with a pyramidal pedicle valve. The shells are transverse. The largest shell is a dorsal valve 9 mm wide and 7 mm long. The long ventral interarea is apsacline, nearly catacline. The delthyrium is very narrow. The shallow, poorly defined dorsal sulcus has two costae that originate 1 to 2 mm from the apex. Coastae and interspaces are broad and have angular cross sections. Of the three valves with complete exteriors preserved, one dorsal valve has 10 and another has 11 costae, and a ventral valve has 10 costae. Four of the five valves have one or more bifurcating costae.

Concentric ornament consists of numerous fine growth lines interspaced between frilled growth lamellae.

*Ventral interior:*

Short dental plates support the teeth. The muscle field is confined to the posterior 1/5 of the valve and is completely surrounded by a low ridge.

*Dorsal interior:*

The platelike cardinal process is set on a high notothyrial platform. The brachiophores are weak and widely divergent. The high, broad median ridge is rounded in cross section.

*Comparison:*

*P. (Ptychopleurella)* sp. closely resembles the two Ordovician species of this subgenus, but the material is not well enough preserved to make a confident assignment. *P. (P.) pirguensis* as illustrated by RÖHMUSOKS (1964) has 13 to 14 costae rather than 10 or 11 costae in the assemblage under study. In addition the notothyrial platform is lower in *P. (P.) pirguensis* than in these specimens. *P. (P.) separata* WRIGHT (1964) has a very similar external morphology to specimens in this assemblage, with approximately the same number of costae, but interiors were not illustrated.

*Material:*

74B4 — 3 dorsal, 1 ventral and 1 articulated valve.

Subgenus GLYPTERINA BOUCOT, 1970

*Ptychopleurella (Glypteria)* sp.  
(Pl. 1, fig. 17)

*Description:*

A single ventral valve referable to *Glypteria* was recovered. The valve is transverse, 6 mm wide and 3 mm long. The valve is pyramidal. The interarea is apsacline, nearly catacline. There are 13 unbranched

costae. Growth lamellae are pronounced. The teeth are supported by short dental plates. The muscle field is confined to the posterior third of the valve.

*Comparison:*

This species is more finely costate than *P. (Ptychopleurella)* sp. from locality 74B4.

*Material:*

74B19 — 1 ventral valve.

Genus SPINORTHIS WRIGHT, 1964

*Spinorthis europa* n. sp.  
(Pl. 2, figs. 1-15).

*Exterior:*

The lateral profile is ventribiconvex. The outline is slightly elongate; maximum width is in the posterior quarter of the shell. Shells more than 10 to 15 mm in length are geniculate in a dorsal direction. The geniculation varies from angular in some specimens to gently curved in others. The largest shell is 22 mm in length. The ventral fold and dorsal sulcus are weak and poorly defined. The short, curved ventral interarea is apsacline. The delthyrium has not been preserved in any of the specimens available for study.

The coarse costellae bifurcate anteriorly. Costellae are steep sided, with very wide interspaces. Six to eight costellae occupy a space of 5 mm measured 5 mm from the beak. Concentric ornament consists of fine, closely spaced growth lines between strong frills or lamellae spaced 1 to 2 mm apart. The frills are constricted above the costellae, producing tubular projections.

*Ventral interior:*

The muscle field is confined to the posterior 1/5 of the valve and is bounded laterally by septa that are convergent medially and anteriorly. The muscle bounding septa are anterior projections of the dental plates. The adductor muscle scars are well defined and have nearly parallel sides. The diductor muscle scars extend forward slightly beyond the adductor muscle scars but do not enclose them. Surfaces of diductor muscle scars have low concentric ridges which parallel the margins of the muscle scars. Variably developed vascula media extend forward from the anterior lobes of the muscle scars.

*Dorsal interior:*

The notothyrial platform is high and the cardinal process is large. Brachiophores are greatly divergent and very weak. The low, broad median ridge extends to the front of the muscle field. Muscle scars are elongate and very faint. The anterior adductor scars are much larger than the posterior adductor scars.

*Comparison:*

*Spinorthis geniculata* WRIGHT (1964) from the Portrane Limestone of Ireland is the genotype and only other species of the genus. *S. europa* differs from *S. geniculata* in 1) being elongate rather than transverse, 2) being larger (with geniculation developed 10-15 mm rather than 6 mm from the beak), 3) having a less angular geniculation, and 4) having a less prominent dorsal median ridge.

*Holotype:*

The holotype (I.R.Sc.N.B. 1414) consists of molds preserving both the interior and exterior of a dorsal valve from locality 74B15.

*Material:*

74B7 — 2 ventral valves; 74B8 — 1 ventral valve; 74B12 — 1 ventral and 3 articulated valves; 74B15 — 5 ventral and 6 dorsal valves; 74B16 — 4 dorsal and 5 ventral valves; 74B17 — 1 articulated and 2 dorsal valves; 74B20 — 2 dorsal and 2 ventral valves.

Identified as *Spinorthis* sp.: 74B4 — 1 dorsal and 1 ventral valve; 74B13 — 1 ventral valve.

## Family PLECTORTHIDAE

SCHUCHERT &amp; LE VENE, 1929

## Subfamily PLATYSTROPHIINAE

SCHUCHERT &amp; LE VENE, 1929

Genus PLATYSTROPHIA KING, 1850

*Platystrophia leserancei* n. sp.

(Pl. 2, figs. 16-29)

*Exterior:*

The shells are dorsibiconvex and transverse, with a length/width ratio of about 2/3. The largest valve is about 22 mm wide and 15 mm long. The only complete, articulated specimen is 18 mm wide, 12 mm long and 8 mm thick. The ventral interarea is apsacline and the dorsal interarea is orthocline. Maximum width is at the hinge line. The lateral margins are curved. The height of the fold progressively increases from posterior to anterior.

The apices of costae and bottoms of interspaces are rounded in cross section. Five to eight costae are on the flanks. The sulcus bears a low median costa; four to six mm from the beak a costa is inserted in the sulcus on each side of the median costa. The pair of low costae on the fold bifurcate four to six mm from the beak. Costae on the fold and sulcus are weaker than those on the flanks.

Two distinct groups of shells can be differentiated by the number of costae on the flanks of the valves. Specimens from localities PS57, PS58, 74B14, 74B15, 74B17, and 74B19 have 5 or 6 costae on the flanks and are referred to as Group A. Specimens from localities 74B9, 74B12, and 74B20 have 6 to 8 costae on the flanks and are referred to as Group B. Since costae are of about the same height in both groups,

and since more costae occupy an equal surface area in group B, the costae of Group B are steeper sided than those of Group A. The steeper sided costae of Group B are also more prominently impressed on the interiors of shells than are costae of Group A.

Growth lamellae are present at the front of valves. The surface is covered with closely spaced, fine granules (see FITZPATRICK, 1971).

*Ventral interior:*

The teeth are supported by strong dental plates which are continuous anteriorly with ridges bounding the postero-lateral margins of the muscle field. The muscle bounding ridges lie at the margins of the impress of the sulcus. The anterior third of the muscle field occupies a flat platform covering the crest of the impress of the sulcus; bounding ridges are absent in this segment of the muscle field.

*Dorsal interior:*

The cardinalia are confined to the posterior 1/5 of the valve. The notothyrial cavity is well developed, but sessile; that is umbonal cavities are filled with shell material. The cardinal process is a weak ridge. The brachiophores are massive but short. The sockets are shallow.

The muscle field is weakly impressed on small shells, but well developed in larger ones. The muscle field is set on the depression and slopes formed by the impress of the fold. The posterior adductor muscle scars are set widely apart and each is bounded medially by a low ridge. These ridges are curved through a right angle and form transverse ridges which separate the posterior and anterior adductor muscle scars. The anterior adductor muscle scars are impressed and have clearly defined lateral and anterior margins. A narrow ridge divides the anterior adductor muscle scars.

*Discussion:*

Though two groups are present, which can be distinguished by the number of ribs on the flanks of valves, both groups are assigned to the same species since other morphologic characters are so similar. Especially noteworthy is that the number of costae on the fold and sulcus is the same in both groups and new costae originate in the fold and sulcus in the same position in both groups.

*Comparison:*

This species belongs to the tricostae group of species defined by CUMMINGS (1903) and MCEWAN (1919). In the tricostate group a median primary costa runs the length of the sulcus and in an early growth stage an additional costa is implanted on each side of the median costa. At the same position the two primary costae on the fold bifurcate.

In *Platystrophia leserancei* the point of origin of new costae in the sulcus is 4 to 6 mm in front of the beak

and this distinguishes it from all other species except *Platystrophia scotica* (WILLIAMS, 1962). Several other features distinguish the latter species, however: 1) There are fewer costae on the flanks of *P. lesperancei* (5 to 8 costae instead of 10 to 12); 2) The cardinal process illustrated by WILLIAMS (1962, Pl. 11, fig. 20) is broader and more robust than that found in *P. lesperancei*; 3) The dorsal muscle field of *P. lesperancei* is strongly impressed and has well developed ridges bounding the muscle field as opposed to the weakly impressed, poorly defined muscle field of *P. scotica*. The single valve of *P. lesperancei* on which thickness could be measured was 8 mm thick and 18 mm wide; WILLIAMS (1962) noted that thickness probably exceeded 1/2 the width of *P. scotica*, but he also stated that this relationship was uncertain because all shells were crushed.

Other species of *Platystrophia* can be distinguished from *P. lesperancei* by the position at which new costae are added on the fold and sulcus (see above). In addition to this feature the well described tricostate European species of *Platystrophia* differ from this species in characters noted below. *Platystrophia biforata* (SCHLOTHEIM) is a much more globose species (with more costae on the fold and sulcus) than *P. lesperancei* (see ÖPIK, 1930, Taf. 5, figs. 47-49). *Platystrophia lynx* (EICHWALD) is a much larger species that is less strongly transverse and has more costae on the flanks than *P. lesperancei* (see NEBEN and KRUEGER, 1971, Taf. 48, figs. 1-3). *Platystrophia sublimis* ÖPIK (1930) is smaller, relatively thicker, and more transverse than *P. lesperancei*.

#### Holotype:

The holotype (I.R.Sc.N.B. 1421) is a fragment of the dorsal exterior and complete interior molds of conjoined valves from locality 74B15.

#### Material:

PS57 — 2 ventral and 2 dorsal valves; PS58 — 3 ventral and 3 dorsal valves; 74B9 — 1 dorsal valve; 74B12 — 6 ventral and 3 dorsal valves; 74B15 — 1 articulated, 2 ventral and 5 dorsal valves; 74B17 — 1 articulated valve; 74B19 — 1 ventral valve; 74B20 — 9 ventral and 2 dorsal valves. Identified as *Platystrophia lesperancei*?: 74B16 — 2 ventral and 1 articulated valve.

#### Family SKENIDIIDAE KOZLOWSKI, 1929

##### Genus SKENIDIoidES

SCHUCHTER & COOPER, 1931

*Skenidioides* cf. *S. paucicostatus* WRIGHT, 1964  
(Pl. 3, figs. 1-6)

*Skenidioides paucicostatus* WRIGHT, 1964, pp. 212-217,  
Pl. 7, figs. 14-20, 22, 25, 27.

#### Exterior:

In lateral profile the dorsal valve is slightly convex

to nearly planar; the ventral valve is subpyramidal because of its long interarea. The shells are transverse with width nearly twice length. The outline is alate. The largest shell is 5 mm long and 10 mm wide. The coarse costae rarely bifurcate. Six of seven shells have 2 costae in a space of 1 mm measured 2 mm from the beak; the seventh shell has 3 costae in this space. The largest costae on each valve is in the prominent fold and sulcus.

#### Ventral interior:

The spondylium is broad and evenly curved. A medium septum is absent; but the spondylium is supported by a thickening of shell material in the apex of the valve.

#### Dorsal interior:

The notothyrial platform contains a ridgelike cardinal process. The medium septum is very thin and extends into the anterior third of the valve.

#### Comparison:

The specimens under study are coarsely costate compared to other species of *Skenidioides*. Other markedly transverse species of the genus such as *S. anthonensis* SARDESON, *S. oklahomensis* COOPER, *S. obtusus* COOPER, *S. perfectus* COOPER, and *S. mediocostatus* COOPER are more finely ribbed than this species (see COOPER, 1956). The transverse shells, coarse costae and prominent median costa agree with *S. paucicostatus* WRIGHT (1964). A significant difference may be the absence of a ventral median septum, since *S. paucicostatus* has a septum supporting the apex of the spondylium according to WRIGHT (1964).

#### Material:

74B4 — 2 ventral 2 dorsal and 2 articulated valves; 74B17 — 1 ventral and 2 dorsal valves.

*Skenidioides* sp.  
(Pl. 3, figs 7-18)

#### Exterior:

The lateral profile is ventribiconvex. The ventral interarea is long; on one 7 mm long valve from locality 74B20 the interarea is 2 mm in length. The length/width ratio is about 3/4 at the 3 mm growth stage and increases to about 5/6 at the 6 mm growth stage. In outline the postero-lateral margins form nearly a right angle with the hingeline. The anterior outline is evenly rounded. There is a broad, gentle dorsal sulcus. The ventral valves are slightly naviculate. Costae branch anteriorly. Costae were counted in a space of 1 mm measured 2 mm from the dorsal beak; 3 valves had 3 costae and 3 valves had 4 costae in this space. A fascicle of costellae is in the sulcus. Shells between 4 and 5 mm in length have 16 to 20 costae. The largest shell is 7 mm long and 8 mm wide.

*Ventral interior:*

A strong median septum extends nearly to the front of the spondylium which is broad and flat bottomed.

*Dorsal interior:*

The notothyrial platform bears a robust, ridgelike cardinal process. The medium septum extends anteriorly beyond midlength.

*Comparison:*

The species is characterized by not being strongly transverse, having a naviculate ventral valve with a fascicle of costae on the fold, being coarsely costate for the genus, having postero-lateral margins which for nearly a right angle. The North American species *Skenidioides billingsi* SCHUCHERT & COOPER, *S. impressa* COOPER & KINDLE, *S. costatus* COOPER, *S. halli* (HALL & CLARKE), and *S. platus* COOPER, the Scottish *S. greenhoughi* (REED), and the Irish *S. cf. greenhoughi* (see MITCHELL, 1977) are more finely costate than this species. *S. rectangulatus* COOPER has a similar outline but lacks the broad, fascicostate sulcus of this species. *S. cf. asteroidea* (REED) described by WRIGHT (1964) and *S. craigensis* (REED) described by WILLIAMS (1962a) most nearly resemble this species. The poor state of preservation does not allow identification, however.

*Material:*

74B4 — 3 ventral valves; 74B12 — 1 ventral valve; 74B13 — 2 dorsal valves; 74B14 — 10 ventral and 10 dorsal valves; 74B15 — 7 ventral and 2 dorsal valves; 74B16 — 1 ventral valve; 74B19 — 4 dorsal and 3 ventral valves; 74B20 — 1 ventral valve.

Suborder DALMANELLOIDEA  
Superfamily DALMANELLACEA  
SCHUCHERT, 1913

Family DALMANELLIDAE SCHUCHERT, 1913  
Subfamily DAMANELLINAE SCHUCHERT, 1913,  
emend. WALMSLEY, BOUCOT & HARPER, 1969  
Genus DALMANELLA HALL & CLARKE, 1892

*Dalmanella sambrensis* n. sp.  
(Pl. 3, figs. 19-29; Pl. 4, figs. 1-20)

*Exterior:*

The shells are ventribiconvex. The ventral valves are dome-shaped with thickness equal to about 1/3 of length and maximum curvature near or slightly in front of midlength. The dorsal valves are gently convex. The outline is transverse with rounded postero-lateral margins. The three least distorted dorsal valves have length/width measurements of 6.2/8.7, 4.8/6.7, and 5.0/6.7 mm. Maximum width occurs in the second fifth of shell length. The width of the hinge line equals about 3/5 of total shell width. The ventral interarea is apsacline and its length is about 1/5 of total shell length. The slightly curved dorsal interarea

is anacline, approaching hypercline, and its length is about 1/15 of total shell length. The broad, poorly defined dorsal sulcus shallows anteriorly. The largest shell is a ventral valve about 12 mm long. Poorly preserved endopunctae are present on one specimen that has shell material preserved.

The costellae increase in strength anteriorly. At 2 mm from the beak 4, 5 and 6 costellae were measured in a space of 1 mm on 13, 9 and 11 valves respectively; whereas at 5 mm from the beak 3, 4 and 5 costellae occupy a space of 1 mm on 4, 6 and 3 valves respectively. A very fine costella is present in a few of the interspaces on most valves. Growth lines are strong and symmetrical in cross section. The growth lines are strongly developed in the interspaces, but only on occasional specimens are they present on the crests of costellae. The growth lines are regularly spaced, and cover the entire valve. Nine to 12 growth lines occupy a space of 1 mm in the median sector of shells.

*Ventral interior:*

Teeth are supported by thick, long dental plates that define the muscle field laterally. Crural fossetts are well developed and triangular in cross section. A pedicle callist is well developed. The dental plates are very slightly divergent anteriorly and are continuous anteriorly with short ridges that define the antero-lateral margins of the muscle field. The length of the narrow muscle field is between .35 and .40 of shell length. The diductor muscle scars are slightly longer than the adductor muscle scars which are set on a low platform with a straight anterior margin. The adductor muscle platform occupies slightly less than half the total width of the muscle field. A narrow, shallow furrow separates the adductor muscle scars posteriorly. Broad vascula media extend forward from the diductor muscle scars, diverging anteriorly at a slight angle.

*Dorsal interior:*

The small cardinal process is bilobed and has deep transverse striae. The shaft of the cardinal process is small, and a very small, short ridge which extends forward from the shaft does not reach as far anteriorly as do the brachiophore bases. The relative strength of the cardinal process increased during shell growth. The cardinal process does not fill the entire notothyrium. The brachiophores are very tall; one 8 mm long dorsal valve has brachiophores more than 1 mm high. The margins of the interarea extend behind the back of the brachiophore bases. The brachiophores are very slightly convergent toward the median plane. The bases of the brachiophores diverge slightly anteriorly. The fulcral plates are well developed. Beneath the fulcral plates are pits which produce conical elevations on internal molds. The length of the cardinalia is between 0.20 and 0.22 of shell length in 5 measured specimens that are from 5 to 8 mm long. Variably developed, low ridges extend forward from the front

of the brachiophores and enclose the muscle field. The median ridge, which divides the muscle scars, is stronger between the anterior adductor muscle scars than between the posterior scars. The muscle field extends about 2/3 of the distance to the anterior margin and is slightly longer than wide. The anterior adductor muscle scars are both longer and wider than the posterior adductor muscle scars, which are set on a low, variably developed platform.

#### Discussion:

A large collection of specimens from locality 74B14 differs from other specimens in having very fine costellae in each interspace. These fine costellae divide the characteristic growth lines in the interspaces and make them less conspicuous than on specimens from the other localities. Specimens of *D. sambrensis* from other localities commonly have fine costellae in only a few interspaces.

#### Comparison:

*Dalmanella* is a broadly defined genus which, as presently delineated, includes many species that are only distantly related. *Dalmanella sambrensis* is included in the genus because it has a bilobed cardinal process, fulcral plates, brachiophore bases that are convergent relative to their tops (in the terminology of WILLIAMS & WRIGHT, 1963), and a ventribiconvex lateral profile. The species is characterized by the development of strong growth lines in the interspaces between costellae, a deep, domed ventral valve, very robust dental plates, a broad ventral adductor muscle field set on a low platform, high brachiophores, and strong fulcral plates.

*Dalmanella sambrensis* differs from *Dalmanella portranensis* WRIGHT (1964) from the Portrane Limestone of Ireland in being more elongate, finer ribbed and having stronger fulcral plates and stronger ridges bounding the dorsal muscle scars. *Dalmanella testudinaria* (DALMAN) is more coarsely ribbed, has a much broader ventral muscle field, and weaker dental plates than *D. sambrensis* (see WILLIAMS & WRIGHT, 1963). *Dalmanella testudinaria transversa* MITCHELL (1977) from the Killy Bridge Formation of Pomeroy, Ireland, has coarser ornament, a wider ventral muscle field and weaker bounding ridges in both valves than *D. sambrensis*. *Onniella trigona* RUBEL (1962) is very similar to *Dalmanella sambrensis*. Both species have growth lines well developed in the interspaces but not on the crests of costellae (see HINTS, 1975, Pl. 11, fig. 8). The costellae are of about the same strength in the two species. Both species have dome shaped ventral valves and gently convex dorsal valves. Internally they have bilobed cardinal processes confined to the posterior of the valve, high, similarly placed brachiophores and a dorsal muscle fields with the median ridge largest at its fronts. *Dalmanella sambrensis* has a stronger dorsal sulcus, much stronger dental plates and stronger fulcral plates than *O. tri-*

*gona*. *Onniella trigona* was assigned to the genus *Onniella* by RUBEL (1962) and this was followed by HINTS (1975); however, *Onniella* is characteristically lenticular in lateral profile, with only slight convexity of the ventral valve, and the inclusion of *O. trigona* in *Onniella* is probably incorrect. The concentric ornament of *Dalmanella sambrensis* resembles that of *Dalmanella elegantula* var. *drummuckensis* from the Drummuck Group of Scotland (see REED, 1917, Pl. 9, fig. 15). However, compared to *D. sambrensis*, REED's species, is elongate rather than transverse has a shorter ventral muscle field without a well developed ventral adductor muscle platform and has weaker fulcral plates.

#### Holotype:

The holotype (I.R.Sc.N.B. 1445) consists of internal and external molds of a dorsal valve from locality 74B10.

#### Material:

74B4 — 10 ventral, 6 dorsal and 2 articulated valves; 74B7 — 8 ventral and 1 articulated valve; 74B10 — 8 ventral and 4 dorsal valves; 74B12 — 10 ventral and 4 dorsal valves; 74B13 — 15 ventral, 6 dorsal and 2 articulated valves; 74B14 — 202 ventral, 62 dorsal and 20 articulated valves; 74B15 — 9 ventral and 3 dorsal valves; 74B17 — 42 ventral and 16 dorsal valves; 74B19 — 21 ventral and 7 dorsal valves; 74B20 — 13 ventral and 6 dorsal valves; 74B21 — 3 ventral, 2 dorsal and 1 articulated valve; PS57 — 9 ventral, 3 dorsal and 1 articulated valve; PS58 — 3 ventral valves. Identified as *Dalmanella sambrensis*?: 74B8 — 20 ventral, 4 dorsal and 2 articulated valves; 74B11 — 17 ventral and 6 dorsal valves.

### Genus PORTRANELLA WRIGHT, 1964

#### Discussion:

When erecting the genus *Portranella*, WRIGHT (1964) assigned it to the Orthidiellidae because of the similarity of its trilobed cardinal process to those found in some genera of this family. However, he was unable to determine whether his silicified shells were impunctate. The species of this genus described below has the characteristic features of *Portranella* including 1) coarse, angular costellae, 2) a short ventral inter-area, 3) a broad, shaftless trilobed cardinal process the lateral margins of which are posterior to the brachiophores, and 4) brachiophores with broadly divergent bases forming the sockets. WRIGHT notes that dalmanellids with trilobate cardinal processes like *Paucicrura* differ from *Portranella* in having the cardinal process "sharply demarcated from the brachiophores by the longitudinal grooves forming the continuation of the longitudinal margins." (WRIGHT, 1964, p. 169). The new species described below has all the features listed by WRIGHT as diagnostic, and it can confidently be assigned to *Portranella*. Since the new species is endopunctate, the genus must be assigned

to the dalmanelloides. It is probably allied with *Paucicrura*, but differs in being more coarsely ribbed and in characters of the cardinalia already discussed.

*Portranella akymatata* n. sp.  
(Pl. 4, figs. 21-35; Pl. 5, figs. 1-17)

*Exterior:*

The lateral profile is ventribiconvex; the ventral valve is evenly curved, but the dorsal valve has maximum curvature in the posterior quarter of the valve. Length exceeds width, but during growth length/width ratios change from about 3/4 in shells 6 mm in length to almost 1/1 in shells larger than 12 mm. The hinge line is about 2/3 of maximum shell width, which occurs near midlength. The ventral interarea is short, approximately 1/10 of the length of the valve. The dorsal interarea is well developed, being about half the length of the ventral interarea. The ventral interarea is apsacline; the dorsal interarea is anacline, approaching catacline. The delthyrial angle is about 80°. The largest shell is about 19 mm long. The largest shells are from locality 74B16; in the other collections shells are no longer than 12 mm. The ventral valve is slightly naviculate. The dorsal valve has a distinct but poorly defined sulcus which shallows anteriorly.

The branching costellae are strong and angular in cross section. Three of four costellae occupy a space of 2 mm measured 5 mm from the dorsal beak; of these costellae only two or three are well developed, and the others are small costellae which developed a short distance behind the point where they were counted. The interspaces are V-shaped in cross section, and a very fine costella is present at the base of well developed interspaces. Growth lines are present anteriorly in large shells. The shell is endopunctate.

*Ventral interior:*

The inner margins of the teeth ridges lie medial to the margins of the delthyrium and are separated from the margin by a narrow groove. The structure is common in dalmanelloides (e.g. *Pionodema suaequata* figured by COOPER, 1956, Pl. 156, fig. 4). The short dental plates bear narrow, slot-like, crural fossetts. The pedicle callist is well defined as is the muscle field which tapers anteriorly. The adductor muscle scars are situated on a slightly raised platform with parallel sides. This platform extends in front of the muscle field as a weak to very strong median ridge which reaches midlength. The external ornament is very weakly impressed on the interior.

*Dorsal interior:*

The cardinal process is situated at the extreme posterior of the shell, filling the notothyrium and extending behind the interarea. It is trilobate with the median lobe the longest. There is no shaft. The lateral margins of the cardinal process are situated posterior to the back of the brachio-phores. The cardinal process is

large, its width equalling about 1/10 of the width of the shell. The widely divergent bases of the brachio-phores bound the sockets. The floors of the sockets are crenulated. A broad, strong, flat-topped median ridge extends from the base of the cardinal process to midlength. The weakly impressed muscle field is quadripartite with the posterior adductor muscle scars equalling about half the length of the anterior scars. Each muscle scar is about equal in width to the median ridge. The external ornament is weakly impressed on the interior.

*Comparison:*

Similarities of *Portranella akymatata* with *Portranella angulocostellata*, the type species, were enumerated in the discussion of the genus. The two species can be distinguished by the median dorsal ridge which in *P. akymatata* begins at the cardinal process but in *P. angulocostellata* originates well in front of the cardinal process. The external ornament of *P. akymatata* is very weakly impressed on the interior, producing a smooth internal surface, hence the derivation of the specific name. *P. angulocostellata* has strongly impressed external ornament (see WRIGHT, 1964, Pl. 2, Figs. 13, 16, 18, 21, 22). *P. akymatata* has a very fine costella in the base of each interspace; the type species lacks this feature: *P. akymatata* has a longer dorsal interarea and a longer cardinal process than *P. angulocostellata*. The posterior of the dorsal valve of *P. akymatata* is more strongly curved in lateral profile than *P. angulocostellata*. Finally the muscle fields are better defined in *P. akymatata* than in the type species. WRIGHT (1964) noted that the length-width ratio of the dorsal valves of *P. angulocostellata* is 64% to 75% of shell width (in 3 valves). The length/width ratio changed with growth in *P. akymatata* averaging about 70% at the 6 mm growth stage and about 90% at the 12 mm growth stage. The ratio also apparently changed with growth in *P. angulocostellata* as evidenced by the large dorsal valve figured by WRIGHT (1964, Pl. 2, fig. 17). The ventral median ridge reported by WRIGHT (1964) in one valve of *P. angulocostellata* is similar to the variably developed ridge in front of the muscle field of *P. akymatata*.

*Holotype:*

The holotype (I.R.Sc.N.B. 1461) consists of interior and exterior molds of an articulated specimen from locality 74B20.

*Material:*

74B9 — 19 ventral and 20 dorsal valves; 74B10 — 1 articulated exterior; 74B11 — 4 ventral and 3 dorsal valves; 74B12 — 1 dorsal and 2 ventral valves; 74B13 — 1 articulated, 2 ventral and 5 dorsal valves; 74B15 — 4 ventral and 2 dorsal valves; 74B16 — 1 articulated, 5 ventral, and 10 dorsal valves; 74B17 — 1 ventral and 1 dorsal valve; 74B19 — 4 ventral and 11 dorsal valves; 74B20 — 3 articulated, 8 ventral and 7 dorsal valves; PS58 — 1 ventral and 8 dorsal valves.

## Family DICOELOSIIDAE CLOUD, 1948

Genus DICOELOSIA KING, 1850

*Dicoelosia* cf. *D. lata* WRIGHT, 1964  
(Pl. 5, figs. 18-28; Pl. 6, figs. 1-4)*Dicoelosia lata* WRIGHT, 1964, pp. 226-231, Pl. 9, figs. 3, 6, 9, 12, 14-19.*Dicoelosia lata* WRIGHT, 1968, pp. 296-297, Pl. 6, figs 2-6.*Exterior:*

The ventral valve is very strongly convex and has rounded lobes. The postero-lateral portions of the dorsal valve are gently concave as is the lateral profile of the crest of the lobes. The ventral sulcus is narrower and better defined than the broad, poorly defined dorsal sulcus. The width of the hinge line is about 60% of maximum shell width. Invagination is weak; the ratio of midline length/shell length ranges from 0.78 to 0.89 on 12 valves between 1.8 and 4.0 mm in length — no change in ratio is apparent over this size range (Fig. 2). The shells are transverse with length equalling about 2/3 of width though many valves are distorted and this ratio is only approximate. Costellae are strong and steep sided. Costellae occur in both sulci, but they are not as strong as on the flanks. On ventral valves a median or submedian costella is commonly stronger than those adjacent to it. A space of 1 mm on the lobes measured 2 mm from the ventral beak contains 4, 5 and 6 costellae on 2, 4 and 2 valves respectively. The largest shell is 4 mm long.

*Ventral interior:*

The muscle field is confined to the posterior 30% of the valve. Dental plates are strong and continue anteriorly as strongly inclined plates upon which are set the antero-lateral portions of the diductor muscle scars. The adductor muscle scars are bounded laterally by faint ridges. The diductor and adductor muscle scars extend about the same distance anteriorly. A broad, poorly defined median ridge occupies the position of the sulcus.

*Dorsal interior:*

Interiors of only two small dorsal valves were recovered. The brachiophores are very widely divergent. The narrow but long sockets are defined anterolaterally by a low ridge.

*Comparison:*

Specimens in these collections resemble *Dicoelosia lata* in their weak invagination, length/width ratios, possessing ribs in the sulcus, and characteristics of the ventral muscle field. These specimens may be more finely ribbed on the average than *D. lata* (compare WRIGHT, 1968, p. 297), and the lateral profile of their dorsal valves may be more strongly concave. In these respects the specimens approach *Dicoelosia inghami* WRIGHT (1968). Primarily because the coarseness of ribbing (number of ribs per mm) falls within the range

of *D. lata* and not *D. inghami* the specimens are allied here with the former species. *Dicoelosia simulata* MITCHELL (1977) from the Killeen Bridge Formation of Pomeroy, Ireland, has a much weaker invagination than *D. cf. lata*.

*Material:*

74B4 — 8 ventral, 1 dorsal, and 1 articulated valve; 74B10 — 1 ventral valve; 74B14 — 9 ventral, 2 dorsal and 1 articulated valve; 74B16 — 2 ventral, 3 dorsal and 1 articulated valve; 74B16 — 2 ventral, 3 dorsal and 1 articulated valve; 74B17 — 1 articulated valve; PS57 — 1 ventral and 1 dorsal valve; PS58 — 1 articulated, 3 ventral and 2 dorsal valves.

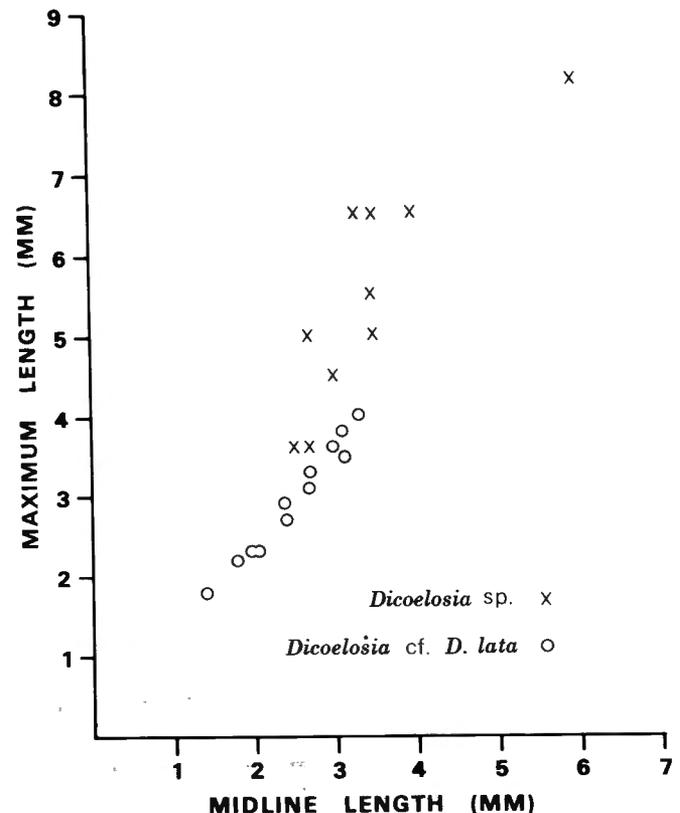
*Dicoelosia* sp.

(Pl. 6, figs. 5-15)

*Exterior:*

The shells are concavo-convex and transverse with length/width ratios between 0.7 and 0.9. The lobes are narrow. The anterior margin is deeply invaginated with median length/maximum length ratios of between 0.53 and 0.75 on 10 measured specimens (Fig. 2). A space of 1 mm measured 2 mm from the ventral beak is occupied by 5, 6 and 7 costellae on 2, 2 and 3 valves respectively. Costellae are weak and narrow with the interspaces much wider than the costellae. The weak ornament is not caused by shell abrasion because more

Figure 2. — Plot of midline length against maximum length of shells of *Dicoelosia* cf. *D. lata* (O) and *Dicoelosia* sp. (X).



strongly ribbed, abraded shells would have broad ribs. The largest specimen is 8.1 mm long.

*Ventral interior:*

The transverse muscle field is confined to the posterior quarter of the valve. Dental plates are extended anteriorly as variably developed plates or ridges upon which the lateral portions of the diductor muscle scars are developed. Anteriorly the diductor muscle scars extend well beyond, but do not enclose, the adductor scars.

*Dorsal interior:*

The brachiophores are strongly divergent. The sockets are elongate and directed well anteriorly.

*Comparison:*

The narrow lobes, deep invagination of the anterior outline, and concave valve of *Dicoelosia* sp. are characters which typify WRIGHT's (1968) "*Dicoelosia jonesridgensis*" group of Ashgillian species. *D. jonesridgensis* is more deeply emarginate than *D. sp.*, has a strong median costella on each lobe and has only a single costella in the sulcus. *Dicoelosia indenta* COOPER (1930) is a more coarsely ribbed species than *Dicoelosia* sp. Specimens assigned to *D. indenta* by WRIGHT (1968) from Keisley in England and the Siljan District of Sweden are less strongly ribbed than the Percé species. Illustrations of these specimens by WRIGHT (1968, Pl. 4, figs. 1-2, 4-13) show finer, narrower ribs than *D. indenta*, and these specimens resemble *Dicoelosia* sp. Note that if the type specimen of *D. indenta* (see WRIGHT, 1968, Pl. 4, figs. 14-15) were abraded, the resulting ribs would be much wider than are the ribs on specimens from Keisley or the Siljan region. The dorsal interiors of *Dicoelosia* sp. do not have a V-shaped dorsal muscle bounding ridge as does the species from the Siljan region, but the dorsal valves are small and a ridge might be present only in large growth stages. *Dicoelosia* sp. can be distinguished from *Dicoelosia* cf. *D. lata* described above by its more deeply emarginate outline (Fig. 2), finer ribbing, and relatively shorter, broader ventral muscle field.

*Material:*

74B14 — 9 ventral and 1 dorsal valve; 74B15 — 1 ventral valve; 74B16 — 3 ventral and 1 dorsal valve; 74B17 — 2 ventral valves; PS57 — 3 ventral valves; PS58 — 1 ventral and 1 dorsal valve.

Family HARKNESSELLIDAE BANCROFT, 1928

Genus REUSHELLA BANCROFT, 1928

*Reuschella* sp.

(Pl. 6, figs. 16-18)

*Exterior:*

A single large dorsal valve was recovered. The lateral

profile is markedly convex but the specimen is laterally compressed, and near midlength the shell has been folded upon itself. Allowing for this distortion the original length was approximately 35 mm and the width was approximately the same. The outline is subquadrate and slightly mucronate. A well defined, deep and very narrow sulcus extends the length of the valve. The 2 mm long dorsal interarea is anacline, approaching orthocline. The surface is coarsely costellate with 2 or 3 costellae occupying a space of 1 mm near the front of the valve.

*Dorsal interior:*

The cardinal process is large and the myophore has a large median lobe flanked by three narrower lobes on each side; in addition the surfaces of the lobes are transversely striate. The shaft of the cardinal process is continuous anteriorly with a massive median ridge which marks the impress of the sulcus. The brachiophores are massive and widely splayed. The ventral surfaces of the brachiophores are concave. Fulcral plates are small. The cardinalia is ponderous and probably many of the structures (ex. fulcral plates) are obscured by secondary shell deposition. The muscle field is weakly impressed.

*Comparison:*

The subquadrate, mucronate outline, deep, narrow sulcus and large cardinal process allow placement of this species in *Reuschella*. The specimen is probably gerontic and assignment to a species is not possible. The stronger sulcus and much more prominent median ridge differentiates this species from *Reuschella* sp. described by WRIGHT (1964) from the Protane Limestone in Ireland.

*Material:*

74B16 — 1 dorsal valve.

Superfamily ENTELETACEA WAAGEN, 1884

Family LINOPORELLIDAE

SCHUCHERT & COOPER, 1931

Genus LATICRURA COOPER, 1956

*Laticrura* cf. *L. erecta* WRIGHT, 1964

(Pl. 7, figs. 10-20)

*Laticrura erecta* WRIGHT, 1964, pp. 233-236, Pl. 10, figs. 17-18, Pl. 11, figs. 16, 18-21.

*Exterior:*

The shells are biconvex. Because all shells are broken the outline could not be determined. Maximum shell width occurs in the posterior third of the shell. The dorsal sulcus is shallow. The surface is finely costellate with 4 to 5 costellae occupying a space of 1 mm, measured 5 mm from the beak. The largest shell, though broken, was originally about 15 mm in length.

*Ventral interior:*

Teeth are supported by strong, subparallel dental plates which bound the posterior quarter of the muscle field. Ridges extending forward from the dental plates bound the muscle field laterally. The muscle field is poorly defined anteriorly. The surface is endopunctate.

*Dorsal interior:*

The cardinal process is a thin ridge. Brachiophores are vertical over most of their height but curve inward toward the floor of the shell and curve outward near the sockets, producing the S-shaped brachiophores which are characteristic of the genus. The bases of the brachiophores are convergent on the median ridge, producing a sessile septalium. The brachiophores are long and extend far forward from the septalium. Fulcral plates are well developed. The median ridge extends anteriorly beyond midlength. The muscle field is quadripartite; posterior adductor scars are deep and about half the length of the anterior adductor scars. Low ridges bound the muscle field laterally.

*Discussion:*

The development of the narrow notothyral platform is reminiscent of *Scaphortis* and *Girardiella*. The assignment to *Laticrura* is certain because of the extremely large, long, S-shaped brachiophores. The specimens are closely comparable to *Laticrura erecta* as described by WRIGHT (1964). The material is too poorly preserved to be certain of the identification, especially important in this respect is the absence of shells showing the shell outline and nature of the interareas. However, the close similarities, particularly the closely set brachiophores, makes this assignment seem likely. Differences noted are minor. The dental plates are more widely spaced in the Belgian than the Irish specimens. WRIGHT (1964) reported counts of 3-5 ribs at the 5 mm growth stage in 1, 7 and 2 valves respectively. However, rib counts of the Belgian specimens show 4 and 5 ribs on 2 and 4 shells respectively. These differing rib counts are minor when the similarities of the internal features are considered. *Laticrura rostrata* HINTS (1975) from the F<sub>1a</sub> and F<sub>1b</sub> Stages of Estonia differs from *L. erecta* in having more widely flaring brachiophores. The Belgian specimens resemble *L. rostrata* in having widely set dental plates. *L. erecta* was compared to Middle Ordovician species of the genus by WRIGHT (1964).

*Material:*

74B4 — 4 ventral and 1 dorsal valve; 74B12 — 1 dorsal and 1 ventral valve; 74B16 — 5 ventral and 1 dorsal valve; 74B17 — 1 dorsal valve; 74B19 — 1 dorsal valve; PS57 — 1 dorsal valve; PS58 — 1 ventral and 2 dorsal valves.

Family SAUKRODICTYIDAE WRIGHT, 1964  
Genus SAUKRODICTYA WRIGHT, 1964

*Discussion:*

The genus *Saukrodictya* was erected by WRIGHT (1964) and placed in a new family which was assigned to the orthacids. Subsequently TEMPLE (1970) found the genus was endopunctate, and the family was re-assigned to the Enteletacea. The genus is characterized by ornament consisting of a honey-comb network developed between the costellae. An essentially identical ornament characterizes *Oleorthis* HAVLÍČEK (1968). HAVLÍČEK (1968) did not comment on the similarities between the genera. The pits of the "honeycomb" (called exopunctae by HAVLÍČEK) are arranged in oblique rows in both genera. Additionally, individuals of both genera are transverse, with very wide hinge lines, are costellate with new costellae arising through intercalation, have a prominent dorsal sulcus and ventral fold, have short but strong dental plates and have medially convergent brachiophores bases forming a notothyral platform. The only obvious difference between the genera is that the dorsal muscle field of specimens of *Saukrodictya* has a raised anterior margin, which is not present in the individuals of *Oleorthis* figured by HAVLÍČEK (1968). Thus in addition to the unique ornament (occurrences of grossly similar exopunctae in other genera are thoroughly discussed by WRIGHT, 1964) the general shell morphology of the genera is very similar. Based on this similarity *Oleorthis* is placed in the Family Saukrodictyidae. *Oleorthis* is known only from the Lower Caradoc of Bohemia; *Saukrodictya* is an Ashgill genus. The new species of *Saukrodictya* described below, appears to be endopunctate reconfirming the affinity of the family. Individuals of the new species have dorsal fields which vary between ones with raised anterior margins and ones without raised margins. Thus the morphologic character which distinguishes the two genera occurs in one species, and if features other than this can not be found to differentiate the two genera, it may eventually be necessary to synonymize *Oleorthis* and *Saukrodictya*.

*Saukrodictya wrighti* n. sp.  
(Pl. 6, figs. 19-25; Pl. 7, figs. 1-7)

*Exterior:*

The shells are ventribiconvex and transverse with the greatest width at the hinge line. All shells are distorted and length/width measurements could be estimated on only four valves; l/w in mm of these valves are 5/8, 5/8, 6/9, and 8/13. The ventral fold and dorsal sulcus are well developed. The fold is narrow and confined to the median quarter of the valve. The curved, apsacline ventral interarea is very short. The ornament consists of steep-sided costellae which increase anteriorly by intercalation and bifurcation. Exopunctae

(honeycomb network of WRIGHT, 1964) are present in the interspaces. Exopunctae are arranged in oblique rows, with 2 to 4 in each row. Three costellae occupy a space of 1 mm measured 2 mm from the beak of 4 ventral valves.

*Ventral interior:*

Teeth are supported by strong dental plates which define the muscle field laterally. The muscle field is short, about 1/5 the length of the valve, and it is bounded anteriorly by a low ridge. The surface is endopunctate.

*Dorsal interior:*

Only three dorsal interiors were available for study, each from a different locality. The shell from locality 74B15 (Pl. 6, figs. 20-23) is 4 mm in length. The cardinal process is a ridge which continues anteriorly to the front of the muscle field. The brachiophores are short and the brachiophore bases are anteriorly convergent, forming a notothyrial platform. Posteriorly the adductor muscle scars lie behind the margins of the notothyrium; anteriorly the muscle field is raised on low plates. The surface is endopunctate.

The dorsal valve from locality 74B16 (Pl. 7, figs. 5-7) is 5 mm long. In this shell the notothyrial platform is more strongly developed than in the previous valve, and the cardinal process is separated from the median ridge by a low, transverse ridge that defines the front of the notothyrial platform. The dorsal adductor muscle scars are on a slightly raised platform and are divided by a median ridge which extends to their anterior margin. The raised platform apparently is the same structure as in the valve from locality 74B15, but in this valve the spaces beneath the plates have been filled with secondary shell material. The surface is endopunctate.

The third dorsal valve, from locality 74B8 (Pl. 6, fig. 19), is broken but was originally more than 7 mm in length. The cardinal process and median ridge are separated by a broad, transverse ridge at the front of the notothyrium. The front of the muscle field is set on plate like structures resembling those found in the shell from locality 74B15. The median ridge is stronger than in the other dorsal valves.

*Comparison:*

The raised anterior margin of the dorsal muscle field of specimens from locality 74B15 and 74B8 are similar to, but more pronounced than, those described for *Saukrodictya hibernica* by WRIGHT (1964). On the other hand the raised dorsal muscle field on the valve from locality 74B16 is similar in development and shape to that illustrated for *Oleorthis porosa* by HAVLÍČEK (1968, Pl. 1, fig. 4). All Belgian specimens are considered to be conspecific because of similar ventral interiors, and exteriors features, especially the ornament and development of the fold and sulcus. If the development of the dorsal muscle

field on either a platform or a raised plate is within the variability of a single species it may be necessary to synonymize *Oleorthis* and *Saukrodictya*, as this is the primary feature which seems to distinguish the genera (see above). *S. hibernica* WRIGHT (1964) differs from *S. wrighti* in having a much stronger fold and sulcus. In addition the median ridge apparently extends forward beyond the muscle field in the Irish species but does not reach beyond the muscle field in the new species. The size of exopunctae is quite variable in both species (see WRIGHT, 1964, Pl. 7, figs. 21 and 30). *Oleorthis porosa* HAVLÍČEK (1968) differs from *S. wrighti* in having a deeper sulcus, lacking a median ridge in the dorsal valve, and having somewhat finer exopunctae. *Saukrodictya* sp. from Wales described by TEMPLE (1970) differs from *S. wrighti* in being smaller, having a relatively smaller cardinalia, lacking a dorsal median ridge and not having the front of the dorsal muscle field raised on a plate.

*Holotype:*

The holotype (I.R.Sc.N.B. 1491) consists of exterior molds of a dorsal valve from locality 74B15.

*Material:*

74B8 — 1 dorsal and 1 ventral valve; 74B15 — 1 dorsal and 1 ventral valve; 74B16 — 7 ventral and 1 dorsal valve; 74B19 — 1 dorsal valve.

*Saukrodictya* sp.  
(Pl. 7, figs. 8-9)

*Exterior:*

A single dorsal valve was recovered. The outline is transverse with a width of 7 mm and a length of slightly over 4 mm. Maximum width is at the alate hinge line. The valve is convex with a deep sulcus bounded by two high lobes. The postero-lateral flanks are slightly concave. Costellae are weakly developed and exopunctae are very coarse for the genus.

*Dorsal interior:*

The cardinal process is a ridge. A median ridge is lacking. The brachiophores are short and triangular in cross section. The brachiophore bases form a notothyrial platform. The front of the muscle field is raised on well-developed plates.

*Discussion:*

This specimen is characterized by its coarse exopunctae, deep sulcus and absence of a dorsal median ridge. These features distinguish it from other species of *Saukrodictya*. In lacking a median ridge and possessing a deep sulcus this species resembles *Oleorthis porosa* HAVLÍČEK (1968). However, the dorsal muscle field is set on a raised platform unlike *O. porosa* and the exopunctae are much coarser.

*Material:*

74B4 — 1 dorsal valve.

Suborder CLITAMBONITOIDEA  
Superfamily CLITAMBONITACEA

WINCHELL &amp; SCHUCHERT, 1893

Family CLITAMBONITIDAE

WINCHELL &amp; SCHUCHERT, 1893

Genus VELLAMO ÖPIK, 1930

*Vellamo* sp.

(Pl. 7, figs. 21-23)

*Exterior:*

Only two dorsal valves were recovered. Length and width are nearly equal. The shells are gently convex. The postero-lateral margins are abruptly curved through nearly a right angle; the shells are not mucronate. The dorsal sulcus is narrow. The costellae are coarse and have well developed growth lines that are closely spaced but not imbricate.

*Dorsal interior:*

The cardinal process is a simple ridge which is connected posteriorly to the strong, convex chilidium. Laterally, the chilidium joins the massive, widely divergent brachiophores. The median ridge is broad and high. Two broad, slightly curved ridges extend anteriorly from the posterior margin to near midlength; the ridges define the sockets laterally and bound the sides of the muscle field. The muscle field is poorly defined anteriorly but in front it contains a domed or elongate raised area on each side of the median ridge.

*Discussion:*

The presence of strong, non-imbricate growth lines and a gently convex dorsal valve with a narrow sulcus allows assignment of this clitambonitid to the genus *Vellamo*. The broad ridges which originate at the posterior margin just beside the sockets and which bound the muscle field laterally distinguish these shells from any species of *Vellamo* known to the author. The absence of ventral valves precludes erection of a new species.

*Material:*

74B20 — 2 dorsal valves.

## Superfamily GONAMBONITACEA

SCHUCHERT &amp; COOPER, 1931

Family KULLERVOIDAE ÖPIK, 1934

Genus KULLERVO ÖPIK, 1932

*Kullervo complectens* (WIMAN, 1907)*albida* (REED, 1917)

(Pl. 7, figs. 24-31; Pl. 8, figs. 1-3)

*Orthisina complectens* WIMAN, 1907, p. 11-12, Pl. 1, figs. 1-4.*Clitambonites complectens* (WIMAN) var. *albida* REED, 1917, p. 917, Pl. 21, figs. 19-20.*Kullervo complectens* (WIMAN) *albida* (REED). WRIGHT, 1964, pp. 241-245, Pl. 10, figs. 3, 10, 13, 15-16, 19-20.*Kullervo complectens* (WIMAN) *albida* (REED). WILLIAMS and WRIGHT, 1965, fig. 227, 1 a-g.*Exterior:*

The dorsal valve is gently convex; the ventral valve is pyramidal. Because of preservation as molds and casts it is difficult to measure the dimensions of the ventral valve. The two best preserved ventral valves have the following dimensions: valve 1 — length (from apex to anterior margin) 7 mm, width approximately 16 mm, length of interarea approximately 7 mm; valve 2 — length 5 mm, width 8 mm, length of interarea 3.5 mm. The shells are bisulcate with both sulci shallow and narrow. The anterior outline is indented medially. The convex deltidium is continuous with a large, irregularly shaped sheet which flares outward from the margins of the pedicle foramen (Pl. 8, figs. 1 & 2). Both concentric and radial ornamentation are strongly developed. The concentric ornament dominates over the radial on the postero-lateral margins. Along the middle third of the valve radial ornament is judged to be dominant on one valve; radial and concentric ornament are about equally strong on one valve, and concentric dominates radial ornament on six valves.

*Ventral interior:*

The spondylium is supported by a median septum. The median septum does not extend anteriorly beyond midlength on valves from localities 74B4, 74B8 and PSS8. The median septum extends into the anterior third of the valve on specimens from locality 74B16.

*Dorsal interior:*

Only a single dorsal interior was recovered. The massive brachiophores are widely divergent. The cardinal process is a minute post. The chilidium is medially grooved. The large, broad median ridge, which extends nearly to the anterior margin, terminates abruptly. The adductor muscle scars are lobate and extend well beyond midlength.

*Discussion:*

When describing the genus *Kullervo* ÖPIK (1934) recognized four groups within the genus. Two groups were characterized by weak concentric ornament. The remaining two groups were included within the species *Kullervo complectens* (WIMAN). One group, on which WIMAN (1907) based his species, has concentric and radial ornament equally developed, and the other group, based on specimens described by REED (1917) from the Girvan District, is characterized by concentric ornament that dominates over radial. REED (1917) designated his specimens as the variety *albida* which was assigned to WIMAN's species. Subsequent to ÖPIK's (1934) work, no new species of *Kullervo* have

been described in which concentric ornament dominates.

WRIGHT (1964) assigned specimens from the Portrane Limestone in Ireland to REED's variety, which he gave subspecies status. WRIGHT (1964) noted that there was considerable variation in the relative development of concentric and radial ornament on specimens in the Irish collection. In view of the variability, and since the variability of WIMAN's specimens is unknown, it is reasonable to retain *albida* as a subspecies of *K. complectens*. The specimens here are included in the subspecies *albida* because most specimens have dominant concentric ornament.

*Material:*

74B4 — 3 ventral valves; 74B8 — 1 ventral valve; 74B15 — 1 ventral valve; 74B16 — 5 ventral and one dorsal valve; PS57 — 1 ventral valve; PS58 — 1 ventral valve. Identified as *Kullervo complectens?* (WIMAN) *albida?* (REED): 74B11 — 2 ventral valves.

Suborder TRIPLESIOIDEA  
Superfamily TRIPLESACEA SCHUCHERT, 1913  
Family TRIPLESIIDAE SCHUCHERT, 1913  
Genus TRIPLESIA HALL, 1859

*Triplesia* sp.  
(Pl. 8, figs. 16-24)

*Exterior:*

The valves are dorsibiconvex and the outline is elongate. The hinge line is wide; maximum width occurs behind midlength. The prominent ventral beak is narrow, and the shallow sulcus increases in strength anteriorly. The dorsal fold is well defined with an abrupt change in slope from the flanks to the margins of the fold. Larger shells have a shallow depression along the middle of the fold. The surface lacks radial ornament and growth lines are weakly developed. The largest shell is a dorsal valve approximately 30 mm long and 23 mm wide.

*Ventral interior:*

The small teeth are supported by vertical, high, thin dental plates that are set along the margins of the impress of the highly arched beak. The muscle field is weakly impressed.

*Dorsal interior:*

The forked cardinal process has a robust base with a longitudinal keel on the anterior surface. The brachio-phores are set widely apart and are strongly divergent. The bases of the brachio-phores are fused with the base of the cardinal process by deposition of secondary shell. The sockets are small. A broad median ridge divides the muscle field but does not connect posteriorly with the base of the cardinal process. A small, narrow groove runs the length of the median ridge. The adductor muscle scars are slightly impres-

sed and more weakly impressed laterally. The muscle field is divided medially by a transverse ridge. The posterior adductor scars are about half the size of the anterior adductor scars.

*Comparison:*

The depression along the midline of the fold resembles *Triplesia biplicata* COOPER & KINDLE (1936) from the Whitehead Formation of Percé, Quebec. However, the Quebec species is transverse rather than elongate as are other species of Late Ordovician *Triplesia*.

*Discussion:*

The internal dorsal mold of an enormous triplesiid referred to *Triplesia?* sp. from locality 74B13 is 40 mm long and though broken must have been about 60 mm wide (Pl. 8, figs. 25-27).

*Material:*

74B4 — 1 ventral valve; 74B7 — 1 dorsal valve; 74B16 — 1 ventral and 2 dorsal valves; 74B17 — 5 dorsal valves; 74B19 — 1 dorsal valve; 74B20 — 1 ventral and 4 dorsal valves; 74B21 — 3 ventral and 15 dorsal valves; PS57 — 3 dorsal valves.

Identified as *Triplesia?* sp.: 74B13 — 1 dorsal valve.

Genus OXOPLECIA WILSON, 1913  
*Oxoplecia* cf. *O. plicata* (WIMAN, 1907)  
(Pl. 8, figs. 4-15)

Cf. *Triplesia plicata* WIMAN, 1907, pp. 12-13, Pl. 2, figs. 13-17.

*Spirifer terebratuliformis* M'COY, 1846, p. 38, Pl. 3, fig. 26.

*Oxoplecia* cf. *plicata* (WIMAN). WRIGHT, 1964, pp. 247-250, Pl. 11, figs. 5, 8, 11-14, 17.

*Exterior:*

The shells are transverse with length/width ratios near 2/3 or 3/4. The hinge line is wide, equalling more than 3/4 of maximum shell width which occurs in the posterior quarter of the valve. The shells are dorsibiconvex with thickness approaching 1/2 of the shell length. The ventral interareas have not been preserved well enough to determine the nature of the pseudodeltidium, though it is very thick. The surface is costate. Three costae occupy the posterior part of the dorsal fold on all specimens; however the apex of all shells is poorly preserved and it can not be determined whether or not all of these costae originate at the very front of the fold. Most valves have 3 costae throughout the length of the fold, but on a few larger shells one or two additional costae are inserted on the fold; of 9 dorsal valves 5 have three costae, three have 4 costae, and one has 5 costae at the front of the fold. Two costae occupy the posterior of the sulcus in the 4 well preserved ventral valves; on one of these an additional costa is inserted about 3 mm from the beak and on another specimen two costae are inserted about 5 mm from the beak. Interspaces are wide and

U-shaped in cross section. Closely spaced growth lines are strongly developed over the entire surface.

*Ventral interior:*

The small hinge teeth are supported by tall, thin dental plates that are inclined toward the midline. The bases of the dental plates diverge anteriorly and are set well to the sides of the impress of the sulcus. The muscle field is weakly impressed. The pedicle collar is well developed and 1.5 mm long in one valve that is about 14 mm in length.

*Dorsal interior:*

The cardinal process is forked and has a broad base. A "hood" is absent and in its position is a small, elongate pit. The ventral side of the base of the cardinal process is grooved and the bases of the widely flaring brachiophores are fused with the cardinal process. In larger specimens the median part of the valve is deeply convex and contains a broad median ridge; on the crest of this broad ridge is a small, narrow but distinct ridge. The median ridge is flanked by two pairs of deeply impressed adductor muscle scars. The anterior and posterior adductor muscle scars are separated by transverse ridges that diverge slightly anteriorly. The posterior pair of adductor muscle scars are transverse whereas the anterior pair are elongate. The muscle scars are deeply impressed adjacent to the median and transverse ridges and weakly impressed laterally.

*Comparison:*

The Swedish *Oxoplecia plicata* (WIMAN) is much more coarsely ribbed than most species of the genus. WRIGHT (1964) identified specimens from the Portrane Limestone of Ireland as *Oxoplecia* cf. *plicata* and noted that his specimens resembled the Swedish species in its relatively coarse ribbing, though the Swedish specimens may be more finely ribbed. Additionally WRIGHT (1964) noted the fossils were similar in the absence of a median fold in the pseudodeltidium, wide cardinal process, and absence of a cardinal process hood. Though the pseudodeltidium is not preserved in the Belgian collections, the cardinal process is wide and a cardinal process hood is lacking. The Belgian specimens further resemble the Irish specimens in having a similar number of ribs on the fold and sulcus, possessing a pit on the cardinal process in the position of the "hood" and having each prong of the cardinal process fused basally more strongly with the adjacent brachiophore than with the other prong of the cardinal process. The coarse ribbing, together with very similar details of many of the internal features, warrants assigning these specimens to the same species as the Irish specimens. Further study of the Swedish *O. plicata* is needed before a confident assignment can be made to that species.

WRIGHT (1964) adequately compared this species with others of the genus erected prior to 1962. Since that

time only one species, *Oxoplecia abnormis kolymica* ORADOVSKAYA (1968, in BALASHOV, et. al., 1968), has been described with similar ribbing in the fold and sulcus. However, the Russian species is much more coarsely ribbed than *O. cf. plicata*.

*Material:*

74B4 — 1 dorsal and 1 articulated valve; 74B14 — 2 dorsal valves; 74B16 — 3 ventral and 9 dorsal valves; 74B17 — 5 dorsal and 1 articulated valve; 74B19 — 1 dorsal and 1 ventral valve; 74B20 — 2 dorsal valves; PS57 — 2 dorsal and 1 articulated valve; PS58 — 5 dorsal valves.

Order STROPHOMENIDA

Suborder STROPHOMENOIDEA

Superfamily PLECTAMBONITACEA JONES, 1928

Family LEPTELLINIDAE ULRICH & COOPER, 1936

Subfamily LEPTESTIININAE HAVLÍČEK, 1961

Genus DIAMBONIA COOPER & KINDLE, 1936

*Diambonia* sp.

(Pl. 9, figs. 1-3)

*Exterior:*

Only four ventral valves were recovered. The shells are strongly convex, nearly hemispherical in lateral profile and are slightly transverse. The ornament consists of five strong, widely spaced costellae; finer costellae, if present, were not preserved. The largest shell is 4.5 mm long.

*Ventral interior:*

The muscle field is set on a low platform that is indented at the anterior margin. A low median ridge divides the muscle scars. In front of the muscle field and extending anteriorly beyond midlength is a strong median septum.

*Discussion:*

The strong convexity together with a ventral median septum which does not connect with the muscle field are sufficient morphologic criteria to assign the species to *Diambonia*. Five species have been assigned to *Diambonia*. Three species are known from the Caradoc: *Diambonia anatoli* from Norway and Scotland (SPJELDNAES, 1957; WILLIAMS, 1962), *Diambonia? leifi* from Norway (SPJELDNAES, 1957), and *Diambonia gibbosa* from the Trenton of Minnesota. *Diambonia septata* (COOPER) from the Ashgill at Percé, Quebec, and *Diambonia discuneata* (LAMONT) from the Ashgillian Lower Drummuck Group of Scotland and from Pomeroy, Ireland (COCKS, 1970; MITCHELL, 1977) are both very similar to the material recovered here, but in the absence of dorsal valves it is not possible to assign these specimens to a species.

*Material:*

74B10 — 3 ventral valves; 74B13 — 1 ventral valve.

## Genus LEANGELLA ÖPIK, 1933

*Leangella namurensis* n. sp.

(Pl. 9, figs. 4-17)

*Exterior:*

The shells are concavo-convex. Maximum curvature of both valves occurs near midlength. The valves are transverse with length/width ratios between 0.56 and 0.74 on 9 ventral valves that are between 7.1 and 9.5 mm wide. The largest valve is 9.9 mm wide. The apsacline ventral interarea is well developed and its length is maintained nearly to the shell extremities. The dorsal interarea is much shorter than the ventral interarea, but its length is also maintained laterally. The shells are parvicostellate with 5 strong costellae originating at the beak of the ventral valve and 7 at the dorsal beak. The fine costellae between the strong costellae number about 9 per mm measured 2 mm from the beak. Additional strong costellae are inserted on larger shells.

*Ventral interior:*

Small ridges extend forward from the front of the short dental plates and surround the muscle platform. The muscle field is deeply invaginated anteriorly and is confined to the posterior 1/5 of the valve. The diductor muscle scars, each of which is bilobed, surround the very small adductor muscle scars. Poorly impressed vascular impressions extend anteriorly from each lobe of the muscle field. The subperipheral rim is well developed around the entire margin of the shell. The subperipheral rim does not deflect the external surface of the shell, even though it is a major feature on the interior. The rim is formed by deposition of secondary shell, and the shell behind the rim is much thicker than in front of the rim. In front of the subperipheral rim the external ornament is impressed on the interior. Behind the rim, where the shell is much thicker, the external ornament is not impressed but the surface is papillose.

*Dorsal interior:*

The cardinal process is trilobate. The sockets are laterally directed slots bounded laterally by ridges and anteriorly by the widely divergent socket plates. Transverse pits, separated by a short, poorly defined ridge, lie immediately in front of the socket plates. The undercut muscle platform is raised well above the floor of the valve. The base of the muscle platform is strongly undercut medially, forming the tubus of ÖPIK (1933). The surface of the muscle field is longitudinally striate. The subperipheral rim is strong and longitudinally ridged. Behind the subperipheral rim, the shell is thickened. The distance from the apex of the shell to the most distant part of the front of the muscle platform support ranges between 1.8 and 2.2 mm in 7 measured valves. The distance from the front of the platform support to the front of the sub-

peripheral rim (along the same line as above) ranges between 1.0 and 1.5 mm in the same 7 valves. In front of the subperipheral rim is a broad region where the external ornament is impressed on the interior of the shell.

*Comparison:*

Only two species of *Leangella* have been reported in the Ordovician (see COCKS, 1970). *Leangella hamari* SPJELDNAES (1957) from the middle Ordovician Cyclocrinus Shale of Norway differs from this species in being smaller, having a relatively smaller ventral muscle field, more numerous strong costellae, and, most importantly, in having a dorsal subperipheral rim that is located much farther from the base of the muscle platform and closer to the shell margin than is found in *Leangella namurensis*. *L. cf. hamari* has been described from the Caradoc of Scotland by WILLIAMS, 1962. *Leangella scissa* (DAVIDSON) has been reported from Late Ordovician deposits in the British Isles (see JONES, 1928, p. 483) but only Llandovery specimens have been described (see especially COCKS, 1970; TEMPLE, 1970). *L. scissa* differs from *L. namurensis* in having a more convex ventral valve, a less bilobate (anteriorly invaginated) ventral muscle field, a much weaker ventral subperipheral rim, and a dorsal subperipheral rim set farther from the base of the muscle platform and closer to the margin of the valve. *Leangella triangularis* (HOLTEDAHL) from the Early Silurian Stage 6 of Norway (see ÖPIK, 1933) is a less transverse species than *L. namurensis*. In addition *L. triangularis* has more strong costellae, has five lobes rather than three on the cardinal process, has a weak rather than strong ventral subperipheral rim, and has a differently shaped dorsal subperipheral rim than *L. namurensis*.

*Holotype:*

The holotype (I.R.Sc.N.B. 1526) consists of interior and exterior molds of a dorsal valve from locality 74B15.

*Material:*

74B15 — 20 ventral and 16 dorsal valves.  
Identified as *Leangella cf. L. namurensis*: 74B8 — 2 ventral and 3 dorsal valves; 74B10 — 1 dorsal valve; 74B21 — 5 ventral and 1 dorsal valve.

*Leangella? sp.*

(Pl. 9, fig. 18)

*Description:*

The interior of a single dorsal valve has been recovered. It is characterized by a unique pair of subperipheral rims.

*Material:*

74B13 — 1 dorsal valve.

Genus SAMPO ÖPIK, 1933  
*Sampo ruralis* (REED, 1917)  
 (Pl. 9, figs. 19-30; Pl. 10, figs. 1-5)

*Plectambonites ruralis* REED, 1917, pp. 879-880, Pl. 14, figs. 25-33.

*Leptelloidea ruralis* (REED). JONES, 1928, pp. 490-492.

*Sampo ruralis* (REED). ÖPIK, 1933, p. 35.

*Sampo ruralis* (REED). KING and WILLIAMS, 1943, Pl. 16, fig. 14.

*Exterior:*

The shells are very strongly concavo-convex and transverse. Maximum curvature of the dorsal valve is near midlength; the ventral valve is evenly convex. The following length/width measurements were made on dorsal valves:

Locality	Width (mm)	Length (mm)
74B8	16	8.5
74B19	32	13
74B19	26	11
74B20	27	13

The interareas are prominent with the concave ventral interarea slightly longer than the convex dorsal interarea. The ventral interarea is anacline; the dorsal interarea is procline. A weak, narrow ventral fold and dorsal sulcus are visible on well preserved shells. The ornament is quite variable from individual to individual. Radial ornament consists of extremely fine costellae between much stronger, widely spaced costellae. The strong, irregular growth lines are most prominent postero-laterally; growth lines are commonly larger than the fine costellae. The number and spacing of the prominent costellae is quite variable among individuals, but spacing is regular on each shell. During growth the prominent costellae became more widely separated anteriorly, and when a critical distance was attained, one of the fine costellae midway between the prominent ones increase in size. The critical distance varies among individuals but is fairly consistent on either side of any particular individual. At the 1 cm growth stage of the dorsal valve the distance between the prominent costellae varies between about 1 and 2.5 mm. The prominent costellae on the ventral valve are stronger and more closely spaced than on the dorsal valve.

*Ventral interior:*

The teeth are supported by strong, divergent dental plates. Denticles are preserved lateral to the teeth but only in the medial half of the valve. The transverse muscle field is set on a platform and is confined to the posterior quarter of the valve. The oval adductor muscle scars are surrounded by the anteriorly bilobate diductor muscle scars. A broad median ridge is commonly present in the muscle field in front of the adductor muscle scars. In the back of the muscle field two plates rise from the floor of the valve. The plates are

positioned medial to and approximately parallel to the dental plates. These plates are separated medially by an apical groove which may have contained the pedicle. The plates are not visible in any shells less than 10 mm in length and may simply be socket plates impressed from the dorsal valve. Strong vascular impressions bounded by spiny ridges are developed in front of the muscle field.

*Dorsal interior:*

The large cardinal process is trilobate and covered basally by a convex chilidium. The sockets are slots bounded laterally by low ridges. Small pits which articulate with the ventral denticles are preserved along the medial half of the hinge line. The socket plates are set widely apart and their bases are very widely divergent. The flabellate muscle field is quadripartite. The front of the posterior adductor muscle scars is raised on a platform. The front of the anterior adductor muscle scars is poorly defined, but extends beyond the maximum shell curvature into the anterior half of the shell. A strong, broad, steep-sided median ridge originates well in front of the cardinal process and extends forward just beyond the front of the posterior adductor muscle scars where it ends abruptly. On some shells the ridge has a deep median groove. The anterior adductor muscle scars are lobate and the muscle field is indented medially. The muscle field, especially the anterior pair of scars, has strong longitudinal ridges. Prominent vascular impressions are present over the remainder of the interior.

*Comparison:*

Only four species have been assigned to *Sampo*. When erecting the genus, ÖPIK (1933) included the Late Ordovician *S. hiiuensis* ÖPIK and *Plectambonites ruralis* REED in *Sampo*. Subsequently SPJELDNAES (1957) assigned a new species, *S. indenta*, from zones 4b<sub>7</sub> and 4b<sub>8</sub> in the Oslo-Asker region of Norway to the genus. At the same time SPJELDNAES (1957) included the poorly known *Leptaena trabeata* LINDSTRÖM (in ANGELIN and LINDSTRÖM, 1880) from the "Trinucleus shales" of Västergötland, Sweden, in *Sampo*. SPJELDNAES (1957) made *Leptellina* a subgenus of *Sampo*, but subsequent workers have not accepted this, and *Leptellina* is now included in the Subfamily Leptellininae. SPJELDNAES (1957) also recognized the subgenus *Sampo* (*Sampo*) into which all species currently assigned to *Sampo* were placed. In what apparently is a misprint SPJELDNAES (1957, p. 67) assigned *Leptelloidea derfelensis* REED to *Sampo* (*Sampo*)? On subsequent pages however, he (SPJELDNAES, 1957, pp. 70, 72) included *L. derfelensis* in *Sampo* (*Leptellina*). The specimens from Belgium are distinguishable from *Sampo indenta* SPJELDNAES by the presence of a denticulate hinge line which is absent in the Norwegian species. *Sampo trabeata* (LINDSTRÖM) is less strongly concavo-convex and is more coarsely costellate than the Belgian species. *Sampo hiiuensis* ÖPIK

from the E and F<sub>1</sub> stages of Estonia differs from these specimens in having a less strongly transverse outline, not attaining as large a size, having more numerous strong costellae, having a larger ventral muscle field, and having two strongly raised platforms in the dorsal muscle field rather than one in the middle of the muscle field as in this species. *Sampo ruralis* (REED) has been reported widely from the Ashgill beds in the British isles as well as from a few Caradoc beds. The type specimen is from the Starfish Beds in the Girvan region, and LAMONT (1935) records it throughout the Drummuck Group. The species has also been reported from the Shoolehook Limestone (or immediately above) at Bronhaul, the "Slade Beds" at St. Clears, the Caradoc of Borwick Fell, Troutbeck and Tyrone, the "Upper Bala" at Blaencycwn, Llandeilo and the Llandovery District, and from Caradoc and Ashgill beds south-west of Coniston (JONES, 1928). It is reported and figured by KING and WILLIAMS (1953) from the *Calymene* Beds at Cautley, and in the same region it is present in INGHAM's (1966) Zones 1 and 2 of the Ashgill. Though this is well known species in Britain it has received little study. The original drawings by REED (1971) have been supplemented by only a single illustration of a ventral valve by KING and WILLIAMS (1953). *Sampo ruralis* from the Starfish Beds in the Girvan District described by REED (1917) resembles the Belgian material in being strongly transverse, having a narrow ventral fold and dorsal sulcus, a ventral muscle field confined to the posterior quarter of the valve, and dorsal adductor muscle scars with the posterior pair having a raised anterior margin with the front of the anterior adductor muscle scars poorly defined. This interpretation of the structure of the dorsal muscle field differs from that of REED (1917) in that he believed the muscle field terminated at the front of what I refer to as the posterior adductor muscle scars. In several specimens from Belgium and the only dorsal interior illustrated by REED (1917, Pl. 14, fig. 31) an area with the characteristic appearance of muscle insertions is in front of the upraised platform containing the posterior adductor muscle scars. This anterior area is considered to be homologous with a similar area in *Sampo hiiuensis* where the area differs only in having a raised anterior border (see ÖPIK, 1933, Pl. 7, fig. 3; reproduced in MOORE, 1965, fig. 242, 5c). Aside from the anterior raised border, the structures of the muscle fields, with a raised platform in the middle of the muscle field, is so similar in the two species that the anterior areas can be considered homologous.

The unusual pair of plates (if they are not socket plates) in the ventral valve may have functioned as a pedicle support. These plates have not been found in any other species of *Sampo*, and they were not mentioned in the descriptions of *Sampo ruralis* by REED (1917) or JONES (1928). However, the plates are clearly present in one valve illustrated by REED (1917, Pl. 14, fig. 30).

The only noticeable difference between specimens of *S. ruralis* from Belgium and Scotland is that the latter have a narrower median ridge in the dorsal valve. This difference is minor in view of the variability of the dorsal median ridge in the Belgian specimens.

*Material:*

74B7 — 2 ventral and 1 articulated shell; 74B8 — 4 ventral and 4 dorsal valves; 74B9 — 2 ventral valves; 74B13 — 1 ventral, 2 dorsal and 1 articulated valve; 74B16 — 11 ventral, 4 dorsal and 3 articulated valves; 74B17 — 1 articulated and 1 ventral valve; 74B19 — 6 articulated, 2 ventral and 8 dorsal valves; 74B20 — 3 articulated, 1 ventral and 3 dorsal valves.

Identified as *Sampo ruralis*?: 74B10 — 1 ventral and 1 dorsal valve.

Family SOWERBYELLIDAE ÖPIK, 1930

Subfamily SOWERBYELLINAE ÖPIK, 1930

Genus SOWERBYELLA JONES, 1928

*Sowerbyella* cf. *S. raegaverensis* RÖÖMUSOKS, 1959  
(Pl. 10, figs. 6-23)

*Sowerbyella* cf. *sladensis* JONES. ÖPIK, 1930, p. 147, Pl. 8, figs. 110-111.

*Sowerbyella sladensis* JONES. ALICHOVA, 1954, p. 28, Pl. 15, figs. 1-6.

*Sowerbyella raegaverensis* RÖÖMUSOKS, 1959, pp. 36-38, 46-47, Pl. 8, figs. 1-8.

*Exterior:*

The lateral profile is concavo-convex. The shell has a transverse outline with the width equal to about twice the length. The surface is parvicostellate. Ventral exteriors are poorly preserved, but 5 accentuated costellae begin at the beak and others are inserted anteriorly. On the dorsal valves 7 accentuated costellae begin at the beak and others are inserted anteriorly. The fine costellae number between 7 and 8 in a space of 1 mm measured 5 mm from the dorsal beak. The largest shell is a dorsal valve that is 24 mm wide and more than 12 mm long.

*Ventral interior:*

The teeth are supported by short, widely divergent dental plates. Short ridges extend forward from the dental plates and define the muscle field laterally. The adductor muscle scars are set in conical cavities which are separated by a strong median septum which continues anteriorly only a short distance. The median septum is 2 mm long in the largest ventral valve which is 14.5 mm long. The diductor muscle scars diverge anteriorly and each lobe has a low median ridge. The muscle field is confined to the posterior third of the valve. The anterior third of the valve is papillose.

*Dorsal interior:*

The cardinal process has a strong median ridge and a pair of weaker lateral ridges. Laterally the cardinal

process is fused with the socket plates which are widely divergent. In front of the cardinal process is a deep pit. The bases of the socket plates are continuous with low ridges that increase in height anteriorly where they become the prominent sub-median septa. In larger valves there is a low, very small median ridge. The adductor muscle field is composed of two petal shaped muscle scars which have low median ridges anteriorly. The muscle field extends anteriorly beyond midlength.

#### Comparison:

Though this species is too poorly preserved for a confident identification, the dorsal interiors very strongly resemble those of *Sowerbyella raegaverensis* RÖÖMUSOKS, from the E Stage of the Estonian Harju Series and from the O<sub>2v</sub> stage of the Russian Platform. For comparison see especially the nearly identical dorsal valve assigned to *S. sladensis* by ALICHOVA (1954, Pl. 15, fig. 6). *Sowerbyella thraivensis* (REED, 1917) from the Drummuck Group of the Girvan area in Scotland and the Killey Bridge Formation, Pomeroy, Ireland (MITCHELL, 1977) is a smaller species which lacks the ridges found in the dorsal adductor muscle field of the Belgian material. *Sowerbyella sladensis* JONES (1928) lacks the conical pits in which the ventral adductor muscles attached in *S. raegaverensis*. In addition the dorsal adductor muscle field has median grooves (JONES, 1928, Pl. 21, fig. 14a) which are lacking in the Belgian specimens. *Sowerbyella gigantea* COOPER (1930) from the Whitehead Formation of Percé, Quebec, attains a much larger size.

#### Material:

74B14 — 17 ventral and 21 dorsal valves; 74B15 — 2 ventral, 2 dorsal, and 2 articulated valves; 74B19 — 7 ventral and 1 dorsal valve. Questionably assigned to *S. cf. S. raegaverensis*: 74B20 — 3 ventral, 1 dorsal and 1 articulated valve; 74B16 — 5 ventral and 2 dorsal valves; 74B12 — 2 ventral, 2 dorsal and 2 articulated valves; 74B13 — 2 ventral and 2 dorsal valves; 74B21 — 1 ventral, 1 dorsal, and 1 articulated specimen.

Subgenus RUGOSOWERBYELLA MITCHELL, 1977  
*Sowerbyella (Rugosowerbyella) subcorrugatella*  
 (REED, 1917)  
 (Pl. 10, figs. 24-34)

*Plectambonites subcorrugatella* REED, 1917, p. 886, Pl. 15, figs. 33-34.

*Sowerbyella subcorrugatella* (REED). JONES, 1928, pp. 463-464, Pl. 24, figs. 14-15.

#### Exterior:

The concavo-convex shells are transverse with width equalling about twice the length. The largest valve is 11 mm wide and 5.5 mm long. The ventral interarea is apsacline, approaching catacline. The surface is parvicostellate with 9 to 11 accentuated costellae

originating at the beak and others inserted anteriorly. There are 6 to 8 fine costellae between the accentuated costellae. Strong concentric rugae cover the entire surface, but are interrupted by the accentuated costellae.

#### Ventral interior:

Hinge teeth are supported by short dental plates which are continuous anteriorly with ridges which completely surround the muscle field. The adductor muscle scars are in conical cavities and are separated by a median septum. In front of the adductor muscle scars the median septum widens and extends to the front of the muscle field. In the largest shell the median septum is massive. The interior is papillose and thickened posteriorly. At the margin of the valve is a fringe which has more numerous papillae and which bears the impress of the external ornament. Behind the fringe the shell is thickened.

#### Dorsal interior:

Only a single dorsal interior was recovered and it is broken. The cardinal process is trilobed, and the socket plates are anteriorly divergent. The adductor muscle field is set on a pair of high platforms with steep anterior margins. The submedian septa are well developed. Three longitudinal ridges are on the muscle scars. As in the ventral valve, a fringe at the margin of the valve bears the impress of the external ornament.

#### Discussion:

When MITCHELL (1977) erected the subgenus *Rugosowerbyella* he essentially formalized the *Sowerbyella subcorrugatella* group of species recognized by JONES (1928). *S. subcorrugatella* was originally described by REED (1917) from the Whitehouse Group, Shallock Mills, Whitehouse Bay, Scotland. Subsequently JONES described specimens which he assigned to the species from the Killey Bridge Formation of Pomeroy, Ireland. Apparently the latter group of shells belong to *S. (R.) ambigua* (REED) which was described from the Killey Bridge Formation by MITCHELL (1977), although the description by JONES is not included in MITCHELL's synonymy. *Plectambonites serica* var. *semirugata* REED was included in the species group by JONES (1928), but this species has since been shown to belong to *Eoplectodonta* by WILLIAMS (1962).

*Sowerbyella (Rugosowerbyella) subcorrugatella* differs from *S. (R.) ambigua* in having fewer accentuated costellae and a more poorly defined anterior margin of the dorsal muscle field. ROZMAN (1970) assigned a similar suite of shells to *Sowerbyella* ex. gr. *subcorrugatella*. His material was from the Upper Ordovician of the Seleniakh Range in the Yakutsk SSR.

#### Material:

74B20 — 5 ventral, 1 dorsal and 2 articulated specimens.

Genus ANISOPLEURELLA COOPER, 1956  
*Anisopleurella quinquecostata* (JONES, 1928)  
 (Pl. 11, figs. 1-8)

*Sowerbyella quinquecostata* JONES, 1928, pp. 464-472, Pl. 24, figs. 16-20.

*Anisopleurella quinquecostata* (JONES). WILLIAMS, 1962, p. 187.

*Anisopleurella quinquecostata* (JONES). WRIGHT, In INGHAM, 1966, p. 501.

non *Orthis quinquecostata* M'COY, 1846, p. 33, Pl. 3, fig. 8.

*Exterior:*

The shells are strongly transverse with the length of the ventral valve less than twice the shell width. The best preserved shell, a dorsal valve, is 7.2 mm long and 14.5 mm wide. The lateral profile is strongly concavo-convex. The length of the gently concave, apsacline ventral interarea is less than 1/20 the length of the shell. The hypercline dorsal interarea is short and gently concave. The ventral valve has three widely spaced accentuated costellae between which are much finer costellae numbering between 10 and 12 in a space of 1 mm measured 4 mm from the ventral beak. The number of accentuated costellae on the dorsal valve is variable. One valve has only a single accentuated costella situated on the midline. Other valves have three accentuated costellae. Concentric ornament is subdued.

*Ventral interior:*

The muscle field is weakly impressed and poorly defined. There is a small pseudodeltidial node (terminology of WILLIAMS in WHITTINGTON and WILLIAMS, 1955). Low, poorly defined ridges diverge from the apical region of the shell. The most obvious of these ridges lie beneath the lateral accentuated costellae. Hinge teeth are very small. Lateral to the teeth the shell is denticulate nearly to the postero-lateral margin. The ventral valve bears mainly denticular sockets, though there are a few denticles. The denticles and sockets are irregularly spaced, and irregular in size and shape, commonly between 0.10 and 0.15 mm in diameter.

*Dorsal interior:*

The medially ridged cardinal process is covered basally by a convex chilidium. The cardinal process is fused laterally with the socket plates. In front of the cardinal process is a deep pit, which produces the "tent like structure" described by COOPER (1956). The socket plates are triangular and strongly curved. The muscle field is petal shaped and defined by a ridge. There is a short median septum. Lateral to the median septum are a pair of submedian septa which define the muscle field medially. The submedian septa become broad ridges anteriorly and the ridges surround the remainder of the muscle field. Each lobe of the muscle field contains a thin, very

high septum which does not extend to the front of the muscle field. Basally the septa in the muscle field are perpendicular to the shell floor, but distally the septa are curved through a right angle (toward the midline) forming small shelves which parallel the shell floor and probably served for muscle attachment. The muscle field is confined to the posterior half of the shell. The septa are well developed in small shells but the ridges which define the muscle field are weakly developed. The posterior margin of the shell, just inside the hinge line, is denticulate, with the number of denticles predominating over denticle sockets.

*Discussion:*

The genus *Anisopleurella* is characterized by its ornament and especially its unique petal-shaped dorsal muscle field. Some species of *Eoplectodonta* and *Kozlowskites* have similar muscle fields, but in these species the median septum is much longer and the submedian septa are much stronger.

Most species of *Anisopleurella* lack a denticulate hinge line. Three species (and possibly a fourth) have a unique denticulation that is unlike that found in other genera of the subfamily in being set inside the margin of the hinge line and in having large denticles of irregular shape, size and spacing. This is the "pseudocrenulation" in *Anisopleurella quinquecostata* described by JONES (1928). *Anisopleurella anceps* MITCHELL (1977) has six coarse, denticle-like structures. *Anisopleurella gracilis* (JONES) also has obscure internal crenulations (see TEMPLE, 1970, p. 38). The margin of *Anisopleurella karina* (SPJELDNAES, 1957) was described as denticulate with denticles resembling those in *Eoplectodonta acuminata*, but it is unclear from the specimen illustrated by SPJELDNAES (1957) if the denticles of this species are regularly spaced small, ventral denticles on the margin of the hinge line as is typical of *Eoplectodonta*, or if they are large, irregular, internal denticles as in *A. quinquecostata*. When the occurrence of denticles in the species is better understood it may be possible to erect a subgenus to accommodate species with this distinct morphology. At present the phyletic relations within *Anisopleurella* are too poorly known for a subgenus to be meaningful.

*Comparison:*

The Belgian specimens closely resemble the Welsh *Anisopleurella quinquecostata* described by JONES (1928). The only notable difference is that large specimens of the Welsh assemblage commonly insert two additional accentuated costae anteriorly while this is not found in the Belgian material. JONES (1928) in describing the Welsh specimens assigned them to the Irish *Orthis quinquecostata* M'COY and designated one of the Welsh specimens as the holotype of M'COY's species. JONES (1928) noted that M'COY's species from Ireland was probably different from the Welsh species (probably belonging to a different genus

than *Sowerbyella*). As WILLIAMS (1962) apparently also noted, this taxonomic procedure is invalid and M'COY's original species must stand on the Irish material. Therefore the species *Sowerbyella quinquecostata* is ascribable to JONES (1928). *A. quinquecostata* is a large species for the genus, being approached in size only by the Caradoc *A. multiseptata* (WILLIAMS, 1955) from the Derfel Limestone of north Wales and by *A. balclatchiensis* (REED, 1917) from the Caradoc of the Girvan Region of Scotland (see WILLIAMS, 1962). *A. multiseptata* has a differently shaped dorsal muscle field than *A. quinquecostata*. *A. quinquecostata* differs from *A. multiseptata*, *A. balclatchiensis*, *A. inaequistriata* COOPER, *A. tricostellata* COOPER, and *A. ovalifera* HAVLÍČEK in having hinge denticles. *A. ovalifera* HAVLÍČEK (1967) from the Králův Dvůr shales of Bohemia is the only other species of *Anisopleurella* described from the Ashgill. In addition to lacking denticles it differs from *A. quinquecostata* in having many accentuated costellae inserted anteriorly and having a long dorsal median septum that resembles those found in species of *Eoplectodonta*. *Anisopleurella karina* (SPJELDNAES, 1957) from Stage 4b<sub>α</sub> and possibly 4b<sub>β</sub> in the Oslo region has denticles that may be similar to those in *A. quinquecostata*. It differs from *A. quinquecostata* in being somewhat smaller, having a more weakly convex ventral valve, and a callosity in the apex of the dorsal valve. *Anisopleurella gracilis* (JONES) from the basal Llandovery of Haverfordwest and Meifod in Wales (TEMPLE, 1968, 1970) is smaller, has somewhat coarser fine costellae and a longer dorsal median septum than *A. quinquecostata*. *Anisopleurella anceps* MITCHELL (1977) from the Killey Bridge Formation and Junction Beds of Pomeroy, Ireland, has more broadly divergent accentuated costellae and a shorter median septum than *A. quinquecostata*.

*Material:*

74B4 — 3 ventral, 2 dorsal, and one articulated valve; 74B15 — 4 ventral and 3 dorsal valves.

*Anisopleurella* sp.  
(Pl. 11, figs. 9-11)

*Exterior:*

The shells are transverse and very strongly concavo-convex with ventral shell depth exceeding 1/2 of the shell length. The outline is trapezoidal and the cardinal extremities are extended. The ventral valve has three accentuated costellae. Fine costellae number about 8 in 1 mm measured 3 mm from the ventral beak. The ventral fold and dorsal sulcus are poorly defined.

*Ventral interior:*

The ventral muscle field is weakly impressed. There is a small pseudodeltidial node.

*Dorsal interior:*

The cardinal process has a median ridge and is covered basally by a chilidium. The socket plates are very narrow. The pattern of ridges and septa in the muscle field is typical of *Anisopleurella*.

*Discussion:*

The extreme convexity of the ventral valve together with its trapezoidal outline and the relatively coarse fine costellae distinguish it from all described species of *Anisopleurella*. However, there are too few specimens, and preservation is too poor to allow description of a new species.

*Material:*

74B8 — 1 ventral, 2 dorsal and 2 articulated valves; 74B14 — 1 dorsal valve.

*Anisopleurella? sartenaeri* n. sp.  
(Pl. 11, figs. 12-21)

*Exterior:*

The concavo-convex shells are transverse with the length more than twice the width. The ornament is parvicostellate with three accentuated costellae originating at the beak and more added anteriorly on large specimens. About 7 fine costellae occupy a space of 1 mm measured 5 mm from the beak. The largest shell is 25 mm wide and more than 14 mm long.

*Ventral interior:*

The teeth are large and closely spaced. Dental plates are absent. The adductor muscle scars are situated in deep cavities on either side of a short, strong median ridge. A distinctive apical platform (pedicle chamber) lies above the adductor muscle scars and behind the diductor muscle scars. The diductor muscle scars are impressed posteriorly but poorly defined anteriorly. In the largest shells (e.g. Pl. 11, figs. 18-19) the diductor muscle scars are deeply impressed.

*Dorsal interior:*

The cardinal process is fused laterally with the socket plates. A median septum extends anteriorly as far as does the muscle field. A strong pair of median septa define the inner sides of the adductor muscle scars. The outer sides of the muscle field are defined by strong lateral septa, and each lobe of the muscle field bears a strong longitudinal septum.

*Discussion:*

The ventral muscle fields resemble those commonly found in species of *Sowerbyella*. The widely spaced accentuated costellae and dorsal median septum distinguishes this species from *Sowerbyella* and suggests assignment to *Anisopleurella*. However, the pedicle chamber or platform above the ventral adductor muscle scars is unlike that found in other species of *Anisopleurella*, as is the long dorsal median septum.

*Holotype:*

The holotype (I.R.Sc.N.B. 1566) consists of interior and exterior molds of a ventral valve from loc. 74B19.

*Material:*

74B13 — 13 ventral and 2 dorsal valves; 74B17 — 2 ventral valves; 74B19 — 10 ventral and 2 dorsal valves.

Subfamily PTYCHOGLYPTINAE COOPER, 1956

Genus PTYCHOGLYPTUS WILLARD, 1925

*Ptychoglyptus* sp.

(Pl. 11, figs. 22-26)

*Exterior:*

The large, transverse shells are plano-convex in lateral profile. The largest valve is about 40 mm wide and though broken anteriorly was more than 16 mm long. Radial ornament is parvicostellate with widely spaced accentuated costellae. Fine costellae number about 10 in a space of 1 mm measured 10 mm from the beak. Concentric rugae are strongly developed and are interrupted by the accentuated costellae. Rugae are commonly somewhat crescentic (convex toward the beak) between the accentuated costellae, and the rugae are not always perpendicular to the accentuated costellae.

*Ventral interior:*

Dental plates are lacking. The slightly impressed muscle field is indented medially. The external ornament is impressed on the interior.

*Dorsal interior:*

The trilobed cardinal process is covered basally by a convex pseudochilidium. The thin socket plates are widely divergent, nearly paralleling the hinge line. The muscle field is weakly impressed and only postero-laterally is it well defined by low ridges. The weak median ridge is very broad. Each of the adductor muscle scars contains a weak submedian ridge.

*Material:*

74B7 — 1 dorsal valve; 74B19 — 1 dorsal and 2 ventral valves.

Subfamily AEGIROMENINAE HAVLÍČEK, 1961

Genus CHONETOIDEA JONES, 1928

*Chonetoidea* sp.

(Pl. 11, fig. 27)

*Description:*

The interior of a single dorsal valve was collected. The shell is transverse with a length of 2.3 mm and a width of 4.0 mm. The shell is strongly concave in lateral profile. The elongate "Ankergrube" (ÖPIK, 1933) is short. There is a short median septum; the

remaining septa are nearly identical on opposite sides of the valve. Postero-laterally there is a pair of gently curved (convex toward the midline) septa. Between the median septum and the curved postero-lateral septa are four pairs of septa set in an arc. A pair of small spines are positioned in front of the arc close to the midline.

*Comparison:*

The species is assigned to *Chonetoidea* rather than *Sericoides* because known species of the latter genus do not have dorsal valves that are as strongly concave as the one found here. The pattern of septa differs from that found in any described species of *Sericoides* or *Chonetoidea*. In addition the symmetry of septa on opposite sides of the valve is unusual because in described species the pattern of septa differs markedly on opposite sides of every valve.

*Material:*

74B15 — 1 dorsal valve.

Family CHRISTIANIIDAE WILLIAMS, 1951

Genus CHRISTIANIA HALL & CLARKE, 1892

*Christiania magna* n. sp.

(Pl. 11, figs. 31-32; Pl. 12, figs. 1-17)

*Exterior:*

The concavo-convex shells are elongate. The strong curvature of the valves makes it difficult to obtain unbroken specimens of large valves. The largest ventral valve is about 24 mm long and has a width exceeding 13 mm. The dorsal valve is shield shaped in outline with slightly extended postero-lateral margins. The protogulum is commonly preserved at the apex of the dorsal valve; it is about 0.5 mm long, convex and has a median ridge. A low, narrow, well defined fold begins in front of the protogulum. The ventral valve has a very low, narrow sulcus. Concentric growth lines dominate the ornament. The growth lines on the dorsal valve are strong but have irregular strength and spacing. Approximately 5 growth lines occur in 1 mm of length measured 10 mm from the beak. Growth lines on the ventral valve are about the same strength as on the dorsal valve but are somewhat more regularly spaced. Very faint costellae are commonly present on both valves. The costellae are widely spaced (1 to 2 mm apart 20 mm from the beak), and they are more obvious on the ventral than on the dorsal valve. The costellae increase in strength anteriorly.

*Ventral interior:*

Widely spaced dental plates are very short and broadly divergent anteriorly. A large pedicle tube (1.5 mm in diameter in one 24 mm long valve) dominates the apex of the valve. The muscle field is very weakly

impressed and divided by a weak median ridge. Vascular markings extending forward from the front of each diductor muscle lobe are set along the impress of the margins of the sulcus and reach nearly to the anterior margin.

*Dorsal interior:*

The cardinal process is composed of two minute knobs in small specimens but is absent in larger individuals. The surface of the cardinal process is longitudinally grooved. The socket plates are broadly divergent. Low ridges bound the sockets postero-laterally. Outer septa originate at the socket plates and bound the adductor muscle scars laterally. The outer septa continue forward from the muscle field and diverge slightly anteriorly. In one valve the septa are 6 mm apart at their junction with the socket plates and 13 mm apart at their front, 15 mm from the socket plates. The inner septa originate in front of the posterior margin and extend to the front of the muscle field. The inner and outer septa are joined by a low ridge. Transverse septa connect the inner and outer septa. The bases of the transverse septa are straight and parallel to the hinge line. The transverse septa are inclined strongly toward the rear of the valve. The transverse septa are set about 3 mm from the socket plates in all valves, regardless of size. The adductor muscles presumably inserted both on the floor of the valve and on the surface of the transverse septa. The field between the inner and outer septa and in front of the transverse septa is papillose, and it increased in size during shell growth. A low median ridge is present on some specimens, absent on others.

*Comparison:*

The large size of *Christiania magna* distinguishes it from all other species of the genus. Ashgill species of the genus are poorly known. *Christiania nilssoni* SHEEHAN (1973) from southern Sweden differs from *C. magna* in having S-shaped transverse septa, fine concentric ornament, and no costellae. *Christiania dubia* COOPER (1930) from the Whitehead Formation of Percé, Québec, lacks costellae and has weaker concentric ornament than *C. magna*. *Christiania portlocki* MITCHELL (1977) has a similar external ornament but lacks transverse septa in the dorsal valve.

*Holotype:*

The holotype (I.R.Sc.N.B. 1576) consists of interior and exterior molds of a dorsal valve from locality 74B19.

*Material:*

74B10 — 1 dorsal valve; 74B11 — 2 ventral valves; 74B12 — 2 ventral valves; 74B15 — 2 ventral and 3 dorsal valves; 74B19 — 16 ventral and 16 dorsal valves; 74B20 — 4 ventral and 4 dorsal valves; PS57 — 1 ventral valve. Identified as *Christiania magna*?: 74B7 — 2 ventral and 4 dorsal valves.

Family FOLIOMENIDAE WILLIAMS, 1965

Genus FOLIOMENA HAVLÍČEK, 1952

*Foliomena folium* (BARRANDE, 1879)

(Pl. 11, figs. 28-30)

*Strophomena folium* BARRANDE, 1879, p. 55, fig. 1.

*Foliomena folium* (BARRANDE). HAVLÍČEK, 1952, pp. 413-414, Pl. 3, figs. 1, 3, 4, 6.

*Foliomena folium* (BARRANDE). HAVLÍČEK, 1967, p. 83, Pl. 9, figs. 1-3, 6-7, 10, 13.

*Foliomena folium* (BARRANDE). SHEEHAN, 1973, pp. 64-65, Pl. 2, figs. 13-18, Pl. 3, figs. 1-3.

*Exterior:*

Only two ventral valves were recovered. The shells are plane with a small convex region in the apex. The outline is transverse with maximum width at the hinge line. One specimen is 10.4 mm wide and 5.4 mm long and the other is 10.8 mm wide and approximately 5.4 mm long. The interareas are apsacline, approaching catacline. The interareas are short, less than 1/2 mm long, and they do not extend to the margins of the hinge line. The edges of the pseudodeltidium are visible in one mold. The only ornament consists of fine, closely spaced growth lines.

*Ventral interior:*

The muscle field is confined to the posterior 1/4 of the shell. The bilobed diductor muscle scars are impressed posteriorly but weakly defined anteriorly. Adductor muscle scars are not visible. A strong median ridge divides the diductor muscle scars. Behind the median ridge is a short pedicle tube.

*Discussion:*

The morphology of the specimens conforms very closely to specimens of *Foliomena folium* from Sweden and Bohemia. The species has also been reported from the Holy Cross Mountains of Poland (BEDNARCZYK, 1971) and Västergötland, Sweden (SHEEHAN, 1977).

*Material:*

74B21 — 2 ventral valves.

Superfamily STROPHOMENACEA KING, 1846

Family STROPHOMENIDAE KING, 1846

Subfamily STROPHOMENINAE KING, 1846

Genus STROPHOMENA RAFINESQUE, 1825

*Strophomena* sp.

(Pl. 12, figs. 18-29; Pl. 13, figs. 1-2)

*Exterior:*

The outline is transverse with length equalling about 3/4 of width. In lateral profile the ventral valve is slightly convex posteriorly with a gentle resupination in front. The dorsal valve is plane or gently convex. The apsacline ventral interarea is long, equalling

about 15% of the length of the valve. The pseudodeltidium is strongly arched. The parvicostellate ornament is coarse and accentuated costellae are only about twice the size of the fine costellae. About 4 fine costellae occur in a space of 1 mm measured 10 mm from the beak. Concentric ornament is well developed with 7 to 9 angular, regularly spaced growth lines in a space of 1 mm, measured 10 mm from the beak.

*Ventral interior:*

The teeth are longitudinally striate. The muscle field is defined postero-laterally by septa (dental ridges) which are continuous anteriorly with short ridges extending around the antero-lateral margin of the muscle field. The adductor scars are more deeply impressed than the diductor muscle scars. The diductor muscle scars do not enclose the adductor muscle scars anteriorly. The muscle field is very poorly defined anteriorly.

*Dorsal interior:*

The cardinal process lobes are strong and extend above the curved socket plates. A small septum between the cardinal process lobes supports the chidium. The sockets are crenulated. There is a broad, low median ridge. The muscle field is weakly impressed and two pair of weak, longitudinal ridges are developed in the largest valves.

*Comparison:*

The external ornament, development of the cardinal process and socket plates, and the weakly defined ventral muscle field resembles *Strophomena valens* REED (1917) from the Starfish beds of the Drummuck Group of Scotland. MITCHELL (1977) included *S. valens* in *Strophomena cancellata* (PORTLOCK) and illustrated specimens of that species which lack the dorsal median ridge found in the Belgian specimens. Unfortunately, the material available for study is not well enough preserved and the Scottish species is too poorly known to assess this relationship more critically.

*Material:*

74B9 — 6 ventral and 8 dorsal valves; 74B12 — 1 dorsal valve; 74B13 — 2 ventral and 1 dorsal valve; 74B15 — 1 ventral valve; 74B19 — 10 ventral and 4 dorsal valves; 74B20 — 3 ventral and 2 dorsal valves.

Subfamily FURCITELLINAE WILLIAMS, 1965

*Revised diagnosis:*

The subfamily was erected by WILLIAMS (1965) and is revised here to include strophomenids which have dental plates that are continuous anteriorly with strong ridges bounding the muscle field, and ventral adductor muscle scars which are narrow and commonly extend forward beyond the diductor muscle

scars, although in the earliest genus they extend only to the front of the diductor muscle scars. In the dorsal valves the notothyrial platform is well developed, the muscle field is divided into broad posterior adductor muscle scars and much narrower anterior adductor muscle scars. The posterior median ridge is strong and commonly bifurcates anteriorly to bound the back of the anterior adductor muscle scar. If a median ridge is present in the anterior field it does not join the median ridge in the posterior muscle field. Similarly, transmuscle septa and ridges bounding the muscle scars do not extend from the posterior to the anterior adductor muscle scars, but are developed separately in the two muscle fields. The shell is finely and densely pseudopunctate.

*Genera included in the subfamily:*

The following genera are assigned to the Furcitellinae:

*Furcitella* COOPER, 1956

*Costistrophomena* new genus

*Holtedahlinea* FOERSTE, 1925

*Katastrophomena* COCKS, 1968

*Luhaia* RÖHMUSOKS, 1956

*Murinella* COOPER, 1956

*Pentlandina* BANCROFT, 1949

Questionably assigned:

*Drummuckina* BANCROFT, 1949

Excluded from the subfamily:

*Tetratelasma* COOPER, 1956

*Discussion:*

As redefined, this subfamily consists of an easily recognizable group of genera with long, very narrow ventral adductor muscle scars, and a dorsal muscle field with broad posterior and narrow anterior adductor muscle scars that have median ridges, transmuscle septa and bounding ridges which do not extend from the anterior to the posterior muscle scars. On the dorsal valve the adductor muscles are assumed to have inserted on both the floor of the valve and on the dorsal septa. When the shells were articulated the dorsal and ventral muscle fields lay opposite each other and the adductor muscle scars of both valves extended anteriorly about the same distance.

Essentially this group was first recognized by BANCROFT (1949) when he described "*Strophomena antiquata*" and allied species which are now assigned to *Drummuckina*, *Pentlandina*, and *Katastrophomena*. *Murinella* from the Middle Ordovician, is the earliest genus assigned to the subfamily. It has the characteristic broad posterior and narrow anterior dorsal adductor muscle scars. The ventral adductor scars, however, are not as long as is common in later genera. The genus is also distinguished by a marginal flange or peripheral band in the dorsal valve. Morphologically, and in its stratigraphic occurrence, *Murinella* is a reasonable ancestor of later furcitellinids. *Furcitella*, known from the Middle and Late Ordovician, was

probably derived from a species of *Murinella*. It is the oldest genus in which species assigned to it have all the characteristic features of the subfamily. *Holte-dahlina* is a Late Ordovician, North American genus in which the dorsal muscle bounding ridges and transverse muscle septae are weakly developed. Since it has a marginal flange or peripheral band in the dorsal valve it was probably derived from *Murinella*. *Katastrophomena* (COCKS, 1968) from the Late Ordovician and Silurian, is so similar to *Furcitella* that its status as a distinct genus might be questioned. *Katastrophomena* is larger and has a smaller pedicle foramen than *Furcitella*. COCKS (1968) also indicated there was a difference in the convexity of the valves with *Furcitella* being biconvex and *Katastrophomena* being resupinate. However, COOPER (1956, p. 875) noted that although the shells of *Furcitella* are biconvex "... the pedicle valve (is) usually flattened to somewhat concave in the anterior half". One additional difference is that the transmuscle septa and ridges bounding the muscle field are commonly (though not always) stronger in *Katastrophomena* than in *Furcitella*. The earliest species of *Katastrophomena* were coarsely costellate. *Katastrophomena* was clearly derived from *Furcitella* which is also coarsely costellate. *Luhaia*, from the Late Ordovician, is assigned to the Furcitellinae because of its characteristic ventral and dorsal muscle fields (see *Luhaia vardi* discussed below). It, along with the new genus *Costistrophomena*, differ from other members of the subfamily in being ventrally geniculate. It has a very fine parvicostellate ornament and may have been derived directly from *Murinella* which has differentiated ornament rather than from *Furcitella* which is irregularly and quite coarsely costellate. BANCROFT (1949) allied his Silurian subgenus *Strophomena* (*Pentlandina*) with the "*Strophomena antiquata*" group. *Pentlandina* was raised to generic status and assigned to the Strophomeninae by WILLIAMS (1965), and this was followed by COCKS (1968). The muscle fields of *Pentlandina* are characteristically furcitellinid (as redefined here) and the genus is reassigned to that subfamily, in agreement with BANCROFT's (1949) interpretation of its phylogenetic relationship. It was apparently derived from *Katastrophomena*.

BANCROFT (1949, p. 11) erected *Drummuckina* as a subgenus of *Strophomena* to include *Stropheodonta donax* REED and a new species, *Strophomena* (*Drummuckina*) *agrestis*. BANCROFT (1949, p. 11) made *S. donax* the genotype of *Drummuckina*, not *S. (D.) agrestis* as indicated by WILLIAMS (1965, p. H384). *Drummuckina* is here raised to generic status because, unlike *Strophomena*, the narrow ventral adductor muscle scars extend beyond the diductor muscle scars in *D. donax* (see REED, 1917). The ventral muscle field strongly resembles that of a furcitellinid, but since the dorsal interiors have not been described, the genus is questionably assigned to the subfamily. The genus differs from others of the subfamily in being

concavo-convex and having a very finely denticulate hinge line (see REED, 1917, p. 892).

The new Late Ordovician genus *Costistrophomena* is characterized by its coarse ornament and geniculate profile. It was probably derived from *Furcitella* although an as yet unknown Ordovician species of *Katastrophomena* is another possibility.

WILLIAMS (1965) assigned *Tetratelasma* to the Furcitellinae; however, when erecting the genus, COOPER (1956) noted its similarity to the leptaenid *Dactylogonia*, and this assignment is accepted here. The ventral muscle field of *Tetratelasma* is unlike other furcitellinids and the transmuscle septa are extravagantly developed tubes.

Members of this subfamily maintained the basic pattern of the muscle fields while evolving ornaments ranging from parvicostellate to costellate to costate, and a wide suite of lateral profiles (dorsi-biconvex, ventrally resupinate, ventrally geniculate and concavo-convex).

#### Genus LUHAIA RÖÖMUSOKS, 1956

*Luhaia vardi* RÖÖMUSOKS, 1956 *roomusoksi* n. subsp.  
(Pl. 13, figs. 3-11)

*Luhaia vardi* RÖÖMUSOKS, 1956, pp. 1091-1092, figs. 1-3.  
*Luhaia vardi* RÖÖMUSOKS. RÖÖMUSOKS in MOORE, 1965, fig. 246, 6a-c.

#### Exterior:

The outline is transverse, but tectonic distortion and shell breakage makes accurate measurements impossible. The best preserved shell was about 30 mm wide, has a disc nearly 20 mm long, and a trail about 18 mm long. There is an abrupt, ventrally directed geniculation and the trail is at nearly a right angle to the disc. The catacline ventral interarea is well developed, attaining a length equal to approximately 10% of the valves length. The short dorsal interarea is anacline. The shells are finely parvicostellate with about 5 costellae in a space of 1 mm at the midline near the geniculation. Four accentuated costellae begin near the beak of both valves, but they become smaller anteriorly and are inconspicuous at the front of the disc. Rugae are prominent only on the postero-lateral margins, but they extend across the entire shell.

#### Ventral interior:

The teeth are longitudinally striate. The muscle field has strong bounding ridges which are undercut marginally. The adductor muscle scars are on a median ridge or platform which extends beyond the front of the diductor muscle scars, but is not bounded in front by the lateral bounding ridges.

#### Dorsal interior:

The bilobed cardinal process is small and set on a convex notothyrial platform. The small socket plates

are widely divergent. The muscle field is composed of broad posterior adductor muscle scars separated by a wide median ridge that is confined to the posterior muscle scars. Each posterior adductor muscle scar has a low, ridge-like transmuscle septum. The shield shaped anterior adductor muscle scars are much narrower than the posterior scars and they do not contain transmuscle septa.

*Comparison:*

A ventrally directed geniculation is found in *Luhaia* and *Kjerulfina*. The length of the ventral adductor muscles, together with the presence of transmuscle septa in the dorsal valve, indicate that this species belongs to the furcitellinid *Luhaia* rather than the rafinesquininid *Kjerulfina*.

*Luhaia vardi* from the Upper Ordovician of Estonia resembles this species closely including its similar size and almost identical dorsal interior (see especially the most recent illustration by RÕMUSOKS in MOORE, 1965, Fig. 246, 6a). The Belgian material differs in having accentuated costellae which anteriorly become equal in size and are essentially indistinguishable from the fine costellae, whereas specimens from Estonia have accentuated costellae which become weaker anteriorly, but they are still readily visible at the front of the disc. In addition, the transmuscle septa, though positioned similarly in both groups, are more strongly developed in the Belgian material. These differences are minor but are sufficient to warrant the erection of a new subspecies.

"*Strophonella undata*" (M'COY) described by REED (1917) from the Drummuck Group of Scotland is apparently ventrally geniculate (REED, 1917, pp. 901-902, Pl. 18, figs. 15-17, but not fig. 18) and may belong to *Luhaia*. It differs from *L. vardi* in lacking accentuated costellae and having concentric rugae of approximately the same strength across the entire valve.

The Belgian species differs from *Luhaia?* sp. from the Killey Bridge Formation of Pomeroy, Ireland, (MITCHELL, 1977) in having weaker external ornament, and in possessing transversa septa in the dorsal muscle field.

*Holotype:*

The holotype of the new subspecies (I.R.Sc.N.B. 1598) consists of interior and exterior molds of a dorsal valve from locality 74B10.

*Material:*

74B10 — 2 ventral and 1 dorsal valve; 74B13 — 3 ventral valves.

Genus COSTISTROPHOMENA n. gen.

*Type species:*

*Costistrophomena costata* n. sp.

*Diagnosis:*

The genus is characterized by its costate ornament and ventrally directed geniculation. The interiors are as in the Subfamily Furcitellinae.

*Discussion:*

The genus is monotypic and known only from the Ashgill of Belgium. This genus becomes the most coarsely ribbed strophomenacid. The Furcitellinae include some of the most coarsely ribbed Ordovician strophomenids, but none approach the strength of the costate ornament found in *Costistrophomena*.

*Costistrophomena costata* n. sp.

(Pl. 13, figs. 20-24; Pl. 14, figs. 1-16)

*Exterior:*

The valves are geniculate in a ventral direction; the angle of geniculation varies from 90° to about 30°. The geniculation, which begins 7 to 11 mm from the beak, is abrupt on most valves but gentle on others. The lateral profile of the dorsal valve is convex with maximum curvature at the geniculation. The ventral valves are plane to very slightly concave behind the geniculation. Maximum width is at the hinge line. The outline is transverse; small shells tend to be more transverse than larger ones. Six shells more than 15 mm in length have length/width ratios which vary between 0.64 and 0.86; the high variability is due to differing angles of geniculation which affect the vector of anterior growth. The concave, apsacline ventral interareas attain a length equalling nearly 20% of the total shell length. The anacline dorsal interareas are short. There is a well developed pseudodeltidium. The surface is costate with individual costae attaining a width of 1 mm at the front of large valves. Six costae originate at the ventral beak, and there are 15 to 20 costae at the 5 mm growth stage. Concentric ornament consists of strong, widely spaced growth lines.

*Ventral interior:*

The small teeth are supported by dental plates that are continuous anteriorly with strong muscle bounding ridges. The muscle field is elongate. The adductor muscle scars are long and narrow, extending beyond the diductor muscle scars. The strong median ridge has a rounded crest and extends to the front of the muscle field. In front of the diductor scars the adductor muscle scars are bounded laterally but not in front by low ridges that are extensions of the ridges which bound the diductor muscle scars. In small shells a median ridge corresponds to the median interspace of the external ornament, and the adductor muscle scars are set in two depressions which are the impress of the two median costae.

*Dorsal interior:*

The bilobed cardinal process is massive and is covered by a medially grooved chilidium. The notothyrial

platform is formed by the bases of the cardinal process, the bases of the divergent socket plates and the back of the median ridge. The median ridge is short, and it bifurcates at its front. The posterior adductor muscle scars are much wider than the anterior adductor muscle scars. In each posterior adductor muscle scar is a transmuscle septum that is inclined away from the midline. The anterior adductor muscle scars narrow anteriorly and in large shells are impressed on a steep sided platform. A small median ridge divides the front half of the anterior adductor muscle scars. The costae are impressed on the interior.

#### Discussion:

*Costistrophomena costata* is characterized by its costate ornament and ventrally directed geniculation. In addition, specimens of this species can easily be distinguished from those of *Katastrophomena catalorni* (with which it occurs) by the latter's much finer growth lines and a parallel sided dorsal anterior adductor muscle field rather than the anteriorly narrowing field of *C. costata*.

In earlier literature this species may have been identified as *Strophomena pecten* in Belgium.

#### Holotype:

The holotype (I.R.Sc.N.B. 1610) consists of interior and exterior molds of a dorsal valve from locality 74B17.

#### Material:

74B4 — 7 ventral and 12 dorsal valves; 74B8 — 3 dorsal valves; 74B14 — 2 ventral and 5 dorsal valves; 74B17 — 4 dorsal valves; 74B19 — 2 ventral and 2 dorsal valves; 74B20 — 1 dorsal and 1 ventral valve; PS57 — 3 ventral and 2 dorsal valves; PS58 — 2 dorsal valves.

### Genus KATASTROPHOMENA COCKS, 1968

#### *Katastrophomena catalorni* n. sp.

(Pl. 14, figs. 17-25; Pl. 15, figs. 1-8)

#### Exterior:

The outline is transverse with maximum width at the hinge line. Representative length and width measurements are given below. In lateral profile the dorsal valve is convex. The ventral valve is convex posteriorly, though not as strongly convex as the dorsal valve, and about 10 mm from the beak the ventral valve becomes resupinate. The short ventral interarea is apsacline, and the dorsal interarea is anacline. There is a strong, convex, but poorly preserved pseudodeltidium. The surface is coarsely costellate with 2 to 3 costellae in a space of 1 mm measured 10 mm from the beak. One ventral valve, that is 30 mm wide and 19.2 mm long, has 105 costellae at its margin. The costellae are irregular in size from one to the next, and individual costellae have irregular widths. In addition to the costellae the front of larger valves

is wrinkled into broad, gently curved undulations or plicae. From crest to crest each plica contains about 7 costellae. Concentric ornament is well developed. Fine, but well defined, growth lines number about 8 to 10 per mm. Some growth lines are accentuated and in addition rugae-like undulations are commonly developed. The variable development of costellae, plicae, growth lines, accentuated growth lines and rugae give the surface of shells a very irregular appearance, and the ornament is highly variable from shell to shell.

Ventral valves		Muscle field:	
width	length	length	width
30 mm	19 mm	5.2 mm	5.2 mm
23	15	5.1	5.1
18	9	4.2	3.6
~ 32	—	6.8	7.0
~ 28	—	6.3	6.0

#### Ventral interior:

The teeth are small and supported by dental plates that extend anteriorly as plates which bound the muscle field. The muscle field is short, being confined to the posterior third of large valves. The muscle field is composed of well differentiated adductor and diductor muscle scars. The diductor muscle scars are set on a platform with strongly undercut margins. The long, linear adductor muscle scars are impressed on either side of a strong, median ridge which has a rounded crest. The adductor muscle scars extend forward well beyond the diductor muscle scars. The undercut ridges which bound the diductor muscle scars anteriorly are deflected toward the front at their junction with the adductor muscle scars, beyond where they bound the lateral margins of the adductor muscle scars. Ridges do not bound the front of the adductor muscle scars. The muscle field is transverse, but it is difficult to measure its width because the shells are preserved as internal molds which conceal the margins of the undercut muscle platform. The width of the muscle field (as measured above) is the distance between the outer bases of the undercut platform; the bases are preserved as slots in the internal molds.

#### Dorsal interior:

The cardinal process is bilobed. The strong chilidium has a median groove. The widely divergent socket plates are well developed and continuous with the chilidium posteriorly. The sockets are bounded antero-laterally by very low ridges. The notothyrial platform is formed by the bases of the cardinal process lobes, socket plates, and the back of a broad median ridge. The ridges and septa in and bordering the muscle field are highly variable in the strength of their development on different individuals. The broad median ridge has a rounded crest and it bifurcates anteriorly but does not extend beyond the posterior adductor muscle scars. Each posterior adductor

muscle scar contains a transmuscle septum, which is inclined away from the midline. The anterior adductor muscle scars are weakly impressed and narrower than the posterior scars. A low, median ridge commonly separates the anterior adductor scars which have postero-lateral margins defined by ridges that vary from weak to strong. The sides of the anterior scars are either parallel or slightly convergent toward the front.

*Comparison:*

This species differs from all others of the genus in having plicae at the front of large valves. It is the first species of the genus to be reported from the Ordovician.

*Katastrophomena woodlandensis* (REED) from the Middle Llandovery of Scotland and Wales has been redescribed by WILLIAMS (1951) and COCKS (1968), and it differs from *K. catalorni* in having weaker concentric ornament, ventral adductor muscle scars that do not extend as far beyond the diductor muscle scars and they are not bounded laterally by extensions of the ridges which bound the diductor muscle scars. The pattern of ridges in the dorsal interiors of both species is quite similar. COCKS (1968, p. 295) noted that the internal structures of the dorsal valve were highly variable in their development as is the case in *K. catalorni*. *Katastrophomena scotica* BANCROFT, 1949 from the Lower Llandovery of Wales and Scotland has been redescribed by WILLIAMS (1951) and COCKS (1968). *K. scotica* has concentric ornament which resembles *K. catalorni* and the development of the ventral muscle bounding ridges is quite similar. However, the ventral muscle field of *K. catalorni* is more transverse and has more angular lateral corners than *K. scotica*. The dorsal interiors also differ in that *K. catalorni* has more widely flaring socket plates, and the transmuscle septa and muscle bounding ridges are more strongly developed than in *K. scotica* (compare COCKS, 1968, Pl. 3, fig. 3). *K. catalorni* is the only known Ordovician species of the genus, and morphologically it is a reasonable ancestor of Silurian species of *Katastrophomena*. *Drummuckina agrestis* LAMONT (1949, Pl. 1, figs. 2-3) from the Slade Beds of Wales has an external ornament and a ventral muscle field which resemble *K. catalorni*; the dorsal interiors are not known. The species can be distinguished by the presence on *D. agrestis* of a well developed ventral sulcus. Since BANCROFT (1949) placed the species in *Drummuckina*, it also presumably has a concave dorsal valve and a denticulate hinge line, as does the type species of the genus.

*Holotype:*

The holotype (I.R.Sc.N.B. 1618) consists of interior and exterior molds of a ventral valve from locality 74B19.

*Material:*

74B19 — 5 ventral and 7 dorsal valves; 74B20 — 3 ventral and 1 dorsal valve.

Identified as *Katastrophomena catalorni?*: 74B13 — 1 dorsal and 2 ventral valves.

Family LEPTAENIDAE HALL & CLARKE, 1894

Genus LEPTAENA DALMAN, 1828

*Leptaena* sp.

(Pl. 15, figs. 9-22)

*Exterior:*

The shells are transverse and sharply geniculate. Costellae number 4 to 5 in a space of 1 mm measured 10 mm from the ventral beak. Rugae are continuous around the disc and number between 7 and 11. The anterior ventral ruga is stronger than the others, forming the characteristic ridge which separates the disc from the trail. The geniculation begins between 11 and 14 mm in front of the ventral beak.

*Ventral interior:*

The muscle field varies between slightly transverse and slightly elongate. Most valves are tectonically distorted and relative length and width ratios were not determinable. The margin of the muscle field is defined by high, narrow ridges. There is a low, variably developed median ridge in the muscle field in front of the elongate adductor muscle scars. The external ornament is strongly impressed on their interior.

*Dorsal interior:*

The cardinal process lobes are strong. The strongly divergent socket plates are very small. A pair of short, low ridges define the muscle field postero-laterally, but in front of the ridges the muscle field is poorly defined. In one specimen there is a low median ridge in front of the muscle field.

*Comparison:*

Described Late Ordovician species of *Leptaena* are numerous, poorly known and in need of revision. The high variability (even among specimens from the same locality) precluded meaningful comparison with other species.

*Material:*

74B4 — 10 ventral and 9 dorsal valves; 74B7 — 1 ventral and 1 dorsal valve; 74B11 — 1 dorsal valve; 74B12 — 1 ventral valve; 74B14 — 13 ventral, 5 dorsal and 1 articulated valve; 74B16 — 1 ventral and 2 dorsal valves; 74B17 — 3 ventral and 1 articulated valve; 74B19 — 7 ventral and 5 dorsal valves; PS57 — 3 ventral and 2 dorsal valves; PS58 — 1 ventral valve.

Genus KIAEROMENA SPJELDNAES, 1957

*Kiaeromena* sp.

(Pl. 13, figs. 12-19)

*Exterior:*

The shells are large and only slightly transverse. The

outline of all shells has been broken, but the largest valve was about 55 mm wide and 48 mm long. The strong, dorsally directed geniculation is broadly rounded. Behind the geniculation the ventral valve is gently convex and the dorsal valve is gently concave. The ornament is coarsely costellate, with 2 to 3 costellae per mm. Rugae are broad, irregularly spaced undulations.

*Ventral interior:*

The teeth are small. The elongate muscle field is bounded laterally by high, undercut ridges which encircle the diductor muscle scars antero-laterally but do not join at the front of the muscle field. The adductor muscle scars are weakly defined and do not extend as far anteriorly as the diductor muscle scars, producing an indented anterior margin of the muscle field. The shell outside the muscle field is very coarsely pseudopunctate. Anteriorly, pseudopunctae are arranged in rows aligned with the impressions of the external ornament.

*Dorsal interior:*

Only a single dorsal interior is available for study. The cardinal process lobes are massive and the distal surfaces bear about 15 thin ribs. The chilidium is supported by a small septum between the cardinal process lobes. The socket plates are very small. The muscle field is set on a smooth area in front of the cardinal process. Outside the muscle field the surface is very coarsely pseudopunctate.

*Discussion:*

This species is characterized by its pseudopunctae which produce a coarsely pustulose interior.

*Material:*

74B10 — 1 ventral valve; 74B11 — 3 ventral valves; 74B12 — 1 ventral and 1 articulated valve; 74B13 — 2 ventral and 1 dorsal valve.

Superfamily DAVIDSONIACEA KING, 1850

Family FARDENIINAE WILLIAMS, 1965

Genus FARDENIA LAMONT, 1935

*Fardenia* sp.

(Pl. 15, figs. 23-24)

*Exterior:*

The lateral profile is gently convex posteriorly and resupinate anteriorly. The outline is transverse; one ventral valve is about 30 mm long and 40 mm wide, though the shell is distorted and these measurements are only an approximation of the original dimensions. Both interareas are well developed; the ventral one is apsacline and the dorsal one is anacline, approaching hypercline. Both the pseudodeltidium and the chilidium are well developed. The surface is coarsely costellate. Fully developed costellae are about 0.3 mm

wide. The costellae are steep-sided with rounded apices. New costellae are inserted in the interspaces. Growth lines are well developed. About 6 growth lines occupy a space of 1 mm on the crest of costellae 15 mm from the beak; however, there are commonly about twice as many growth lines present in the interspaces, with alternating growth lines not continuing over the costellae. Toward the front margin, growth lines are more closely spaced and most are continuous over the costellae.

*Ventral interior:*

The dental plates are short and widely divergent. The muscle field is very weakly defined. Very low ridges bound the transverse muscle field postero-laterally. The adductor muscle scars are set on a broad, low, but well defined median ridge. The ornament is strongly impressed anteriorly. There is no evidence of pseudopunctae, though preservation is not good.

*Dorsal interior:*

The cardinal process lobes are well developed and set on a very short, low median ridge. The socket plates merge into the hinge line and the base of the cardinal process lobes. The sockets are crenulated. The internal surface is poorly preserved on the one dorsal interior available for study. One small fragment of this valve has a series of very low longitudinal ridges.

*Discussion:*

The costellate ornament (which is strongly impressed on the interior) and the nature of the cardinal process and socket plates are the basis for assigning this species to *Fardenia*. Unfortunately, the interiors are not well enough preserved to be certain the shell was impunctate.

The classification of *Fardenia* follows COOPER and GRANT (1974).

In earlier literature this species may have been identified as *Strophomena pecten* in Belgium.

*Material:*

PS58 — 1 ventral and 1 dorsal valve; PS57 — 1 ventral valve.

Order ATRYPIDA

Suborder ATRYPOIDEA

Superfamily ATRYPACEA GILL, 1871

Family ATRYPIDAE GILL, 1871

Subfamily ATRYPINAE GILL, 1871

Genus SPIRIGERINA D'ORBIGNY, 1849

Subgenus EOSPIRIGERINA

BOUCOT & JOHNSON, 1967

*Spirigerina (Eospirigerina)* cf.

*S. (E.) sulevi* (JAANUSSON, 1954)

(Pl. 16, figs. 18-27)

*Plectatrypa sulevi* JAANUSSON, 1954. In ALICHOVA, 1954, pp. 33-34, Pl. 20, figs. 4-6, (*non* Pl. 20, figs. 3-7).

*Plectatrypa sulevi* JAANUSSON. JAANUSSON, 1956, pp. 397-398, Pl. 1, fig. 7, Text-fig. 4b.

*Spirigerina (Eospirigerina) sulevi* (JAANUSSON). BOUCOT & JOHNSON, 1967, p. 88.

?*Plectatrypa* n. sp. A. JAANUSSON, 1956, Pl. 1, fig. 8. BOUCOT & JOHNSON, 1967, p. 88.

#### Exterior:

The lateral profile is ventribiconvex. Length and width are nearly equal and maximum width occurs near midlength. The ventral interarea is gently curved. The ventral valve has a narrow, posterior fold which gives way about 1 mm from the beak to a deep, narrow, well-defined sulcus which is bounded by high margins. In the dorsal valve there is a posterior sulcus which, about 1 mm from the beak, changes to a deep, narrow fold. Costae are rounded in cross section. At the 15 mm growth stage there are about 20 costae. The floor of the ventral sulcus has a single costa which is much narrower than the other costae.

The two costae on the fold originate by bifurcation of a single median costa that lies in the apical dorsal sulcus. The largest shell is a ventral valve 15 mm long and 16 mm wide.

#### Ventral interior:

The teeth are supported by short dental plates. The short muscle field is triangular in outline and confined to the posterior 1/10 of the valve. In front of the muscle field the external ornament is strongly impressed.

#### Dorsal interior:

The hinging mechanism is cyrtomatodont. Hinge plates are small and divided. The sockets are widely separated. Muscle scars are not visible. The external ornament is strongly impressed.

#### Comparison:

Preservation does not permit a confident identification of these specimens. *Spirigerina (Eospirigerina) sulevi* (JAANUSSON, 1956) from the F<sub>1ca</sub> and possibly F<sub>1cb</sub> stages of Estonia and Latvia resembles these specimens more closely than any other species. Similarities include the outline, the deep, narrow ventral sulcus with a small median costa, and the strength and cross sectional profile of costae. The Belgian specimens are larger than those from Estonia. However, BOUCOT and JOHNSON (1967, p. 88) included the large, coarsely ribbed specimens from F<sub>1c</sub> Stage, which are described by JAANUSSON (1956) as *Plectatrypa* n. sp. A. in *S. (E.) sulevi*; and if this assignment is valid, the size range of *S. (E.) sulevi* includes specimens as large as those from Belgium.

*Spirigerina (Eospirigerina) praemarginalis* (SAVAGE, 1913), "*Plectatrypa* sp. B" JAANUSSON (1956), *Spirigerina (Eospirigerina) gaspeensis* (COOPER, 1930), *Spirigerina mavra* ROZMAN (1968) and *Spirigerina (Eospirigerina) expansa* (LINDSTRÖM, 1880) are more finely

costate and have broader, less well-defined sulci than the Belgian specimens. "*Plectatrypa*" *pennata* from Kazakhstan differs from *S. (E.) cf. sulevi* in having a broader sulcus with a linguaform extension (See RUKAVISHNIKOVA, 1956). *Spirigerina (Eospirigerina) putilla* (HALL and CLARKE, 1894) is slightly more finely ribbed and has stronger dental plates than *S. (E.) cf. sulevi* (see AMSDEN, 1974). *Spirigerina dulkumensis* YADRENKINA (1974) has a more circular outline and coarser ribbing than *S. (E.) cf. sulevi*. *Spirigerina sublaevis* is a very finely ribbed species with a deeply furrowed ventral fold and a deep, wide dorsal sulcus bearing a strong plication (see ROZMAN, 1968). *Spirigerina (Eospirigerina) hibernica* (REED, 1952) is a much smaller, more finely ribbed species (see MITCHELL, 1977). The classification of *Spirigerina* follows JOHNSON (1973).

#### Material:

74B7 — 2 ventral and 1 dorsal valve; 74B10 — 1 dorsal and 3 ventral valves; 74B11 — 1 ventral and 1 dorsal valve; 74B14 — 4 ventral and 1 dorsal valve; 74B17 — 1 ventral valve; PS58 — 1 ventral valve.

Identified as *Spirigerina (Eospirigerina) sulevi*?: 74B4 — 1 ventral and 1 articulated valve.

Subfamily ZYGOSPIRINAE WAAGEN, 1883

Genus CATAZYGA HALL & CLARKE, 1893

*Catazyga?* sp.

(Pl. 16, figs. 1-4)

#### Exterior:

Only two dorsal valves were recovered. Both shells are about 4 mm long and 5 mm wide. The anterior outline is evenly rounded; maximum width is near midlength. The lateral profile is gently convex. There is a shallow, poorly defined sulcus. The surface is finely costellate. The costellae are steep-sided and have rounded crests. Costellae increase in strength anteriorly, and no new costellae are added after the shell attains a length of 1 mm.

#### Dorsal interior:

The hinge plates are disjunct. A median ridge extends about 1/3 of the distance to the anterior margin. The external ornament is strongly impressed.

#### Discussion:

The non-branching costellae and disjunct hinge plates resemble *Catazyga*.

*Catazyga parva* NASEDKINA (1973) from the Ashgill of the Urals has an elongate outline and is more coarsely ribbed than *Catazyga* sp. The Upper Ordovician *Catazyga salairia* SEVERGINA (1960) is quite similar externally to *Catazyga* sp. but interiors of the Salair species have not been illustrated. *Catazyga homeospiroides* ROSS and DUTRO (1966) from Alaska is more

coarsely ribbed and much more elongate than the Belgian species.

*Material:*

74B4 — 1 dorsal valve; PS57 — 1 dorsal valve.

Suborder DAYIOIDEA

Superfamily DAYIACEA WAAGEN, 1883

Family DAYIIDAE WAAGEN, 1883

Subfamily CYCLOSPIRINAE SCHUCHERT, 1913

Genus CYCLOSPIRA HALL & CLARKE, 1893

*Cyclospira?* sp.

(Pl. 16, figs. 5-17)

*Exterior:*

The lateral profile is ventribiconvex with a gently convex dorsal valve and a highly arched ventral valve. The incurved ventral beak extends well behind the hinge line. The shells are compressed and meaningful measurements are difficult to make. The best preserved articulated specimen is 9 mm long, 10 mm wide, and 6 mm thick. The high ventral fold is flat topped posteriorly but has a shallow median depression at the front of the valve. The flanks of the fold are slightly concave. The dorsal valve has a broad, anteriorly expanding sulcus. Radial ornament is lacking; growth lines are faint. The largest ventral valve is 11 mm long.

*Ventral interior:*

The small, cyrtomatodont teeth are supported by short dental plates. Posteriorly, the muscle field is deeply impressed in the apically thickened shell. Anteriorly, the muscle field is set on a high platform which has a nearly vertical anterior margin. The adductor muscle scars do not extend as far anteriorly as do the diductor muscle scars and as a result the front of the muscle platform has a concave outline.

*Dorsal interior:*

The hinge plates are disjunct, but closely set. The strong median ridge extends beyond midlength.

*Comparison:*

The Ordovician species of *Cyclospira* were discussed by the author in an earlier paper (SHEEHAN, 1973).

Since the nature of the jugum and spiralia is not known in these specimens the assignment to *Cyclospira* is queried.

Most Ordovician species of *Cyclospira* have a narrow fold in the front of the dorsal sulcus (e.g. "*Protozyga*" cf. *perplexa* of MITCHELL, 1977; *C.?* *glansfagea* COOPER and KINDLE, 1936; *C. elegantula* ROZMAN, 1964; *C. globosa* ROZMAN, 1964; *C.?* *barrandei* COOPER, 1930). In lacking this dorsal fold the Belgian species most closely resembles *C.?* *scanica* from the Ashgill of southern Sweden, *Cyclospira?* *levisulcata* RÕÕMUSOKS (1964) from the F<sub>1a</sub> of Estonia, *C?* *cymbula* (DAVIDSON) var. *girvanensis* REED (1917) from the Drummuck and Whitehouse Groups of Scotland, and *C.?* *minuscule* COOPER (1930) and *Cyclospira?* *canadensis* COOPER (1930) from the Ashgill of eastern Gaspé, Canada. The Belgian specimens are larger than *C.?* *scanica*, *C.?* *cymbula* var. *girvanensis*, and *C.?* *minuscule*. Specimens of *C.?* *canadensis* are only slightly smaller than those from Belgium but they are more transverse. *C.?* *levisulcata* is the most similar species described to date but its interiors have not been described.

*Material:*

74B8 — 3 ventral and 1 articulated valve; 74B12 — 2 ventral valves; 74B13 — 1 dorsal valve; 74B15 — 1 ventral valve; 74B16 — 2 ventral and 2 articulated valves; 74B19 — 14 ventral, 3 dorsal and 1 articulated specimen; 74B20 — 17 ventral, 4 dorsal and 3 articulated specimens.

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### Locality Register

- 74N4 – Lower member Fosse Formation, Faulx region. This is locality 112, on Fig. 18 of MARTIN (1968). MICHOT (1934, p. 64) reported a diverse brachiopod assemblage from this locality. Collected by LESPÉRANCE, 1974.
- 74B7 – Upper member Fosse Formation, Fosse region. This is 10 m north of locality 11 of Fig. 26 of MARTIN (1968), see also MICHOT (1928, Pl. 7; 1934, p. 35, Fig. 9, Pl. 2). The horizon is in the middle of the upper member. Collected by LESPÉRANCE, 1974.
- 74B8 – Upper member Fosse Formation, Fosse region. This is locality 6 on Fig. 26 of MARTIN (1968), see also MICHOT (1928, Pl. 7). The horizon is in the middle of the upper member. Collected by LESPÉRANCE, 1974.
- 74B9 – Upper member Fosse Formation, Puagne region. This is locality 123 on Fig. 20 of MARTIN (1968), and corresponds to locality g of MICHOT (1934, Fig. 1, pp. 14-15), see also MICHOT (1928, Pl. 7). The horizon is near the top of the formation. Collected by LESPÉRANCE, 1974.
- 74B10 – Upper member Fosse Formation, Puagne region. This is locality 4 on Fig. 27 of MARTIN (1968), see also MICHOT (1934, pp. 19-20, Fig. 3, Pl. 1). The horizon is near the top of the formation. Collected by LESPÉRANCE, 1974.
- 74B11, 74B12, 74B13, 74B19, 74B20 – Upper member Fosse Formation, Puagne region. These localities were collected in series through a section from low in the upper member toward the middle of the upper member. The section was collected along the road which extends north-west from the intersection between localities 4 and 18 on Figure 27 of MARTIN (1968). These localities are on line b-c on Fig. 3 and Pl. 1 of MICHOT (1934). A diverse brachiopod fauna was recorded from a locality in this section by MICHOT (1934, pp. 19-20). The localities were collected on the north west side of the road, and were located by measuring horizontally from the north corner of the intersection. Distance from corner: 74B11 — 6.4 m; 74B12 — 11.2 m; 74B13 — 15.2 m; 74B19 — 19.2 m; 74B20 — 29.8 m.
- 74B11 – Fosse Formation, Le Roux region. The locality is from near locality 49 on Fig. 22 of MARTIN (1968). It is located 45 m north of the main road and 15 m west of the secondary dirt road. See also MICHOT (1928, section 4, Pl. 4; section 9, Pl. 6; Pl. 7) for a geologic map and structural interpretation of this region. The horizon within the formation is uncertain but it is probably in the lower member. Collected by LESPÉRANCE, 1974.

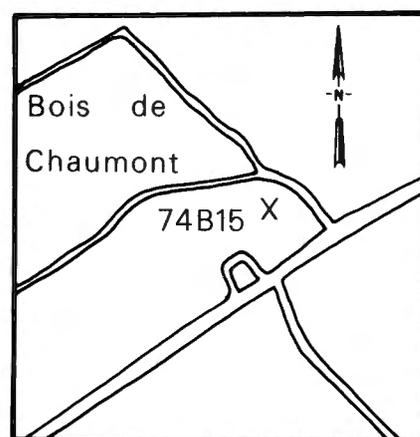
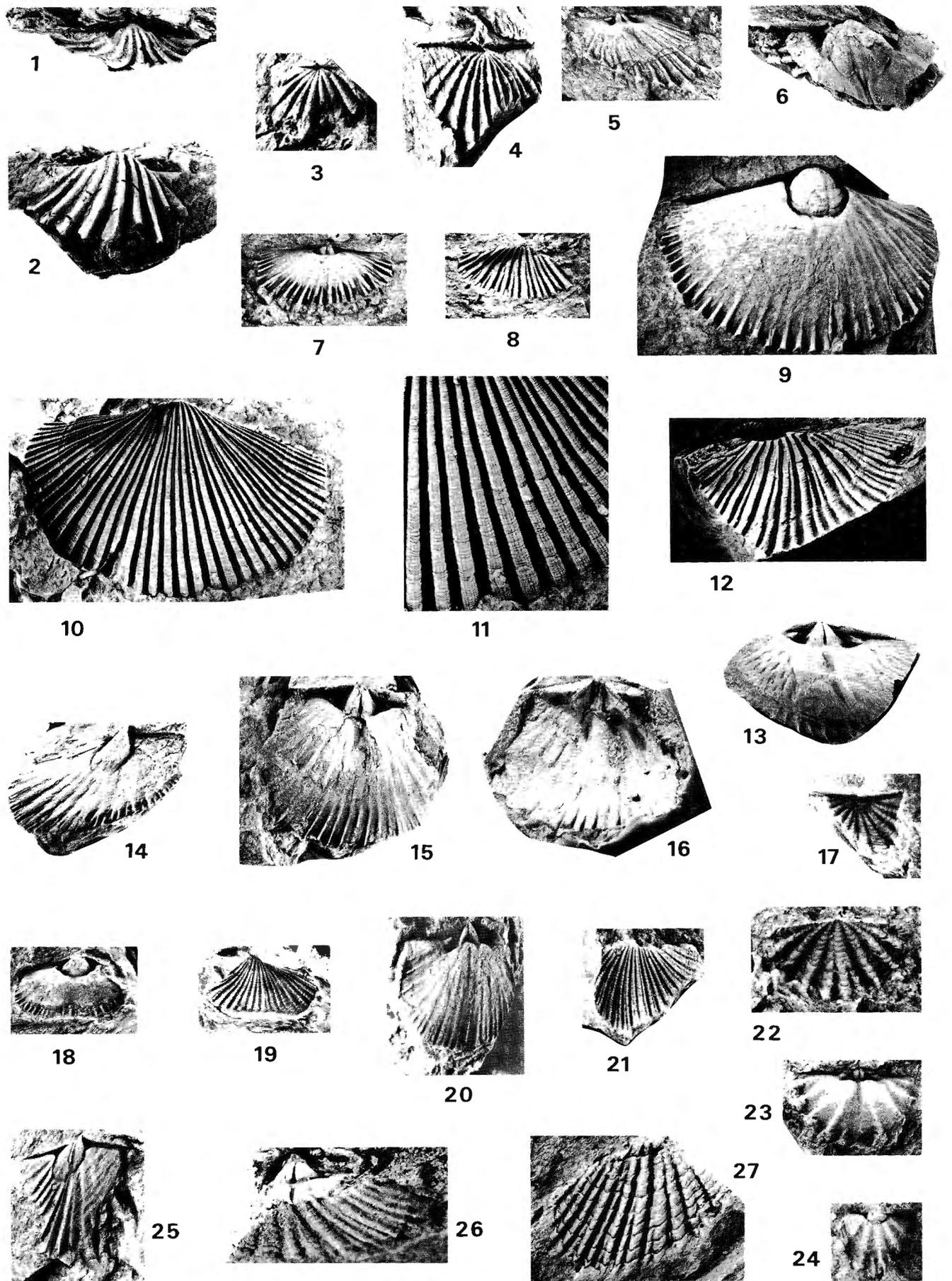


Figure 3. – Location of locality 74B15, Bois de Presles region, Tamines 154 W map.

- 74B15 – Fosse Formation, Bois de Presles region. The position of this locality is shown on Fig. 3. See also MICHOT (1928, Pl. 7) for a geologic map of this region. The locality is from the lower member. Collected by LESPÉRANCE, 1974.
- 74B16 – Lower Member Fosse Formation, Dave region. This is locality 14 on Fig. 25 of MARTIN (1968), and the locality with a diverse brachiopod fauna recorded by MICHOT (1930, pp. 60-61). The locality is from the base of the formation. Collected by LESPÉRANCE, 1974.
- 74B17 – Lower Member Fosse Formation, Vitruval-Bruyère region. This is a recollection of localities PS57 and PS58 (see below) by LESPÉRANCE, 1974.
- 74B21 – Upper Member Fosse Formation, Faulx region. This is locality 114 on Fig. 18 of MARTIN (1968) and the locality from which MICHOT (1934, pp. 64-65) recorded *Tretaspis seticornis*. Collected by LESPÉRANCE, 1974.
- PS57, PS58 – Lower Member Fosse Formation, Vitruval-Bruyère region. These localities were collected at the northern extremity of the U-shaped turn in the road between La Bruyère and La Gilogrie, about 75 m south of the rail road tracks (see MARTIN, 1968, Fig. 28; MICHOT, 1928, pl.7; 1934, Fig. 4). The localities are on the south side of the road; PS57 is 2 m west of PS58. The locality is very close to the base of the formation (see MICHOT, 1934, Figs. 4 and 5; note base of the Fosse Formation is the contact between units A and B of these figures). Collected by the author, 1972.



## PLATE 1

*Nicolella* sp. A

- Figs. 1, 2. – Posterior and interior views of the mold of a ventral valve (I.R.Sc.N.B. 1397), × 2.0. Locality 74B4.  
 Fig. 3. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1398), × 3.0. Locality 74B4.

*Nicolella* sp. B

- Fig. 4. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1399), × 2.5. Locality 74B16.  
 Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1400), × 2.5. Locality 74B16.  
 Fig. 6. – Interior mold of a ventral valve (I.R.Sc.N.B. 1401), × 2.0. Locality 74B19.

*Boreadorthis recula* ÖPIK, 1934.

- Figs. 7, 8. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1402), × 2.0. Locality 74B19.  
 Figs. 9-11. – Interior, exterior, and enlargement of a portion of the exterior (to show ornament) of the molds of a ventral valve (I.R.Sc.N.B. 1403), × 1.5, × 1.5, × 3.0. Locality 74B19.  
 Figs. 12, 13. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1404), × 2.0. Locality 74B16.  
 Fig. 14. – Interior mold of a ventral valve (I.R.Sc.N.B. 1405), × 2.0. Locality 74B16.  
 Figs. 15-16. – Interior and latex cast of the mold of a dorsal valve (I.R.Sc.N.B. 1406), × 2.0. Locality 74B20.

*Ptychopleurella* (Glypterina) sp.

- Fig. 17. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1407), × 4.0. Locality 74B19.

*Glyptorthis* sp. A

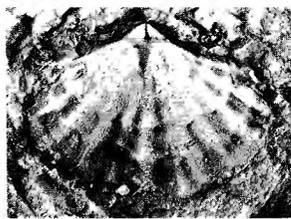
- Figs. 18-19. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1408), × 3.0. Locality 74B8.  
 Figs. 20-21. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1409), × 3.0. Locality 74B8.

*Ptychopleurella* (*Ptychopleurella*) sp.

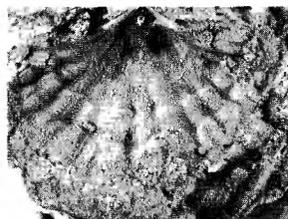
- Figs. 22-23. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1410), × 4.0. Locality 74B4.  
 Fig. 24. – Interior mold of a ventral valve (I.R.Sc.N.B. 1411), × 4.0. Locality 74B4.

*Glyptorthis* sp. B

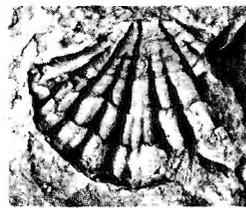
- Fig. 25. – Interior mold of a ventral valve (I.R.Sc.N.B. 1412), × 3.0. Locality 74B16.  
 Figs. 26-27. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1413), × 3.0. Locality 74B16.



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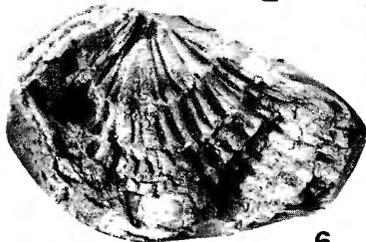
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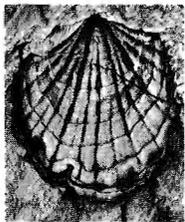
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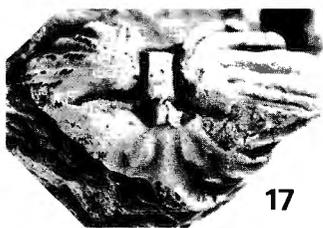
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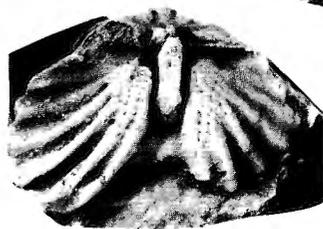
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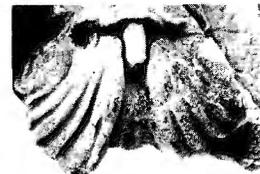
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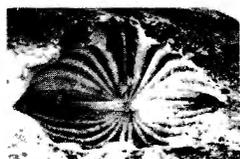
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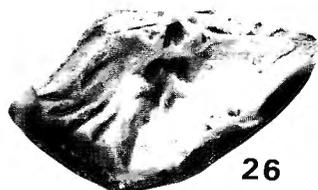
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## PLATE 2

*Spinorthis europa n. sp.*

- Figs. 1-3. – Interior, latex cast of the interior, and exterior molds of a dorsal valve (I.R.Sc.N.B. 1414), × 3.0. Holotype. Locality 74B15.
- Figs. 4-8. – Posterior view of ventral exterior mold, ventral exterior mold, latex cast of ventral exterior mold, dorsal exterior mold, latex cast of dorsal exterior mold of an articulated specimen (I.R.Sc.N.B. 1415), × 2.0. Locality 74B12.
- Figs. 9-10. – Interior and latex cast of interior of a mold of a dorsal valve (I.R.Sc.N.B. 1416), × 2.0. Locality 74B17.
- Fig. 11. – Interior mold of a ventral valve (I.R.Sc.N.B. 1417), × 2.0. Locality 74B16.
- Fig. 12. – Interior mold of a ventral valve (I.R.Sc.N.B. 1418), × 2.0. Locality 74B16.
- Figs. 13-14. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1419), × 2.0. Locality 74B16.
- Fig. 15. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1420), × 2.0. Locality 74B16.

*Platystrophia leserancei n. sp.*

- Figs. 16-18. – Latex cast of ventral interior mold, posterior view of interior mold of articulated valves, and ventral interior mold of a specimen (I.R.Sc.N.B. 1421), × 2.5. Holotype. Locality 74B15.
- Fig. 19. – Interior mold of a ventral valve (I.R.Sc.N.B. 1422), × 2.5. Locality 74B15.
- Fig. 20. – Latex cast of an interior mold of a ventral valve (I.R.Sc.N.B. 1423), × 2.5. Locality 74B15.
- Figs. 21-22. – Posterior and anterior views of the exterior mold of conjoined valves (I.R.Sc.N.B. 1424), × 2.0. Locality 74B17.
- Fig. 23. – Interior mold of a ventral valve (I.R.Sc.N.B. 1425), × 2.0. Locality 74B20.
- Figs. 24-25. – Interior and lateral views of the mold of a dorsal valve (I.R.Sc.N.B. 1426), × 2.0. Locality 74B20.
- Figs. 26-27. – Latex cast of a dorsal interior and interior mold of a dorsal valve (I.R.Sc.N.B. 1427), × 2.0. Locality 74B20.
- Figs. 28-29. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1428), × 2.0. Locality 74B20.



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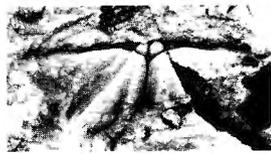
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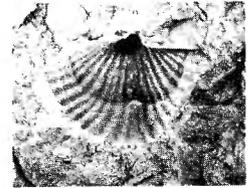
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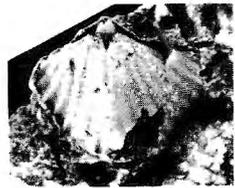
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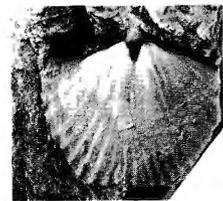
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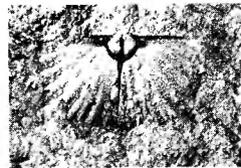
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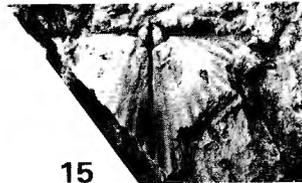
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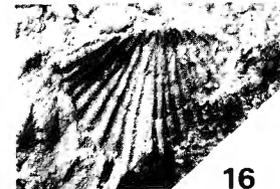
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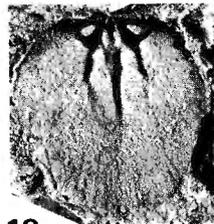
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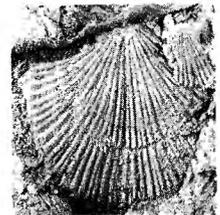
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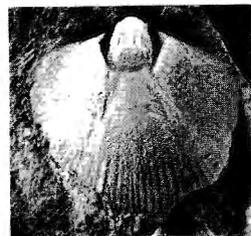
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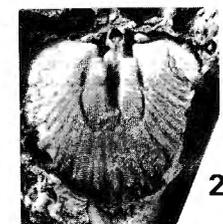
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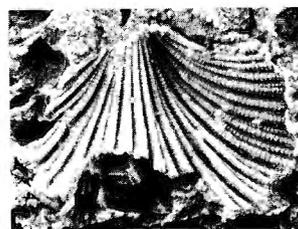
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## PLATE 3

*Skenidioides* cf. *S. pauciplicatus* WRIGHT 1964

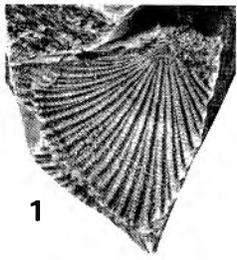
- Figs. 1, 2. – Interior and posterior view of the mold of a ventral valve (I.R.Sc.N.B. 1429), × 4.0. Locality 74B4.  
Figs. 3, 4. – Interior and last cast of the mold of a dorsal valve (I.R.Sc.N.B. 1430), × 4.0. Locality 74B4.  
Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1431), × 4.0. Locality 74B4.  
Fig. 6. – Interior mold of a ventral valve (I.R.Sc.N.B. 1432), × 4.0. Locality 74B17.

*Skenidioides* sp.

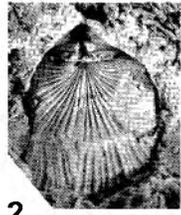
- Figs. 7, 8. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1433), × 4.0. Locality 74B4.  
Fig. 9. – Interior mold of a ventral valve (I.R.Sc.N.B. 1434), × 4.0. Locality 74B12.  
Figs. 10-11. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1435), × 4.0. Locality 74B13.  
Fig. 12. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1436), × 4.0. Locality 74B19.  
Fig. 13. – Interior mold of a ventral valve (I.R.Sc.N.B. 1437), × 4.0. Locality 74B14.  
Fig. 14. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1438), × 4.0. Locality 74B14.  
Figs. 15-16. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1439), × 4.0. Locality 74B14.  
Figs. 17-18. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1440), × 4.0. Locality 74B14.

*Dalmanella sambrensis* n. sp.

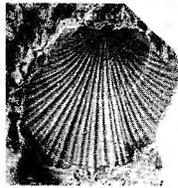
- Figs. 19-22. – Interior mold, latex cast of the interior, latex cast of the exterior, and exterior mold of a dorsal valve (I.R.Sc.N.B. 1441), × 3.0. Locality 74B14.  
Fig. 23. – Interior mold of a ventral valve (I.R.Sc.N.B. 1442), × 3.0. Locality 74B14.  
Figs. 24-25. – Exterior and latex cast of the mold of a ventral valve (I.R.Sc.N.B. 1443), × 3.0. Locality 74B14.  
Fig. 26. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1444), × 3.0. Locality 74B10.  
Figs. 27-28. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1445), × 3.0, × 5.0. Holotype. Locality 74B10.  
Fig. 29. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1446), × 3.0. Locality 74B10.



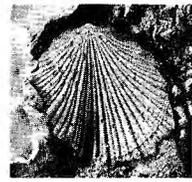
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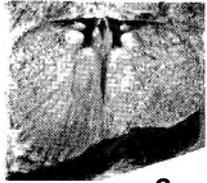
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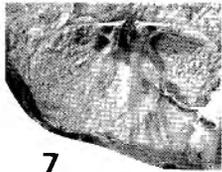
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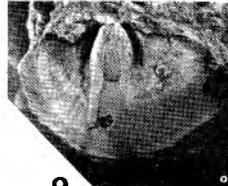
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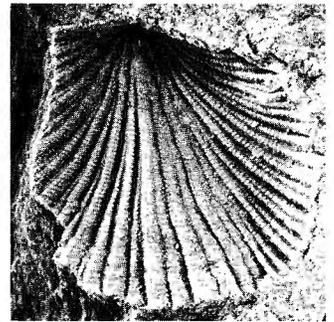
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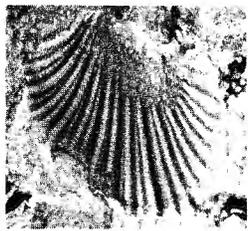
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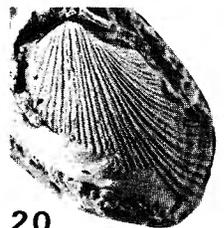
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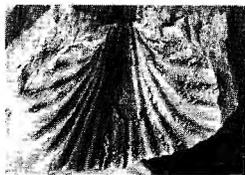
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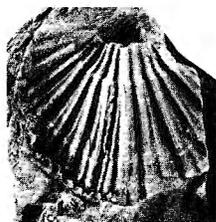
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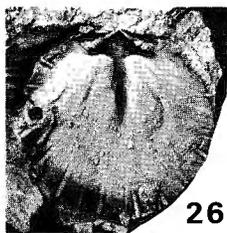
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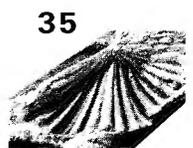
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## PLATE 4

*Dalmanella sambrensis n. sp.*

- Fig. 1. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1447), × 6.0. Locality 74B8.  
 Fig. 2. – Posterior view of the exterior mold of a dorsal valve (I.R.Sc.N.B. 1448), × 3.0. Locality 74B11.  
 Figs 3, 4. – Exterior and latex cast of the mold of a dorsal valve (I.R.Sc.N.B. 1449), × 3.0. Locality 74B11.  
 Fig. 5. – Interior mold of a ventral valve (I.R.Sc.N.B. 1450), × 3.0. Locality 74B11.  
 Figs. 6-8. – Interior mold, latex cast of interior mold, posterior view of latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1451), × 3.0. Locality 74B13.  
 Fig. 9. – Interior mold of a ventral valve (I.R.Sc.N.B. 1452), × 3.0. Locality 74B13.  
 Fig. 10. – Interior mold of a ventral valve (I.R.Sc.N.B. 1453), × 3.0. Locality 74B17.  
 Fig. 11. – Interior mold of a ventral valve (I.R.Sc.N.B. 1454), × 3.0. Locality 74B19.  
 Figs. 12-15. – Interior, latex cast of interior, latex cast of exterior, exterior mold of a dorsal valve (I.R.Sc.N.B. 1455), × 3.0, × 3.0, × 3.0, × 6.0. Locality 74B19.  
 Fig. 16. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1456), × 6.0. Locality 74B19.  
 Fig. 17. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1457), × 3.0. Locality 74B20.  
 Fig. 18. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1458), × 3.0. Locality 74B20.  
 Figs. 19-20. – Interior mold and latex cast of an exterior mold of a ventral valve (I.R.Sc.N.B. 1459), × 3.0. Locality 74B20.

*Portranella akymatata n. sp.*

- Fig. 21. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1460), × 2.5. Locality 74B20.  
 Figs. 22-25. – Posterior view of exterior, dorsal exterior, ventral interior, and dorsal interior molds of a complete individual (I.R.Sc.N.B. 1461), × 3.0. Holotype. Locality 74B20.  
 Figs. 26-27. – Interior and latex cast of the interior mold of a dorsal valve (I.R.Sc.N.B. 1462), × 2.5. Locality 74B20.  
 Fig. 28. – Interior mold of a ventral valve (I.R.Sc.N.B. 1463), × 3.0. Locality 74B20.  
 Figs. 29-30. – Interior, and posterior view of an interior mold of a ventral valve (I.R.Sc.N.B. 1464), × 2.5. Locality 74B20.  
 Fig. 31. – Exterior mold of a dorsal valve, with ventral interarea (I.R.Sc.N.B. 1465), × 5.0. Locality 74B20.  
 Figs. 32-33. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1466), × 3.0. Locality 74B20.  
 Figs. 34-35. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1467), × 3.0. Locality 74B19.



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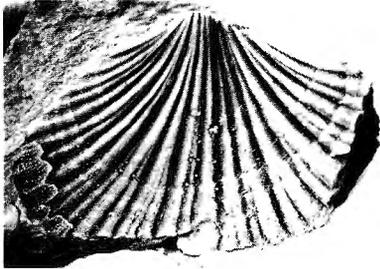
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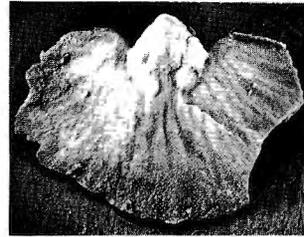
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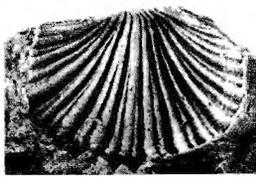
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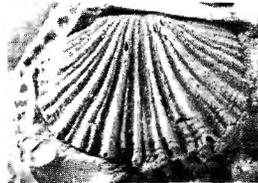
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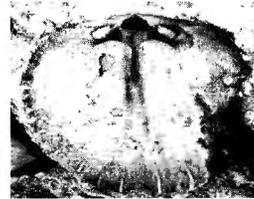
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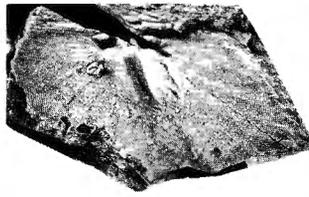
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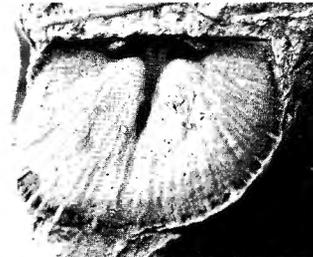
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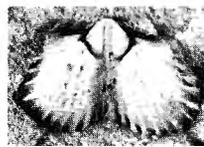
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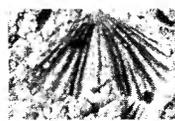
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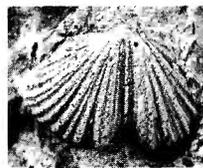
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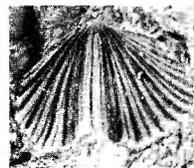
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## PLATE 5

*Portranella akymatata n. sp.*

- Figs. 1, 2. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1468), × 3.0. Locality 74B19.  
Figs. 3, 4. – Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1469), × 3.0. Locality 74B19.  
Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1470), × 2.0. Locality 74B16.  
Figs. 6-8. – Ventral exterior, dorsal interior, and ventral interior molds of an articulated specimen (I.R.Sc.N.B. 1471), × 2.5. Locality 74B16.  
Fig. 9. – Interior mold of a ventral valve (I.R.Sc.N.B. 1472), × 2.5. Locality 74B9.  
Figs. 10-13. – Exterior, latex cast of exterior, interior, latex cast of interior molds of a dorsal valve (I.R.Sc.N.B. 1473), × 2.5. Locality 74B9.  
Figs. 14-15. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1474), × 1.5. Locality 74B16.  
Figs. 16-17. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1475), × 4.0, × 2.5. Locality PS58.
- Dicoelosia cf. D. lata* WRIGHT 1964
- Figs. 18-19. – Posterior view of interior and interior mold of a ventral valve (I.R.Sc.N.B. 1476), × 5.0. Locality 74B14.  
Figs. 20-21. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1477), × 5.0. Locality 74B14.  
Fig. 22. – Interior mold of a ventral valve (I.R.Sc.N.B. 1478), × 5.0. Locality 74B14.  
Figs. 23-26. – Interior, latex cast of interior, latex cast of exterior, exterior molds of a ventral valve (I.R.Sc.N.B. 1479), × 5.0. Locality 74B14.  
Figs. 27-28. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1480), × 5.0. Locality 74B14.



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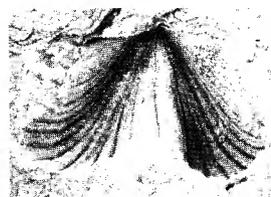
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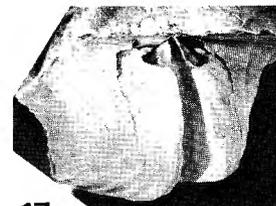
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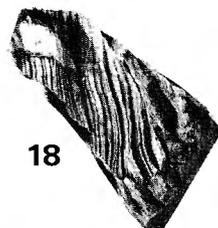
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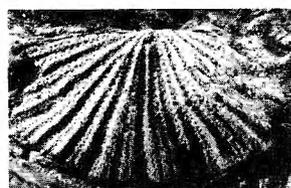
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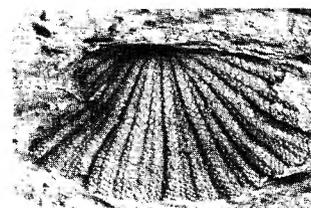
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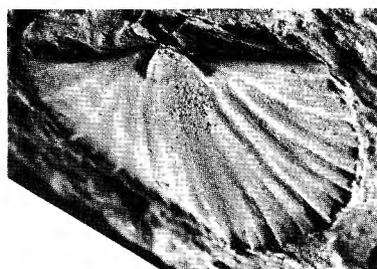
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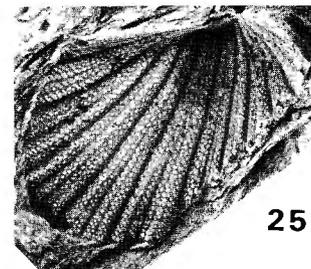
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## PLATE 6

*Dicoelosia cf. D. lata* WRIGHT 1964

- Figs. 1, 2. – Ventral exterior and dorsal exterior molds of an articulated specimen (I.R.Sc.N.B. 1481), × 5.0. Locality 74B4.  
Figs. 3, 4. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1482), × 5.0. Locality 74B16.

*Dicoelosia* sp.

- Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1483), × 5.0. Locality 74B14.  
Figs. 6-9. – Exterior, latex cast of the exterior, interior, posterior view of the interior of molds of a ventral valve (I.R.Sc.N.B. 1484), × 5.0. Locality 74B14.  
Fig. 10. – Interior mold of a ventral valve (I.R.Sc.N.B. 1485), × 5.0. Locality 74B14.  
Figs. 11-12. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1486), × 5.0. Locality 74B14.  
Figs. 13-14. – Anterior and posterior views of the mold of a ventral valve (I.R.Sc.N.B. 1487), × 5.0. Locality 74B15.  
Fig. 15. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1488), × 5.0. Locality 74B14.

*Reuschella* sp.

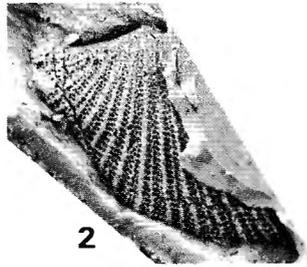
- Figs. 16-18. – Lateral view of interior, interior, and exterior molds of a dorsal valve (I.R.Sc.N.B. 1489), × 1.0. Locality 74B16.

*Saukrodictya wrighti* n. sp.

- Fig. 19. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1490), × 4.0. Locality 74B8.  
Figs. 20-23. – Interior, latex cast of exterior, exterior, posterior view of interior of molds of a dorsal valve (I.R.Sc.N.B. 1491), × 5.0. Holotype. Locality 74B15.  
Figs. 24-25. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1492), × 5.0. Locality 74B15.

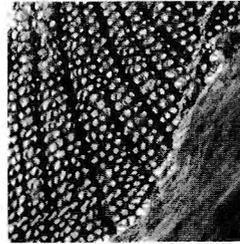


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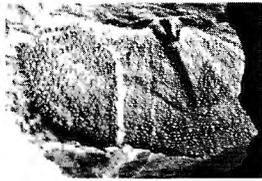
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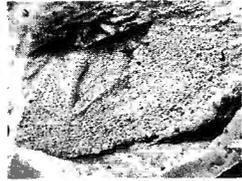


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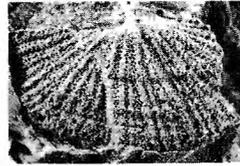
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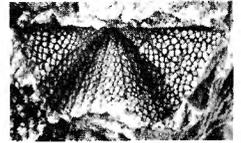


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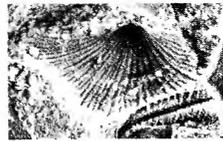
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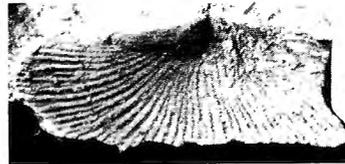
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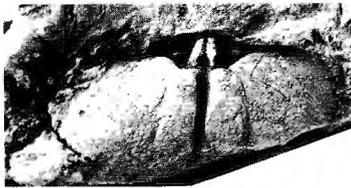
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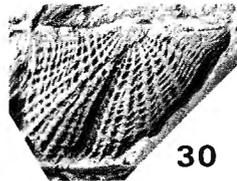
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## PLATE 7

*Saukrodictya wrighti* n. sp.

- Figs. 1-3. – Interior, latex cast of exterior, exterior molds of a ventral valve (I.R.Sc.N.B. 1493), × 4.0, × 4.0, × 8.0. Locality 74B16.  
 Fig. 4. – Interior mold of a ventral valve (I.R.Sc.N.B. 1494), × 4.0. Locality 74B16.  
 Figs. 5-7. – Interior, latex cast of interior, latex cast of exterior molds of a dorsal valve (I.R.Sc.N.B. 1495), × 4.0. Locality 74B16.

*Saukrodictya* sp.

- Figs. 8, 9. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1496), × 4.0. Locality 74B4.

*Laticrura* cf. *L. erecta* WRIGHT 1964

- Figs. 10-12. – Interior, posterior view of interior, latex cast of the mold of a dorsal valve (I.R.Sc.N.B. 1497), × 3.0. Locality 74B12.  
 Fig. 13. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1498), × 3.0. Locality 74B16.  
 Fig. 14. – Interior mold of a ventral valve (I.R.Sc.N.B. 1499), × 3.0. Locality 74B16.  
 Figs. 15-16. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1500), × 4.0. Locality 74B16.  
 Figs. 17-18. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1501), × 3.0, × 2.0. Locality 74B19.  
 Figs. 19-20. – Interior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1502), × 2.5, × 4.0. Locality 74B17.

*Vellamo* sp.

- Fig. 21. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1503), × 2.0. Locality 74B20.  
 Figs. 22-23. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1504), × 2.0. Locality 74B20.

*Kullervo complectens* (WIMAN 1907) *albida* (REED 1917)

- Figs. 24-26. – Posterior and anterior views of interior, and exterior molds of a ventral valve (I.R.Sc.N.B. 1505), × 3.0. Locality 74B16.  
 Fig. 27. – Posterior view of interior mold of a ventral valve (I.R.Sc.N.B. 1506), × 3.0. Locality 74B16.  
 Figs. 28-31. – Interior, latex cast of interior, latex cast of exterior, exterior molds of a dorsal valve (I.R.Sc.N.B. 1507), × 3.0. Locality 74B16.



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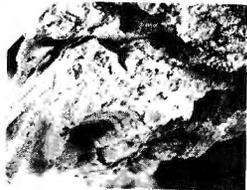
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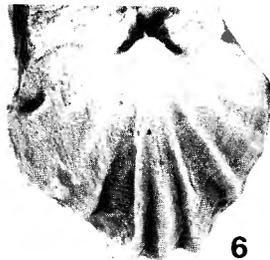
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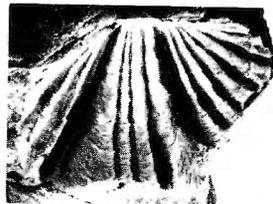
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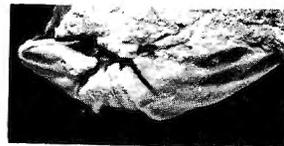
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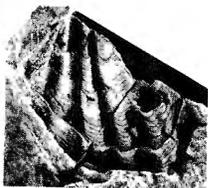
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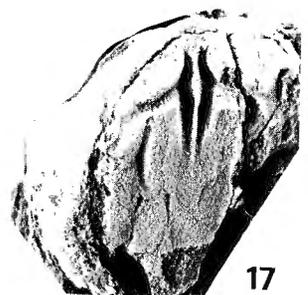
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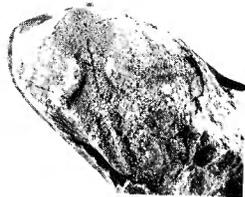
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## PLATE 8

*Kullervo complectens* (WIMAN, 1907) *albida* (REED, 1917)

Figs. 1-3. – Interior, latex cast of interior, and exterior molds of a ventral valve (I.R.Sc.N.B. 1508), × 3.0. Locality 74B19.

*Oxoplecia* cf. *O. plicata* (WIMAN, 1907)

Fig. 4. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1509), × 2.5. Locality 74B17.

Fig. 5. – Interior mold of a ventral valve (I.R.Sc.N.B. 1510), × 2.5. Locality 74B19.

Figs. 6, 7. – Interior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1511), × 2.5. Locality 74B19.

Fig. 8. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1512), × 2.5. Locality 74B16.

Fig. 9. – Interior mold of a ventral valve (I.R.Sc.N.B. 1513), × 2.5. Locality 74B16.

Figs. 10-12. – Exterior, posterior and anterior views of interior molds of a ventral valve (I.R.Sc.N.B. 1514), × 2.0. Locality 74B20.

Figs. 13-15. – Exterior, interior, latex cast of interior molds of a dorsal valve (I.R.Sc.N.B. 1515), × 2.5, × 2.0, × 2.0. Locality 74B20.

*Triplesia* sp.

Figs. 16-17. – Posterior view of interior and interior mold of a dorsal valve (I.R.Sc.N.B. 1516), × 2.0. Locality 74B7.

Figs. 18-19. – Posterior view of interior and interior mold of a dorsal valve (I.R.Sc.N.B. 1517), × 2.0. Locality 74B17.

Fig. 20. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1518), × 2.0. Locality 74B20.

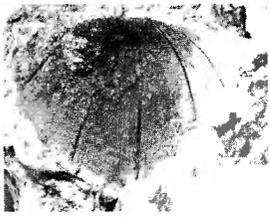
Fig. 21. – Interior mold of a ventral valve (I.R.Sc.N.B. 1519), × 2.5. Locality 74B20.

Figs. 22-23. – Anterior and posterior views of latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1520), × 2.0. Locality 74B20.

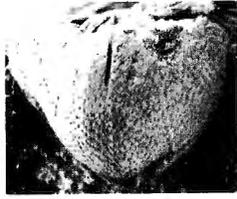
Fig. 24. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1521), × 2.0. Locality 74B20.

*Triplesia?* sp.

Figs. 25-27. – Posterior view of interior, interior, lateral view of interior mold of a dorsal valve (I.R.Sc.N.B. 1522), × 1.0. Locality 74B13.



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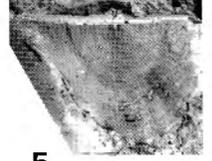
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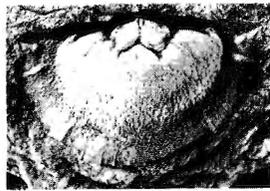
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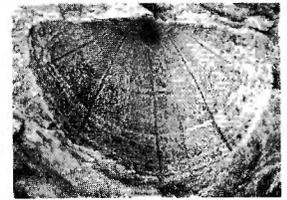
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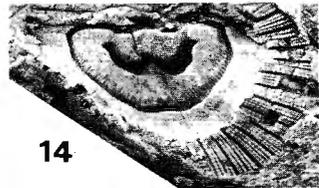
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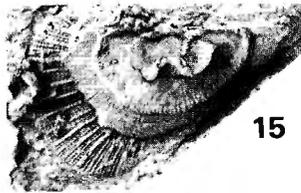
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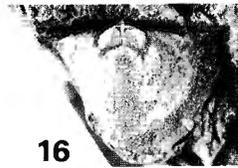
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## PLATE 9

*Diambonia* sp.

- Figs. 1, 2. – Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1523), × 5.0. Locality 74B10.  
 Fig. 3. – Interior mold of a ventral valve (I.R.Sc.N.B. 1524), × 5.0. Locality 74B10.

*Leangella namurensis* n. sp.

- Figs. 4, 5. – Exterior, latex cast of exterior mold of a dorsal valve (I.R.Sc.N.B. 1525), × 4.0. Locality 74B15.  
 Figs. 6-8. – Interior, latex cast of interior, exterior molds of a dorsal valve (I.R.Sc.N.B. 1526), × 4.0. Holotype. Locality 74B15.  
 Fig. 9. – Posterior view of exterior mold of a dorsal valve with ventral interarea (I.R.Sc.N.B. 1527), × 4.0. Locality 74B15.  
 Fig. 10. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1528), × 4.0. Locality 74B15.  
 Figs. 11-13. – Interior, latex cast of interior, exterior molds of a ventral valve (I.R.Sc.N.B. 1529), × 4.0. Locality 74B15.  
 Figs. 14-15. – Exterior, latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1530), × 4.0. Locality 74B15.  
 Fig. 16. – Interior mold of a ventral valve (I.R.Sc.N.B. 1531), × 4.0. Locality 74B15.  
 Fig. 17. – Interior mold of a ventral valve (I.R.Sc.N.B. 1532), × 4.0. Locality 74B15.

*Leangella?* sp.

- Fig. 18. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1533), × 4.0. Locality 74B13.

*Sampo ruralis* (REED, 1917)

- Fig. 19. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1534), × 2.0. Locality 74B16.  
 Fig. 20. – Interior mold of a ventral valve (I.R.Sc.N.B. 1535), × 2.0. Locality 74B13.  
 Fig. 21. – Exterior mold of part of a ventral valve (I.R.Sc.N.B. 1536), × 2.0. Locality 74B20.  
 Figs. 22-24. – Posterior view of interior, interior and lateral view of interior mold of a ventral valve (I.R.Sc.N.B. 1537), × 2.0. Locality 74B19.  
 Fig. 25. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1538), × 2.0. Locality 74B19.  
 Figs. 26-28. – Exterior, latex cast of interior, interior molds of a dorsal valve (I.R.Sc.N.B. 1539), × 2.0. Locality 74B19.  
 Figs. 29-30. – Latex cast of interior, interior mold of a ventral valve (I.R.Sc.N.B. 1540), × 2.0. Locality 74B19.



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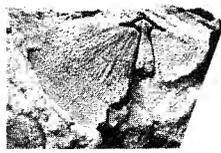
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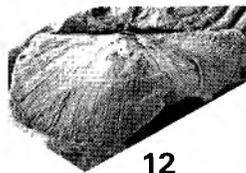
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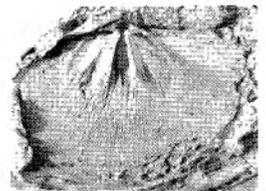
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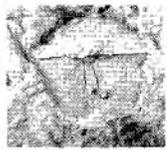
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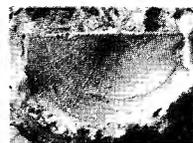
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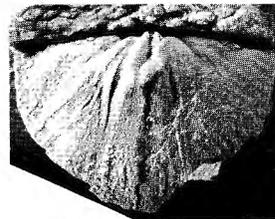
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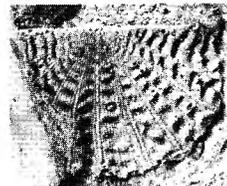
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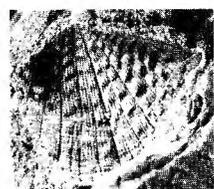
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## PLATE 10

*Sampo ruralis* (REED, 1917)

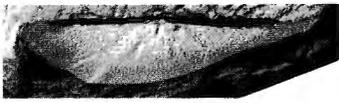
- Figs. 1, 2. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1541), × 2.0. Locality 74B19.  
 Figs. 3, 4. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1542), × 1.5. Locality 74B19.  
 Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1543), × 2.0. Locality 74B19.

*Sowerbyella* cf. *S. raegaverensis* RÖDMUSOKS, 1959

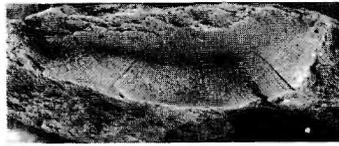
- Figs. 6-9. – Interior, latex cast of interior, exterior, latex cast of exterior molds of a dorsal valve (I.R.Sc.N.B. 1544), × 2.0. Locality 74B14.  
 Figs. 10-12. – Interior and latex cast of interior, exterior molds of a dorsal valve (I.R.Sc.N.B. 1545), × 1.5. Locality 74B14.  
 Fig. 13-14. – Interior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1546), × 1.5, × 2.0. Locality 74B14.  
 Fig. 15. – Interior molds of articulated valves (I.R.Sc.N.B. 1547), × 3.0. Locality 74B14.  
 Figs. 16-17. – Exterior and latex cast of exterior mold of a ventral valve (I.R.Sc.N.B. 1548), × 2.0. Locality 74B14.  
 Figs. 18-19. – Interior and latex cast of interior mold of a ventral valve (I.R.Sc.N.B. 1549), × 2.0. Locality 74B14.  
 Fig. 20. – Interior mold of a ventral valve (I.R.Sc.N.B. 1550), × 2.0. Locality 74B14.  
 Fig. 21. – Interior mold of a ventral valve (I.R.Sc.N.B. 1551), × 2.0. Locality 74B14.  
 Figs. 22-23. – Lateral view of interior and interior mold of a ventral valve (I.R.Sc.N.B. 1552), × 2.0. Locality 74B14.

*Sowerbyella* (*Rugosowerbyella*) *subcorrugatella* (REED, 1917)

- Figs. 24-26. – Interior, exterior, latex cast of exterior molds of a dorsal valve (I.R.Sc.N.B. 1553), × 4.0. Locality 74B20.  
 Figs. 27-29. – Interior, lateral view of interior, latex cast of interior mold of a ventral valve (I.R.Sc.N.B. 1554), × 3.0. Locality 74B20.  
 Fig. 30. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1555), × 4.0. Locality 74B20.  
 Fig. 31. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1556), × 3.0. Locality 74B20.  
 Fig. 32. – Interior mold of a ventral valve (I.R.Sc.N.B. 1557), × 3.0. Locality 74B20.  
 Figs. 33-34. – Interior and latex cast of interior mold of a ventral valve (I.R.Sc.N.B. 1558), × 3.0. Locality 74B20.



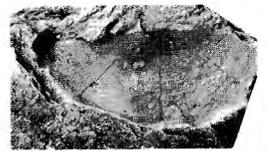
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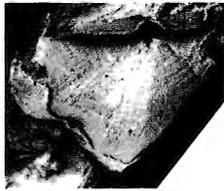
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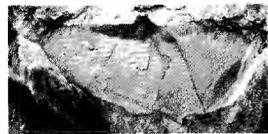
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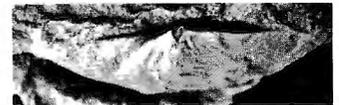
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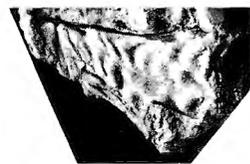
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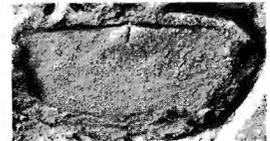
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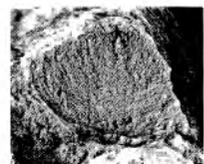
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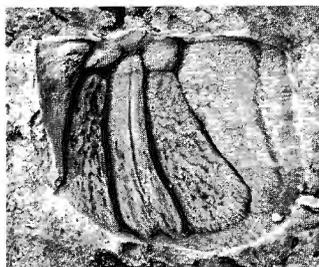
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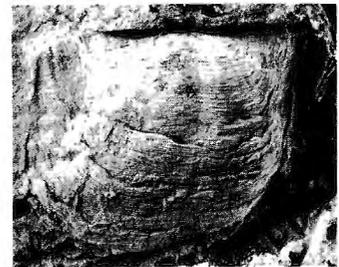
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## PLATE 11

*Anisopleurella quinquecostata* (JONES, 1928)

- Figs. 1, 2. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1559), × 4.0. Locality 74B15.  
 Figs. 3, 4. – Dorsal and ventral exterior molds of a specimen (I.R.Sc.N.B. 1560), × 2.5. Locality 74B15.  
 Figs. 5-7. – Interior, latex cast of interior, exterior molds of a dorsal valve (I.R.Sc.N.B. 1561), × 2.5. Locality 74B15.  
 Fig. 8. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1562), × 4.0. Locality 74B15.

*Anisopleurella* sp.

- Figs. 9-11. – Interior, exterior, lateral view of exterior molds of a dorsal valve (I.R.Sc.N.B. 1563), × 4.0. Locality 74B14.

*Anisopleurella?* *sartenaeri* n. sp.

- Fig. 12. – Interior mold of a ventral valve (I.R.Sc.N.B. 1564), × 2.0. Locality 74B19.  
 Figs. 13-14. – Exterior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1565), × 2.0. Locality 74B19.  
 Figs. 15-17. – Exterior, interior and lateral view of interior molds of a ventral valve (I.R.Sc.N.B. 1566), × 2.0. Holotype. Locality 74B19.  
 Figs. 18-20. – Exterior, posterior view of interior, and interior molds of a ventral valve (I.R.Sc.N.B. 1567), × 1.5, × 2.0, × 2.0. Locality 74B13.  
 Fig. 21. – Interior mold of a ventral valve (I.R.Sc.N.B. 1568), × 3.5. Locality 74B13.

*Ptychoglyptus* sp.

- Fig. 22. – Interior mold of a ventral valve (I.R.Sc.N.B. 1569), × 1.0. Locality 74B19.  
 Fig. 23. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1570), × 2.0. Locality 74B19.  
 Fig. 24. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1571), × 2.0. Locality 74B19.  
 Figs. 25-26. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1572), × 1.5. Locality 74B7.

*Chonetoidea* sp.

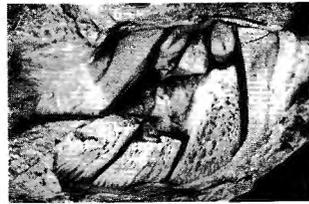
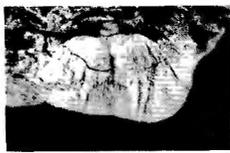
- Fig. 27. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1573), × 6.5. Locality 74B15.

*Foliomena folium* (BARRANDE, 1879)

- Fig. 28. – Interior mold of a ventral valve (I.R.Sc.N.B. 1574), × 2.5. Locality 74B21.  
 Figs. 29-30. – Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1575), × 2.5. Locality 74B21.

*Christiania magna* n. sp.

- Figs. 31-32. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1576), × 2.0. Holotype. Locality 74B19.



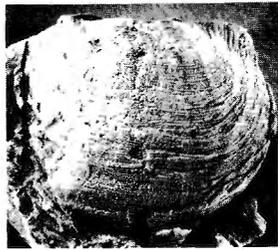
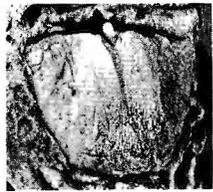
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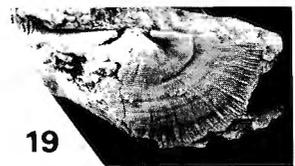
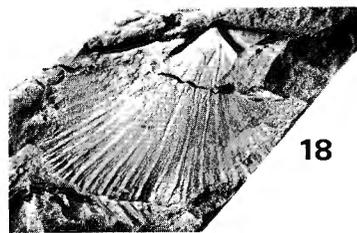
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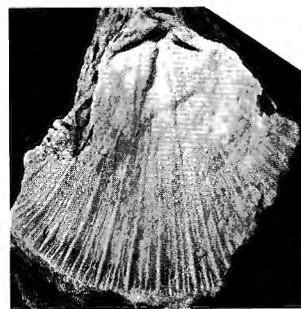
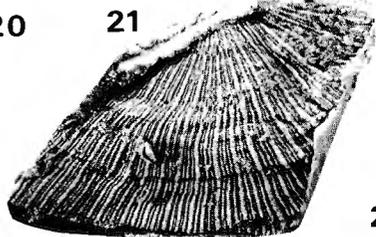
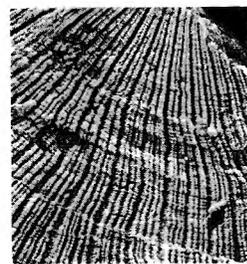


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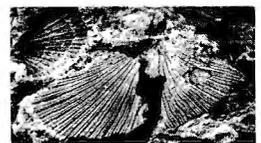
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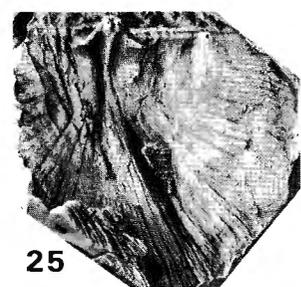
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## PLATE 12

*Christiania magna n. sp.*

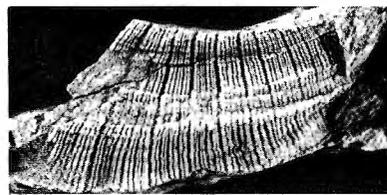
- Figs. 1, 2. – Interior and posterior view of interior of a ventral valve (I.R.Sc.N.B. 1577),  $\times 1.5$ ,  $\times 2.0$ . Locality 74B19.  
Figs. 3, 4. – Posterior view of interior (broken to show height of septa) and interior mold of a dorsal valve (I.R.Sc.N.B. 1578),  $\times 2.0$ . Locality 74B19.  
Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1579),  $\times 4.0$ . Locality 74B19.  
Fig. 6. – Interior mold of a ventral valve (I.R.Sc.N.B. 1580),  $\times 2.5$ . Locality 74B19.  
Figs. 7, 8. – Exterior and lateral view of exterior mold of a dorsal valve (I.R.Sc.N.B. 1581),  $\times 2.0$ . Locality 74B19.  
Fig. 9. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1582),  $\times 2.0$ . Locality 74B19.  
Fig. 10. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1583),  $\times 2.0$ . Locality 74B19.  
Fig. 11. – Exterior mold of a dorsal valve (I.R.Sc.N.B. 1584),  $\times 1.5$ . Locality 74B19.  
Figs. 12-14. – Interior, posterior view of interior, lateral view of interior mold of a ventral valve (I.R.Sc.N.B. 1585),  $\times 2.0$ . Locality 74B12.  
Fig. 15. – Exterior mold of a ventral valve (I.R.Sc.N.B. 1586),  $\times 2.0$ . Locality 74B20.  
Figs. 16-17. – Interior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1587),  $\times 2.0$ . Locality 74B20.

*Strophomena sp.*

- Fig. 18. – Interior mold of a ventral valve (I.R.Sc.N.B. 1588),  $\times 1.5$ . Locality 74B19.  
Fig. 19. – Interior mold of a ventral valve (I.R.Sc.N.B. 1589),  $\times 1.5$ . Locality 74B19.  
Figs. 20-21. – Exterior and latex cast of the mold of a ventral valve (I.R.Sc.N.B. 1590),  $\times 4.0$ ,  $\times 2.5$ . Locality 74B19.  
Fig. 22. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1591),  $\times 1.5$ . Locality 74B19.  
Figs. 23-24. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1592),  $\times 1.5$ . Locality 74B19.  
Figs. 25-26. – Latex cast of interior and interior mold of a dorsal valve (I.R.Sc.N.B. 1593),  $\times 1.5$ ,  $\times 1.25$ . Locality 74B9.  
Fig. 27. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1594),  $\times 1.25$ . Locality 74B9.  
Figs. 28-29. – Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1595),  $\times 2.5$ . Locality 74B9.



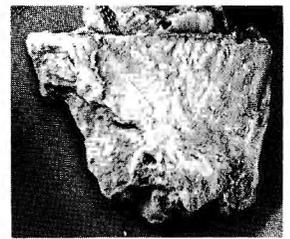
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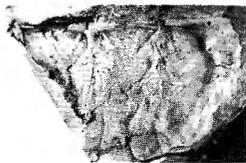
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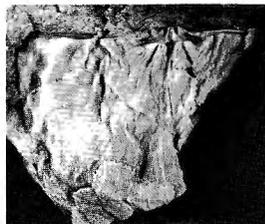
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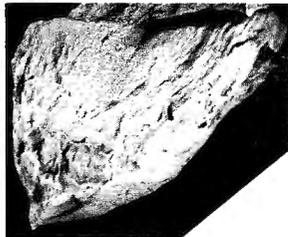
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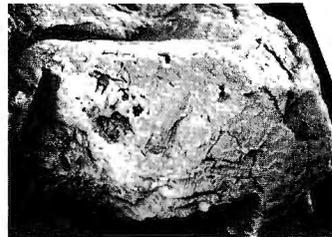
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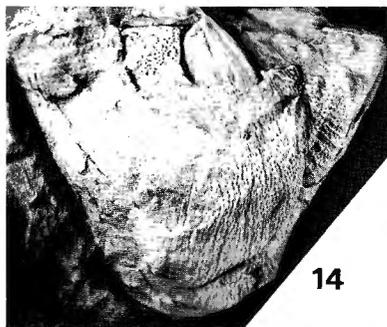
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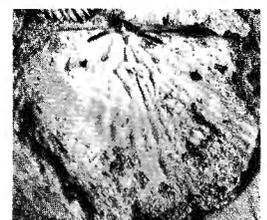
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## PLATE 13

*Strophomena* sp.

Figs. 1, 2. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1596),  $\times 1.25$ ,  $\times 2.5$ . Locality 74B20.

*Luhaia vardi* RÖÖMUSOKS, 1956, *roomusoksi* n. subsp.

Figs. 3, 4. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1597),  $\times 1.5$ . Locality 74B10.

Figs. 5-7. – Latex cast of interior, interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1598),  $\times 1.5$ . Holotype of subspecies. Locality 74B10.

Fig. 8. – Interior mold of a ventral valve (I.R.Sc.N.B. 1599),  $\times 1.5$ . Locality 74B13.

Figs. 9-11. – Interior, exterior, lateral view of exterior molds of a ventral valve (I.R.Sc.N.B. 1600),  $\times 1.5$ . Locality 74B13.

*Kiaeromena* sp.

Figs. 12-13. – Interior and lateral view of interior mold of a ventral valve (I.R.Sc.N.B. 1601),  $\times 1.0$ . Locality 74B10.

Fig. 14. – Interior mold of a ventral valve (I.R.Sc.N.B. 1602),  $\times 1.0$ . Locality 74B11.

Figs. 15-17. – Exterior, interior, latex cast of interior molds of a dorsal valve (I.R.Sc.N.B. 1603),  $\times 1.5$ . Locality 74B13.

Figs. 18-19. – Ventral and dorsal exterior molds of a specimen (I.R.Sc.N.B. 1604),  $\times 1.5$ . Locality 74B12.

*Costistrophomena costata* n. gen., n. sp.

Figs. 20-21. – Interior and latex cast of a mold of a dorsal valve (I.R.Sc.N.B. 1605),  $\times 2.0$ . Locality 74B14.

Figs. 22-23. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1606),  $\times 2.0$ . Locality 74B14.

Fig. 24. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1607),  $\times 1.5$ . Locality PS58.



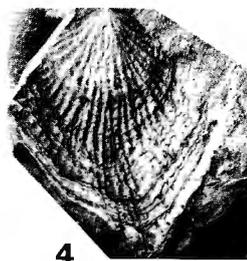
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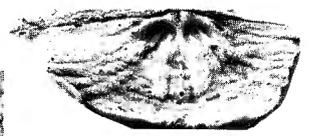
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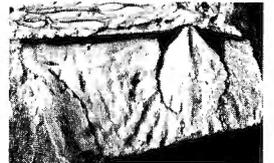
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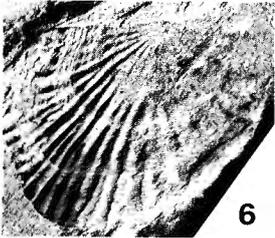
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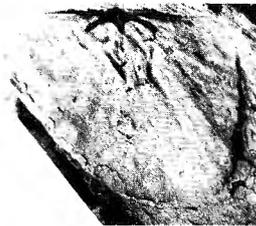
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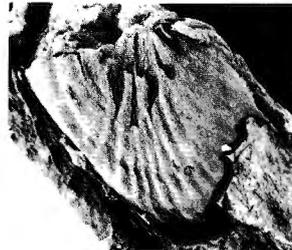
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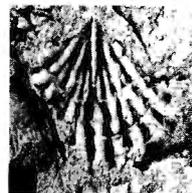
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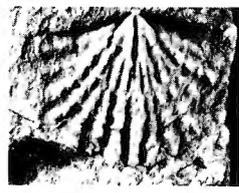
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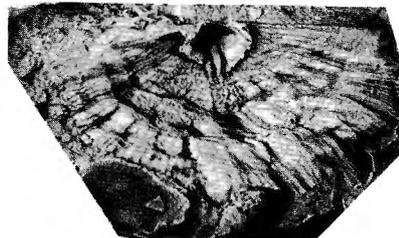
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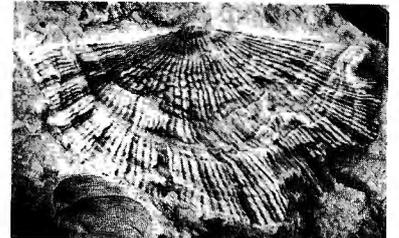
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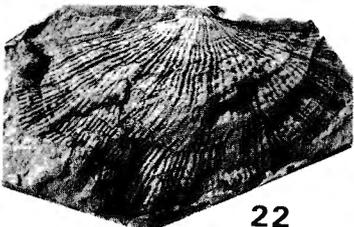
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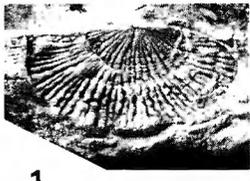
## PLATE 14

*Costistrophomena costata* n. gen., n. sp.

- Figs. 1-4. - Interior, latex cast of interior, exterior and latex cast of exterior of the molds of a ventral valve (I.R.Sc.N.B. 1608),  $\times$  1.5. Locality 74B19.
- Fig. 5. - Latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1609),  $\times$  2.0. Locality 74B20.
- Figs. 6, 7. - Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1610),  $\times$  2.0. Holotype. Locality 74B17.
- Fig. 8. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1611),  $\times$  2.0. Locality 74B17.
- Fig. 9. - Interior mold of a ventral valve (I.R.Sc.N.B. 1612),  $\times$  2.0. Locality 74B4.
- Fig. 10. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1613),  $\times$  2.0. Locality 74B4.
- Figs. 11-12. - Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1614),  $\times$  3.0. Locality 74B4.
- Figs. 13-14. - Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1615),  $\times$  3.0. Locality 74B4.
- Figs. 15-16. - Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1616),  $\times$  1.5. Locality 74B8.

*Katastrophomena catalorni* n. sp.

- Figs. 17-18. - Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1617),  $\times$  1.5. Locality 74B19.
- Figs. 19-22. - Interior, latex cast of interior, exterior, latex cast of exterior molds of a ventral valve (I.R.Sc.N.B. 1618),  $\times$  1.5. Holotype. Locality 74B19.
- Figs. 23-24. - Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1619),  $\times$  1.5. Locality 74B19.
- Fig. 25. - Interior mold of a ventral valve (I.R.Sc.N.B. 1620),  $\times$  1.5. Locality 74B19.



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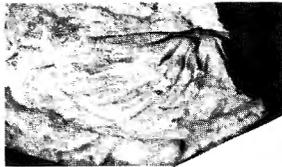
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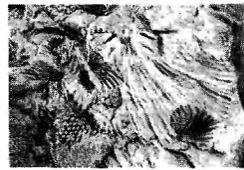
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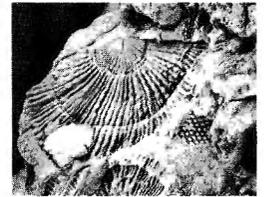
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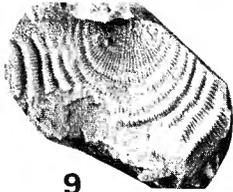
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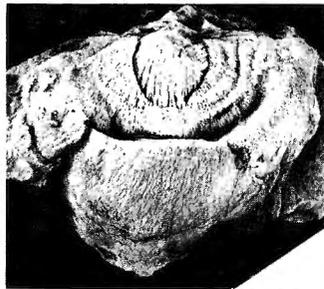
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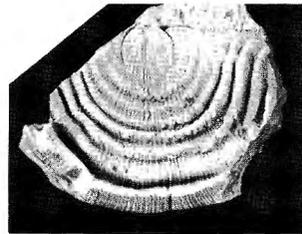
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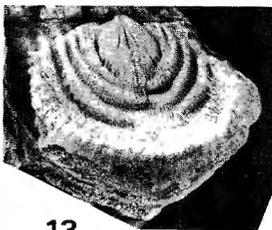
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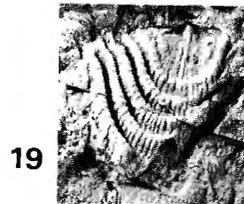
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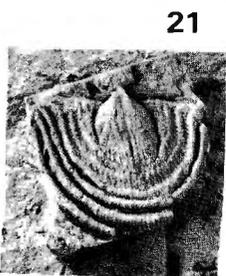
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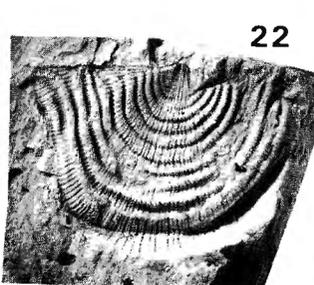
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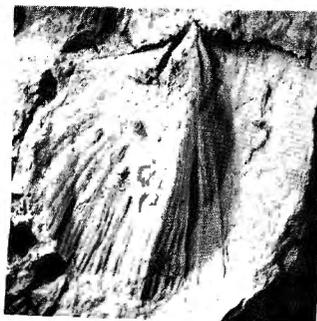
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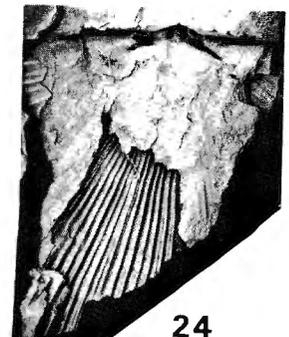
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## PLATE 15

*Katastrophomena catalorni n. sp.*

- Figs. 1-3. - Exterior, interior, latex cast of interior of molds of a dorsal valve (I.R.Sc.N.B. 1621),  $\times 2.0$ . Locality 74B19.  
Fig. 4. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1622),  $\times 2.0$ . Locality 74B19.  
Figs. 5, 6. - Interior and posterior view of interior mold of a dorsal valve (I.R.Sc.N.B. 1623),  $\times 1.5$ . Locality 74B19.  
Figs. 7, 8. - Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1624),  $\times 1.5$ . Locality 74B19.

*Leptaena sp.*

- Figs. 9-10. - Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1625),  $\times 1.5$ . Locality 74B14.  
Fig. 11. - Interior mold of a ventral valve (I.R.Sc.N.B. 1626),  $\times 1.5$ . Locality 74B14.  
Fig. 12. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1627),  $\times 3.0$ . Locality 74B14.  
Fig. 13. - Interior mold of a ventral valve (I.R.Sc.N.B. 1628),  $\times 1.5$ . Locality 74B14.  
Fig. 14. - Interior mold of a ventral valve (I.R.Sc.N.B. 1629),  $\times 1.5$ . Locality 74B14.  
Figs. 15-16. - Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1630),  $\times 1.5$ . Locality 74B19.  
Fig. 17. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1631),  $\times 1.5$ . Locality 74B19.  
Fig. 18. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1632),  $\times 1.5$ . Locality PS57.  
Figs. 19-20. - Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1633),  $\times 3.0$ . Locality 74B4.  
Figs. 21-22. - Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1634),  $\times 1.5$ . Locality 74B4.

*Fardenia sp.*

- Fig. 23. - Interior mold of a ventral valve (I.R.Sc.N.B. 1635),  $\times 1.0$ . Locality PS57.  
Fig. 24. - Interior mold of a dorsal valve (I.R.Sc.N.B. 1636),  $\times 1.5$ . Locality PS58.



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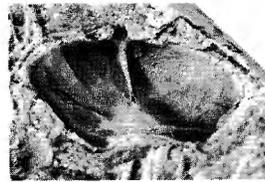
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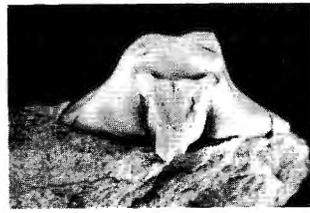
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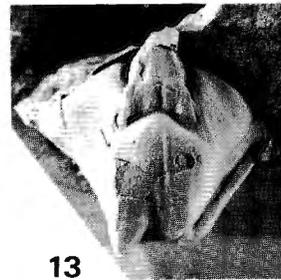
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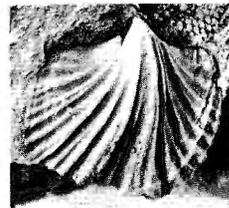
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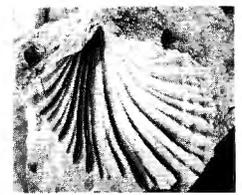
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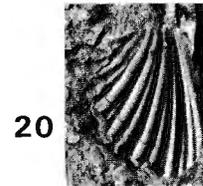
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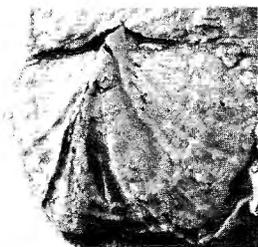
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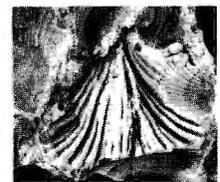
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## PLATE 16

*Catazyga? sp.*

Figs. 1, 2. – Exterior and interior molds of a dorsal valve (I.R.Sc.N.B. 1637), × 6.0. Locality PS57.

Figs. 3, 4. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1638), × 6.0. Locality 74B4.

*Cyclospira? sp.*

Fig. 5. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1639), × 3.0. Locality 74B16.

Fig. 6. – Lateral view of interior mold of a ventral valve (I.R.Sc.N.B. 1640), × 3.0. Locality 74B19.

Figs. 7, 8. – Interior and latex cast of interior mold of a dorsal valve (I.R.Sc.N.B. 1641), × 3.0. Locality 74B19.

Fig. 9. – Interior mold of a dorsal valve (I.R.Sc.N.B. 1642), × 3.0. Locality 74B19.

Fig. 10. – Interior mold of a ventral valve (I.R.Sc.N.B. 1643), × 3.0. Locality 74B20.

Figs. 11-14. – Lateral view of interior, posterior view of interior, interior, latex cast of interior mold of a ventral valve (I.R.Sc.N.B. 1644), × 3.0. Locality 74B20.

Figs. 15-16. – Interior, lateral view of interior mold of a ventral valve (I.R.Sc.N.B. 1645), × 3.0. Locality 74B20.

Fig. 17. – Posterior view of interior mold of a ventral valve (I.R.Sc.N.B. 1646), × 3.0. Locality 74B20.

*Spirigerina (Eospirigerina) cf. S. (E.) sulevi (JAANUSSON, 1954)*

Figs. 18-19. – Interior and exterior molds of a ventral valve (I.R.Sc.N.B. 1647), × 2.0. Locality 74B10.

Figs. 20-21. – Exterior and interior molds of a ventral valve (I.R.Sc.N.B. 1648), × 2.0. Locality 74B14.

Fig. 22. – Interior mold of a ventral valve (I.R.Sc.N.B. 1649), × 3.0. Locality 74B14.

Fig. 23. – Posterior view of interior mold of a ventral valve (I.R.Sc.N.B. 1650), × 2.0. Locality 74B14.

Figs. 24-25. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1651), × 2.0. Locality 74B11.

Figs. 26-27. – Interior and exterior molds of a dorsal valve (I.R.Sc.N.B. 1652), × 2.0. Locality 74B11.

