Maastrichtian brachiopods from Ciply: palaeoecological and stratigraphical significance

by Eric SIMON

Abstract

Maastrichtian brachiopods from the phosphatic chalk of Ciply and brachiopods collected in the sediments trapped in the cavities of the overlying hardground were studied for their palaeoecological significance. Stratigraphical correlations with the micromorphic brachiopod zones described by SURLYK for the white chalk of Denmark and Northern Germany are proposed. A new species of *Isocrania* JAEKEL, 1902 and a new species of *Rugia* STEINICH, 1963 are described.

Key words: Brachiopods, Cretaceous, Maastrichtian, Ciply, Belgium.

Résumé

Les brachiopodes Maastrichtiens de la craie phosphatée de Ciply ainsi que ceux observés dans les sédiments extraits des cavités du hardground qui recouvre la craie phosphatée ont été étudiés dans une perspective paléoécologique. Des corrélations stratigraphiques sont proposées avec les zones à microbrachiopodes décrites par SURLYK pour les craies du Danemark et de l'Allemagne du nord. Deux nouvelles espèces ont été décrites; l'une appartient au genre *Isocrania* JAEKEL, 1902 et l'autre au genre *Rugia* STEINICH, 1963.

Mots-clefs: Brachiopodes, Crétacé, Maastrichtien, Ciply, Belgique.

Introduction

The Belgian locality of Ciply is of great interest for the study of Maastrichtian brachiopods. The author has already published a synthesis of the papers dealing with this rich fossiliferous area (SIMON, 1992, pp. 121-122).

This paper deals with all the macromorphic and micromorphic brachiopods collected from Van Damme quarry (Fig. 1) which is the only accessible place for readily sampling the phosphatic chalk of Ciply. A sample of phosphatic chalk from the underground "La Malogne" quarry in Cuesmes (Fig. 1) is also included in the present paper. All species cited herein were effectively found by the author. In order to avoid all possible stratigraphical errors due to the use of old collections (which were not always collected with enough precision), other species from museum collections, labelled "Ciply" or "phosphatic chalk of Ciply", which were not found effectively by the author, are not taken into account.

In the Van Damme quarry, the exposed section of phosphatic chalk has a thickness between three and five meters. This quarry is disused today and the underlying white chalk, called "Craie de Spiennes" of Late Campanian age, is no longer visible. The phosphatic chalk is overlain by a one meter thick hardground which is penetrated by many cavities filled with soft sediment. Although this paper deals primarily with the brachiopods from the phosphatic chalk, specimens were also collected in large numbers from the sediment infilling the hardground cavities.

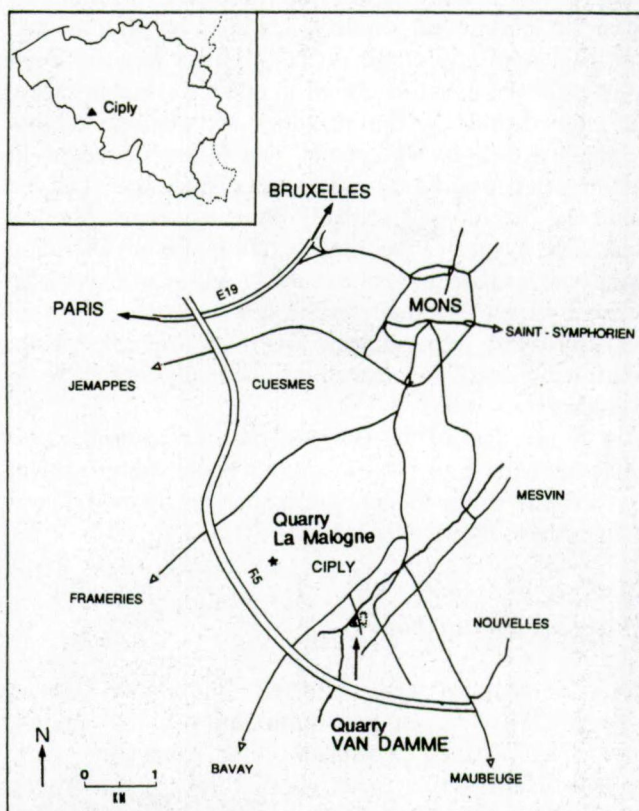At Ciply, the hardground overlying the phosphatic chalk

Fig. 1 – Map showing the position of Van Damme quarry, Ciply, and of the underground La Malogne quarry in Cuesmes (Mons Basin, Hainaut, Belgium).

is not covered by the "Tuffeau de Saint-Symphorien" (uppermost Maastrichtian) which is present in other parts of the Mons basin. In the Van Damme quarry, the hardground capping the phosphatic chalk is directly overlain by the "Poudingue de La Malogne" which is of Middle Danian age. This "Poudingue de La Malogne" fills the cavities in the upper part of the hardground. The Danian fossils from the "Poudingue de La Malogne" are not considered in this paper.

The stratigraphical level of the phosphatic chalk of Ciply was established recently by ROBASZYNSKI & CHRISTENSEN (1989) who referred this sediment to the *Belemnella obtusa* Zone. This belemnite is a good marker for the upper part of the lower Lower Maastrichtian.

The hardground capping the phosphatic chalk is stratigraphically complex. The hardground itself is composed of indurated phosphatic chalk and is of Lower Maastrichtian age. However, the sediments infilling the numerous hardground cavities contain a mixture of fossils of different ages. Generally Lower Maastrichtian species from the phosphatic chalk are mixed with representatives typical of the Upper Maastrichtian and uppermost Maastrichtian, but in the upper part of the hardground, Danian fossils predominate. The hardground cavities are particularly interesting because they acted as traps for transported fossils over an extended interval of time and various transgressions, which occurred after the formation of this hardground, were "registered" by these natural traps. Study of the micromorphic brachiopods from the hardground provides new data on both the age and palaeoecology of the different Upper Maastrichtian transgressions which occurred in this area. For instance, brachiopods found in these cavities never belong to large secondary free living species which are abundant in sediments deposited in quiet water situations. On the contrary, brachiopods strongly fixed by means of their pedicle, i. e. species regarded as living in more energetic environments, are more abundant. As the same taxa occur in some parts of the phosphatic chalk, together with large secondary free living brachiopods, it is inferred that the phosphatic chalk is palaeoenvironmentally and palaeoecologically complex.

A furher goal of the study of the micromorphic brachiopods from Ciply was to attempt some stratigraphical correlations using the micromorphic brachiopod Zones defined by SURLYK (1982, 1983).

Materials and methods

Forty-six samples were collected in the Van Damme quarry. Thirty-two samples representing a total amount of 158 kg of dried phosphatic chalk from Ciply were collected from a five meter interval directly underlying the hardground. Fourteen samples of soft sediment, weighting a total of 43 kg, were collected from the cavities located between the base and the middle part of the hardground. The cavities of the upper part of the hardground, filled exclusively with Danian sediment, were not investigated. For comparison, a sample of phosphatic chalk was also collected from the underground "La Malogne" quarry at Cuesmes (sample n° 45) at a depth of 12 meters below the base of the hardground.

All samples were air dried at a temperature of 20°C for at least two weeks. When dry, each sample was weighed and treated with Glauber salt solution following the method of SURLYK (1972). This method was also described in detail in SIMON (1992, p. 123).

To establish the total number of individuals of each species in a sample, the highest number of isolated ventral valves or dorsal valves was added to the number of complete bivalved specimens found. Sometimes the number of fragments is taken into account.

The number of specimens collected for each species, can be found in the systematical part of this paper.
The number of individuals / kg of chalk was found to be extremely variable from one sample to another (Table 1), consequently a large number of samples were collected in order to obtain more accurate results.

The bivalved micromorphic brachiopods were measured for their length, width and thickness. Where possible, size-frequency diagrams were established. As shown previously by SURLYK (1972, pp. 36 - 37), an ecological evaluation of size-frequency distribution can only be made if some factors are carefully controlled. For instance, size-selective transport, crushing or solution are factors influencing the shape of the histograms and stable conditions of deposition must be confirmed for the specimens investigated.

For these reasons, studies of size-frequency distributions were not undertaken on some species affected by transport and crushing and also for species for which stable conditions of deposition could not be confirmed.

Specimens of micromorphic brachiopods illustrated in this paper were cleaned in a ultrasonic bath and SEM photographs were made at Institut royal des Sciences naturelles de Belgique in Brussels.

Macromorphic brachiopods were also regularly collected in the phosphatic chalk of Ciply and special attention was paid to their exact positions in the exposed section.

The ecological groups cited in this paper were designated by SURLYK in 1972 (pp. 16 -27, text-fig. 5).

The material collected for this work is preserved in the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

State of preservation of the collected brachiopods

The phosphatic chalk of Ciply is strongly bioturbated and brachiopods are never found in living position.

The state of preservation of the micromorphic brachiopods collected in the phosphatic chalk of Ciply is variable. Some species are always well preserved, either as intact bivalved shells or as whole disarticulated valves,

and fragments of those shells are not numerous. Representatives of such species did not suffer of transportation.

Some other species are always poorly preserved and are generally present as undeterminable fragments, e. g. many small *Argyrotheca* species. Some species are found as fragments accompanied by several separated and often broken valves. Such material has probably been transported over a relatively long interval of time.

Similar observations were made for the macromorphic brachiopods.

The fact that parts of the material are well preserved and that other parts are poorly preserved, indicates that different assemblages are mixed in the phosphatic chalk. One purpose of this paper was to establish the composition in brachiopods of the different assemblages encountered in the phosphatic chalk of Ciply.

Macroanalysis of the samples collected in the phosphatic chalk

Direct evidence of transport is shown by the extremely abundant isolated valves of *Microchlamys pulchella* (NILSSON, 1827). Several beds of numerous transported valves of *Microchlamys pulchella* are easily visible in the Van Damme quarry. In some samples, a few isolated valves are found, whereas in other samples, this mollusc is so abundant that it represents the largest part of the weight of the sieved sample.

Sclerostyla mosae (BRONN, 1837) is another species which is always found together with *Microchlamys pulchella*. The relative abundance of *S. mosae* is related to the relative abundance of *M. pulchella*, indicating that these two organisms were probably living in the same community of organisms.

In samples where *M. pulchella* and *S. mosae* are dominant, well preserved macromorphic brachiopods are virtually absent. On the contrary, a lot of poorly preserved micromorphic brachiopods (*Argyrotheca div. sp.*, *Terebratulina chrysalis* etc.) are present and sometimes abundant in those samples.

Samples, poor in *M. pulchella* and *S. mosae*, yield well preserved macromorphic and micromorphic brachiopods, often found as intact bivalved shells. Within the shell cavity of some micromorphic brachiopods, complete recrystallized spicular skeletons have been found. These indicate that these brachiopods were living in a quiet environment and that no preburial transport occurred as already shown by SURLYK (1972, p. 14). Well preserved Bryozoa fragments are often present in this type of samples.

Samples collected on both sides of a limit between two beds of phosphatic chalk, contain several exclusive species of micro- and macromorphic brachiopods. These species are member of a specialized assemblage adapted to palaeoecological conditions with a low sedimentation rate and/or with more energetic water conditions.

Results

The macromorphic brachiopods

A total of 1038 individuals of macromorphic brachiopods, attributable to 13 species, were found in the phosphatic chalk. The relative abundance of each species is illustrated in Figure 2. They belong to different ecological groups and are unevenly distributed in the profile studied. In total, two different macromorphic brachiopod assemblages are recognized.

Assemblage of brachiopods adapted to rapid sedimentation and non-energetic water conditions (Lower Maastrichtian phosphatic chalk assemblage *sensu stricto*)

This assemblage is dominated by the rhynchonellid brachiopod *Cretirhynchia limbata* (VON SCHLOTTHEIM, 1813). *Carneithyris carnea* (J. SOWERBY, 1812), *Trigonosemus palissii* WOODWARD, 1854 and *Carneithyris ciplyensis* (SAHNI, 1929) are also abundant. The relative abundance of these species in the phosphatic chalk assemblage is represented in Figure 2a.

Trigonosemus palissii and *Carneithyris ciplyensis* are two representatives of the ecological group of secondary free-living forms (Group 2 of SURLYK, 1972, p. 17). The pedicle tube in *T. palissii* is completely infilled by secondary shell material. In *C. ciplyensis* the canal of the pedicle is blocked by a greatly swollen cardinal process. A reduced pinhole foramen is observed in these two species.

Cretirhynchia limbata was considered as a secondary free living brachiopod by SURLYK (1972, p. 24) who compared the behaviour of this species to the free living behaviour tof *Cretirhynchia retracta* (ROEMER, 1841) demonstrated by STEINICH (1965, p. 16, pl. 3, fig. 1 a-b). The extremely flat anterior lobes of the ventral valve of *C. limbata* are supposed to provide high stability to this brachiopod if it was living with its ventral valve down in contact with the substrate.

This hypothesis, though attractive, is not totally convincing. If *C. limbata* was living with its extremely flat ventral valve down, its anterior and lateral commissures would be situated very near the substrate itself. In the Mons basin, the rate of sedimentation of the phosphatic chalk was relatively significant, with new phosphatic sediment continuously introduced from the open ocean. Under these conditions, such a life position for *C. limbata* would result in its rapid burial and death.

Fifteen specimens of *Cretirhynchia* limbata were sectioned longitudinally. In these specimens, it was observed that the pedicle tube was not filled with secondary shell material and consequently a functional pedicle is inferred for this species. Externally, the foramen is small, but it is surrounded by deltidial plates which form a short, wide-mouthed tube, a character generally observed in rhynchonellid brachiopods living fixed by means of their pedicle.

SURLYK (1972, p. 49, text-fig. 24) stressed the importance of gastropod borings from an ecological point of view because such borings must have been made on living specimens. Studying the gastropod borings distribution on the shells of *Trigonosemus pulchellus* (NILSSON, 1827), he demonstrated that this brachiopod was a secondary free living species on the sea bottom with its ventral valve down.

A similar method was applied to *Cretirhynchia limbata* specimens from the phosphatic chalk of Ciply. The results are indicated in Figure 3. Four hundred and seven bivalved shells were investigated and gastropod borings were found on seventeen shells only (less than 3% of the individuals are affected). The borings are cylindrical in shape and as suggested by SURLYK, they are most likely attributable to muricid gastropods. For nine shells, borings were observed in the flat ventral valve, mostly in the mid-valve region (Figure 3a). If *C. limbata* was attacked on the sediment surface (and not by burrowing naticid gastropods), it becomes difficult to accept that *C. limbata* was free living on the sea botton with its ventral valve down.

Eight shells exhibit similar borings on their dorsal valve. As illustrated in Figure 3b, the distribution of these borings seems to affect a peripherical zone of the dorsal valve, whereas the middle posterior zone of this valve was not attacked by gastropods. These results are consistent with the hypothesis of a fixed *C. limbata* living on the sediment with its dorsal valve down as drawn on Figure 3c. It is suggested that a divided pedicle occurred in *C. limbata* as it has been observed for other brachiopods directly rooted in the sediment, e. g. *Terebratulina retusa* LINNAEUS, 1758 (SURLYK, 1972, p. 21).

A typical feature of *Cretirhynchia limbata* is the rapid development of the fold present on the dorsal valve. In very young specimens, this fold is relatively low, but this part of the shell develops very rapidly during ontogeny. The high growth rate of the dorsal fold was useful to elevate the commissure of the shell continuously above the substrate throughout ontogeny. The posterior part of the dorsal valve, including the posterior part of the dorsal fold, was probably inserted in the subtrate giving a stable position to the whole shell. This overall growth strategy could mitigate the deleterous effect of the high sedimentation rate. This hypothesis implies that the extremely flat ventral valve cannot be interpreted as a stability device for this shell. The flat lobes and the very deep sinus present in the ventral valve should be regarded as an hydrodynamic adaptation improving the movement of water circulation useful for feeding.

Adaptations to care with rapid sedimentation are also observed in *Trigonosemus palissii* and *Carneithyris ciplyensis*.

The shell of *T. palissii* shows a distinct elongation during the growth and the posterior part of the shell is strongly thickened. The pedicle canal is infilled with secondary callus. Differential weighting of the posterior part of the shell was sufficient to achieve a living position

with the beak nearer the substrate while at the same time the anterior commissure was continuously elevated during the growth. Consequently, the risk of burial of *T.*
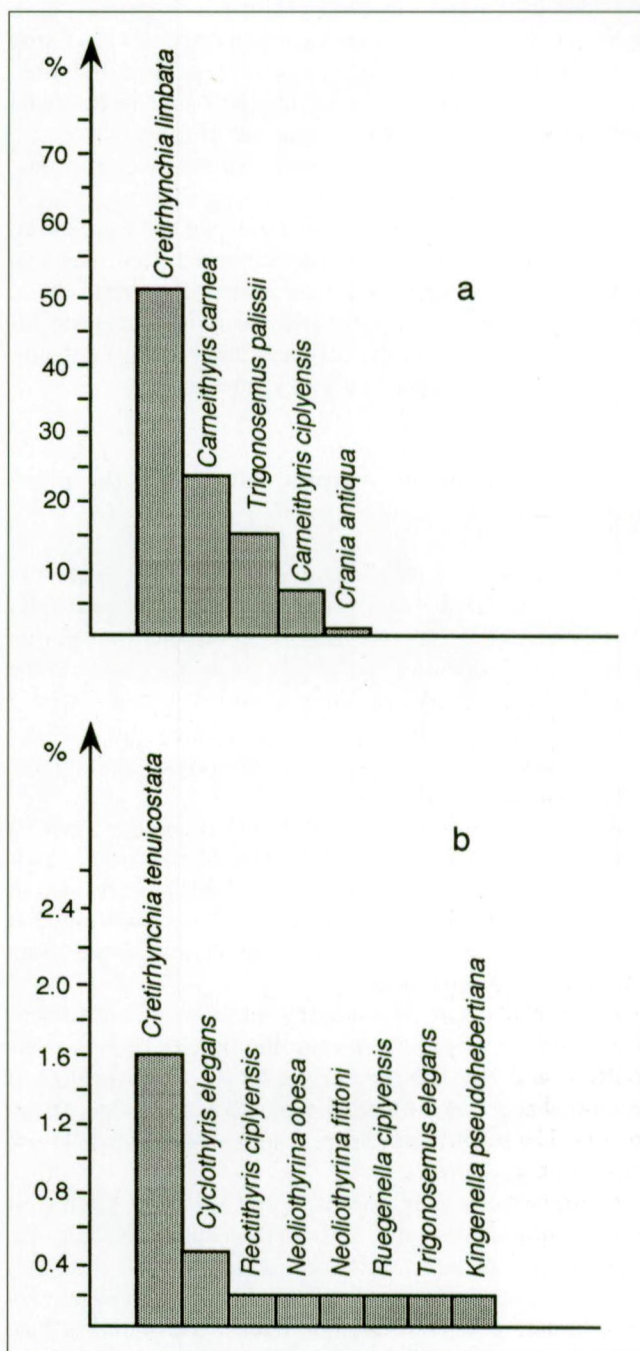

Fig. 2 – Relative abundance (in % of total number of individuals) of macromorphic brachiopod species collected from the phosphatic chalk of Ciply (Van Damme quarry, Ciply, Mons Basin, Hainaut, Belgium). A total amount of 1038 individuals representing 13 species were collected. 2a: Relative abundance of macromorphic brachiopods from the assemblage of species adapted to rapid sedimentation and non-energetic water conditions. 2b: Relative abundance of macromorphic brachiopods from the assemblage of species adapted to low sedimentation and more energetic water conditions.
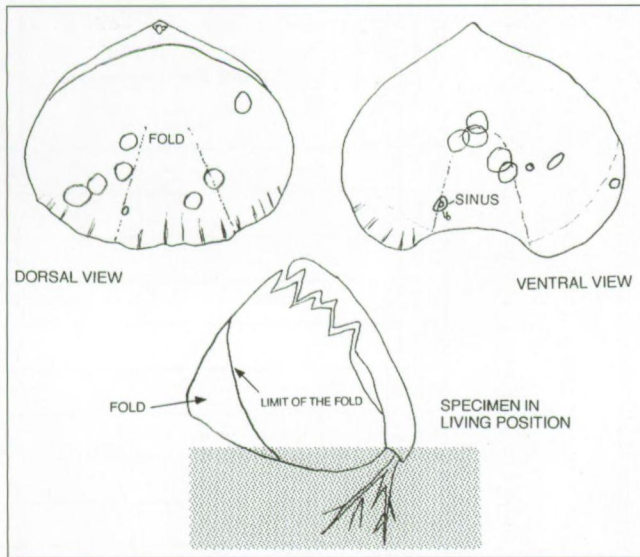
Fig. 3 – Relative positions of gastropod borings on the external shell surface of *Cretirhynchia limbata* (VON SCHLOTTHEIM, 1813) found in the phosphatic chalk of Ciply and illustration of a specimen in supposed living position (lateral view). The positions of gastropod borings in the middle of the ventral valve surface are an argument for invalidating the proposition of a rhynchonellid brachiopod free living on the sea bottom with its ventral valve down. The borings placed on the dorsal valve are in agreement with the proposed solution of a rhynchonellid brachiopod fixed directly in the sediment. A rooted (?) pedicle is a suggestion.

Assemblage of Lower Maastrichtian brachiopods adapted to low sedimentation and more energetic water conditions

The other macromorphic brachiopods found in the phosphatic chalk are much rarer. All species constituting this assemblage and their relative abundance in the phosphatic chalk are indicated in Figure 2b. *Cretirhynchia tenuicostata* (VON HANSTEIN,1879), *Cyclothyris elegans* (VON HANSTEIN,1879) and *Kingenella pseudohebertiana* (PÉRON, 1894) possess a relatively large foramen. *Rectithyris ciplyensis* (VON HANSTEIN,1879), *Neoliothyrina fittoni* (VON HAGENOW, 1842) and *N. obesa* (SAHNI, 1925) have a short beak with a large and labiate foramen. These species were fixed to large, hard substrates by their short and robust pedicle. The foramen of *N. obesa* is attrite. Those species were found at the base of the beds of phosphatic chalk. They are not found in association with any species of the *Cretirhynchia limbata* - dominated assemblage described above. This restricted position in the section, indicates that these brachiopods were probably living during periods characterized by a low sedimentation rate and when water currents were developing. They belong to the ecological group of medium to very large sized forms confined to large hard substrates (Group 1b of SURLYK, 1972, p. 17). *C. tenuicostata*, *C. elegans*, *R. ciplyensis* and *N. fittoni* were also found in the sediments collected in the cavities of the overlying hardground. It is inferred that these specimens were transported by water currents and trapped in the cavities of the

palissii due to the high rate of sedimentation, was avoided. This is one of the most striking distinction between *T. palissii* and *T. pulchellus* (NILSSON, 1827) from the white chalk facies of Denmark and Germany (Figure 4). In *T. pulchellus*, no elongation of the shell occurred and this brachiopod appears to have lived in a horizontal position as described by SURLYK (1972, text-fig. 12). The higher rate of sedimentation observed in the phosphatic chalk of Ciply induced distinctive adaptations in the brachiopod populations for avoiding a rapid burial of their shells.

Such an adaptation is also seen in *Carneithyris ciplyensis*. The posterior part of its shell was so heavy that the life position of whole shell was nearly erect. This has been observed in all complete bivalved shells of *C. ciplyensis* in which the matrix was removed.

Carneithyris carnea is thought to have used its pedicle as a drag anchor (ASGAARD, 1975, p. 361). When living, the life position of its shell was continuously regulated to avoid any burial problem.

All these brachiopods are specifically found in the thick beds of phosphatic chalk and were never extracted from the sediments infilling the cavities of the overlying hardground. These species constitute a distinct assemblage, adapted to a relatively low energetic environnement affected by rapid sedimentation.
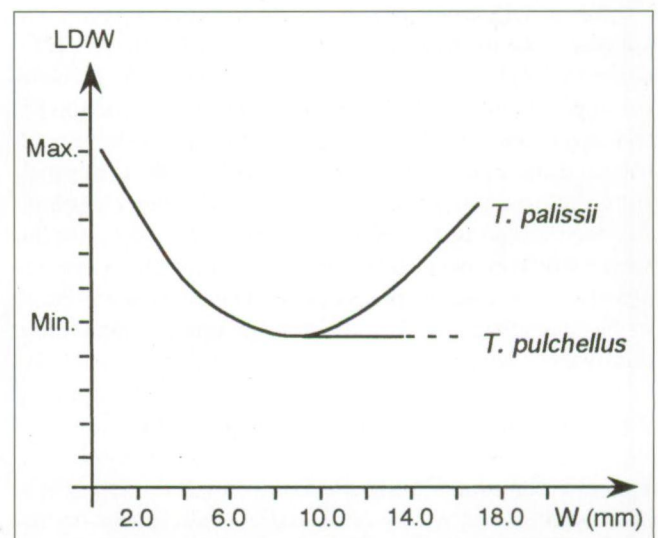

Fig. 4 – Schematic comparison between *Trigonosemus palissii* WOODWARD, 1854 and *Trigonosemus pulchellus* (NILSSON, 1827) showing respective variation in the ratio length of dorsal valve to width (LD/W) during growth. Shell elongation characterizing the adult growth stage of *T. palissii* is not observed in *T. pulchellus* . The curve for *T. palissii* is based on Figure 11 B (this paper). The curve for *T. pulchellus* is based on figure 262, p. 173 of STEINICH (1965). Max: maximal value for the ratio LD/W. Min: minimal value of the ratio LD/W.

hardground. This adds an argument for associating this brachiopod assemblage with more energetic water conditions.

Trigonosemus elegans KOENIG, 1825 was discovered exclusively at the limit between the uppermost part of the phosphatic chalk and the base of the hardground: this indicates that *T. elegans* was probably confronted with strong water current conditions.

The large, but very rare, *Terebratulina carinata* (VON HANSTEIN, 1879) is also a member of this assemblage.

A species directly cemented to its substrate

Crania antiqua DEFRANCE, 1818 is the only species found in the phosphatic chalk which belongs to the ecological group consisting of forms cemented directly to large substrates (Group 4b of SURLYK, 1972, p. 17). Only ventral valves were found.

C. antiqua was cemented to quite large subtrates and most of the large specimens investigated appear to be fixed by their posterior zone and not by their entire outer surface. A specimen (Plate 1, Figure 1 a - b) was cemented on a tube of *Sclerostyla mosae* (BRONN, 1837). In the other specimens collected, the zone of fixation of the shell is always clearly visible but the substrate is missing. A smaller specimen (Plate 1, Figure 2 a-b), 8.1 mm long, cemented by its entire outer surface on the dorsal valve of a *Carneithyris carnea*, is precisely oriented with regard to its "substrate": The posterior part of its valve is near the anterior commissure of the specimen of *C. carnea* and its anterior part extends posteriorly on the valve surface of the *Carneithyris*. The plane of symmetry of the valve of *C. antiqua* is nearly parallel to the plane of symmetry of the shell of *Carneithyris*. In all probability, this *C. antiqua* was fixed on a living *Carneithyris* where it installed itself at the best place to avoid burial, to profit from the best current for feeding, and without disturbing the way of life of *Carneithyris*. Although a lot of quite large subtrates such as belemnites, tubes of numerous *Sclerostyla mosae*, tests of echinoids etc. were available in the phosphatic chalk of Ciply, *C. antiqua* remains a relatively rare species.

The micromorphic brachiopods

A total amount of 772 individuals of small sized brachiopods were found in the phosphatic chalk. Eight micromorphic species are represented. Juvenile individuals of five macromorphic species were extracted. Specimens representing two species of *Isocrania* were also found using the same method of extraction. The detailed results concerning this material are presented in Table 1. The relative abundance of each species is illustrated in Figure 5.

The mean density of the species is 49 individuals / 10 kg of phosphatic chalk, a value which is low when compared to the results obtained by SURLYK for the Danish white chalk. But, the mean diversity, based on

Table 1 – Small sized brachiopods from the phosphatic chalk of Ciply extracted by the Glauber salt method. Minimal number of individuals extracted in 32 samples from the Van Damme quarry in Ciply and in one sample (n° 45) collected in the underground "La Malogne" quarry in Cuesmes. The mean depth indicated in this table corresponds in practice to the mid point of a sampling range equal to the mean depth ± 10cm above and below mean depth value. This depth is measured from the base of the hard-ground overlying the phosphatic chalk. The samples are arranged in increasing order of collected depths in the section. The brachiopod species are arranged in decreasing order of abundance. The ratio "total amount of individuals /10 kg of chalk" gives, for each sample, a measurement of the density of micromorphic species in the phosphatic chalk of Ciply.

| Samples N°	12	24	25	4	36	38	2	46	40	42	35	41	43	16	18	19	21	14	20	22	5	26	30	31	33	9	29	27	28	34	39	45	Total amount of individuals/species
Mean depth (cm)	10	10	10	25	55	85	100	120	150	160	180	200	200	200	200	200	200	250	250	250	270	280	280	280	280	300	350	400	400	400	400	1200	Total amount of chalk investigated 158 Kg
Dry weight of chalk (in Kg)	12.1	5.1	6.7	5.3	5.1	5.3	4.8	3.8	5.2	2.1	4.9	4.3	2.0	5.1	5.8	2.5	6.4	9.3	4.9	8.0	5.5	1.1	5.0	5.0	5.2	6.6	5.1	4.2	5.0	2.2	1.9	0.6	
Argyrotheca popelae				135	49		1	13	8	43		9	31	14	66	4	50	10	15	11	14	1	7	7								3	495
Rugia curvirostris n. sp.	3	4	8	1	4			2	3	5				1	9	4	13	11		14	8		3	6		4	1					8	111
Leptothyrelopsis polonicus		1	1		2		1	4				4	1	1	6	3		5			1	1	2	4	1	4	1						43
Isocrania phosphatica n. sp.									1	4				6	6		5	1	1	6	9	3	5	5	1				2		1		39
Isocrania praecostata				2	2								1	2	2		2	1						1					2		1		28
Terebratulina chrysalis								3				1	1		1		1		1	1			2	1	1	1	2		1				26
Trigonosemus pallisii (juvenile)										1		1	2							1			1	2		1							12
Megathiris bidiscoidea										2			2								3												8
Aemula inusitata										2																							2
Kingena sp.														1																			2
Argyrotheca cf. acunosa					1											1																	2
Argyrotheca aff. corniuncta			1																										1				1
Carneithyris sp. (juvenile)																		1															
Cretirhynchia sp. (juvenile)																													1				2
Total amount of individuals/sample	3	5	10	138	58	0	2	22	12	57	0	15	37	25	90	9	73	29	17	33	36	5	20	26	2	11	4	0	7	0	2	11	772
Total amount of individuals/10kg chalk	3	10	15	260	114	0	4	58	63	271	0	35	185	49	155	36	114	31	35	41	65	46	40	52	4	17	8	0	14	0	11	183	48.9
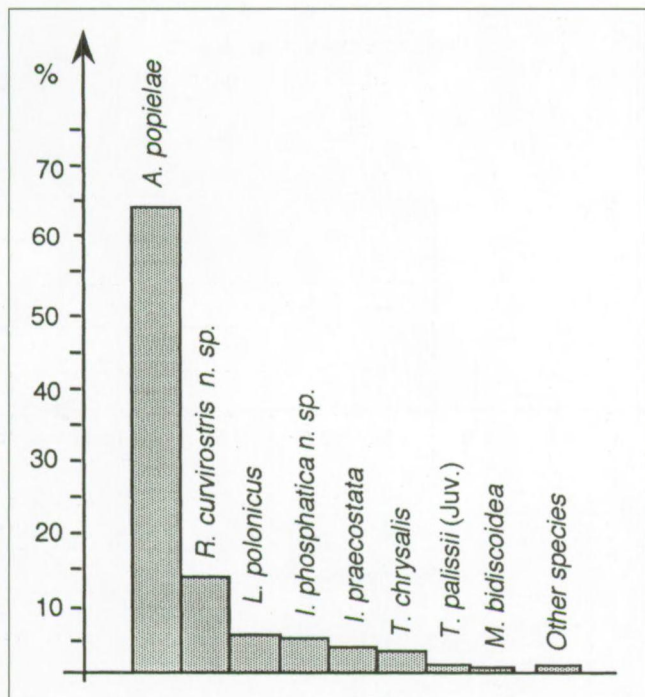
Fig. 5 – Relative abundance of individuals of small sized brachiopod species collected in 158 kg of phosphatic chalk of Ciply (Van Damme quarry, Ciply, Mons basin, Hainaut, Belgium). A total amount of 772 individuals representing 15 species were collected. All the rare species, representing respectively less than 1% of the total amount of individuals, were put together under the caption "Other species".

the number of species discovered is similar to the diversity observed in the Danish white chalk (SURLYK, 1972, p. 11, text-fig. 3). If the macromorphic brachiopods are taken into account (13 species) the diversity is even higher in the phosphatic chalk, however mean values remain subjective and a finer analysis of the results is useful.

The density of the brachiopods in the phosphatic chalk is extremely variable. The distribution of small sized brachiopods varies through the profile studied and is discontinuous. The density is often higher in the samples including a limit between two beds of phosphatic chalk. This is mainly due to the relative abundance in these samples of *Argyrotheca popielae* SIMON 1992, a species probably favoured by more energetic water conditions. In the samples collected in the middle part of beds of phosphatic chalk, the density is more regular but it is rather lower.

Some samples (±10%) did not provide any well preserved, small sized brachiopods. Most of these samples were rich in *Microchlamys pulchella* and in *Sclerostyla mosae* and contained a lot of small fragments of diverse unrecognizable *Argyrotheca* species. It is impossible to establish precise numbers of individuals in these conditions, therefore they are not included in the results of Table 1.

Lower Maastrichtian micromorphic brachiopods assemblage (Phosphatic chalk assemblage *sensu stricto*)

Argyrotheca popielae SIMON, 1992, *Rugia curvirostris* n. sp., *Leptothyrellopsis polonicus* BITNER & PISERA, 1979 and juveniles of *Trigonosemus palissii* WOODWARD, 1854, all together represent 89% of the total number of micromorphic brachiopods collected. Other micromorphic brachiopod species were discovered only because a large number of samples were treated. The diversity in the phosphatic chalk of Ciply appears quite low, if rare species are not taken into account. A similar conclusion was already drawn for the macromorphic brachiopods.

A. popielae, *R. curvirostris* n. sp. and *L. polonicus* are micromorphic species present troughout the whole investigated section. *R. curvirostris* n. sp. and *L. polonicus*, which belong to the ecological group of the small forms, attached to the substrate by means of their pedicle (Group 1a of SURLYK, 1972, p. 17), were probably associated with bryozoa.

R. curvirostris n. sp. , *L. polonicus*, and, pro partim, *A. popielae* constitute an assemblage of micromorphic brachiopods which is characteristic of the phosphatic chalk sensu stricto. They are associated with the macromorphic brachiopod assemblage including *Cretirhynchia limbata*, *Carneithyris carnea*, *C. ciplyensis* and *Trigonosemus palissii*.

Size-frequency diagrams have been established for *Rugia curvirostris* n. sp. and *Leptothyrellopsis polonicus* (Figure 6). A clear right skewed distribution is observed for *L. polonicus*. This effect is also seen for *R. curvirostris* n. sp. but not so strongly. Right skewed distributions have previously been observed by SURLYK (1972, text-figs. 16-18) for micromorphic brachiopods from the Danish chalk. This distribution indicates that small pedunculate brachiopod populations consist mainly of juveniles and young adult specimens.

The size-frequency distribution established for juveniles and young specimens of *Trigonosemus palissii* is totally different. Very few juveniles were found and this species shows a left skewed distribution characteristic for the free living brachiopods as already shown by SURLYK (1972, p. 40). An initial greater growth rate is inferred for these species.

Assemblage of Lower Maastrichtian small sized brachiopods adapted to low sedimentation and/or more energetic water conditions

Two small sized species are considered in this assemblage which is found in the samples collected at the base of phosphatic chalk beds.

One is *Argyrotheca popielae*, which is more abundant in these samples than in those from the middle part of the phosphatic chalk beds. This *Argyrotheca* species has a large foramen which is suitable for a short, wide and strong pedicle. This can be considered as an adaptation to energetic environments.
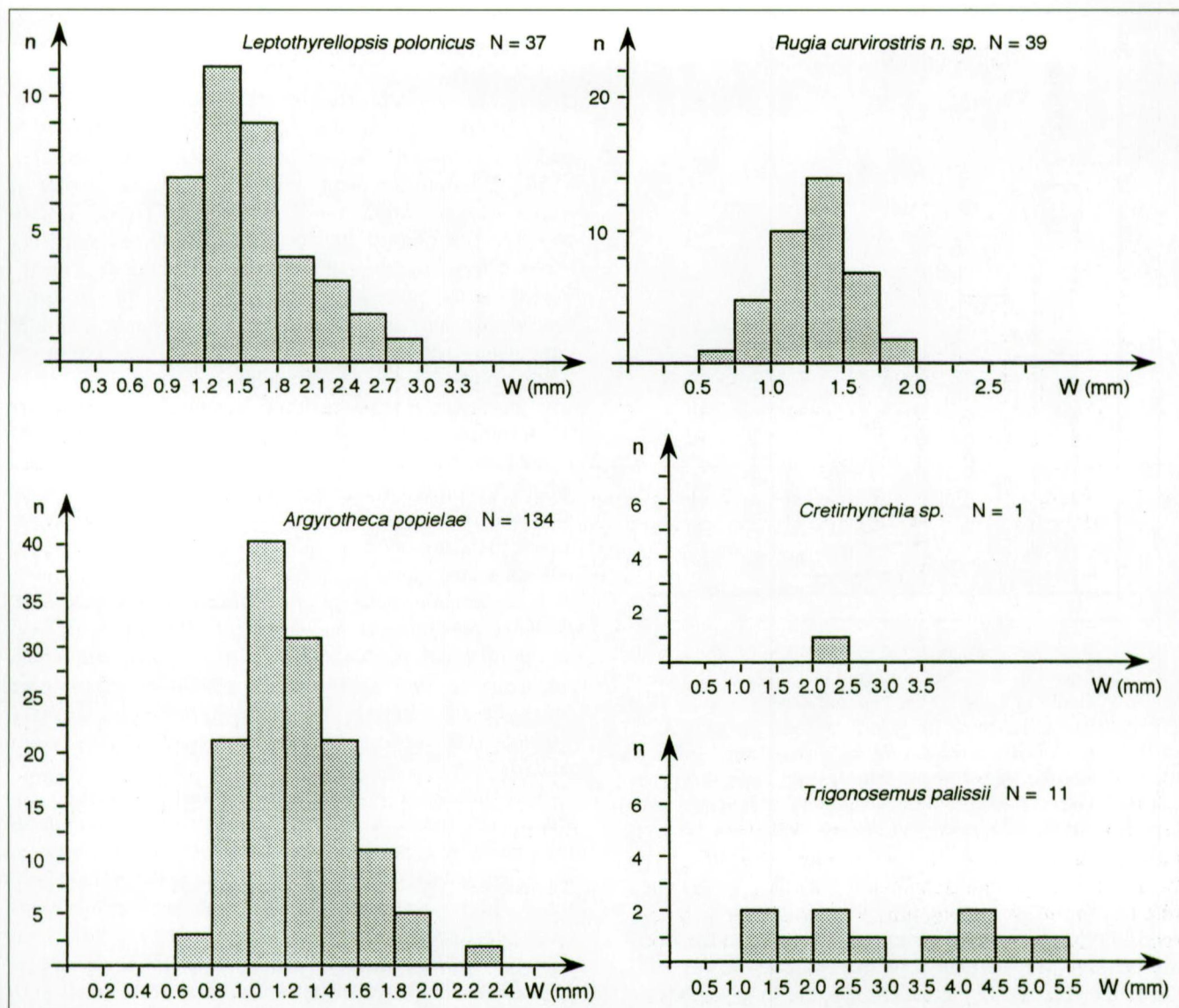
Fig. 6 – Size-frequency diagrams of the species found in samples collected in the phosphatic chalk of Ciply, Van Damme quarry, Ciply (Hainaut, Belgium). N: total numbers of individuals measured. Damaged specimens are omitted. n: number of individuals in the different size-classes. Abscissa is width of individuals measured. For *Cretirhynchia sp. and for Trigonosemus palissii*, juveniles and very young individuals only are taken into account.

The size-frequency diagram established for *A. popielae* is illustrated in Figure 6. A strong right skewed distribution for this brachiopod is apparent.

The second species is *Isocrania phosphatica* n. sp. Specimens of *I. phosphatica* are well preserved, especially the ventral valves. The ventral valve is extremely flat and a small attachment surface is clearly visible. On some specimens fragments of tiny substrate remain still attached. Other ventral valves show a damaged attachment surface as if the valve was harshly pulled away by water current. *I. phosphatica* n. sp. was not a free living species but was cemented to small subtrates. Size frequency diagrams illustrated for this species in Figure 7 shows a unimodal distribution typical for a fixed brachiopod species. Secondary free living *Isocrania* species, such as *I. costata* (SOWERBY, 1823), exhibit a typical

bimodal distribution in their size frequency diagrams (SURLYK, 1973, p. 226, text-fig. 5). The protegular node of the ventral valve is placed posteriorly: this character is typical for the fixed species of *Isocrania* as demontrated by ERNST (1984, p. 30).

The number of ribs and the smooth surface of the shell between the ribs indicate that this species was living in an environment subject to water currents. As shown by SURLYK (1973, p. 231), the very flat, circular ventral valve is a useful adaptation giving greater stability in high energy situations.

Many dorsal valves collected in the phosphatic chalk are partly polished (often, the ribs are partly erased). This is not observed for the ventral valves. This difference could be attributed to frequent current actions causing abrasion of the exposed dorsal valve. Water current ef-
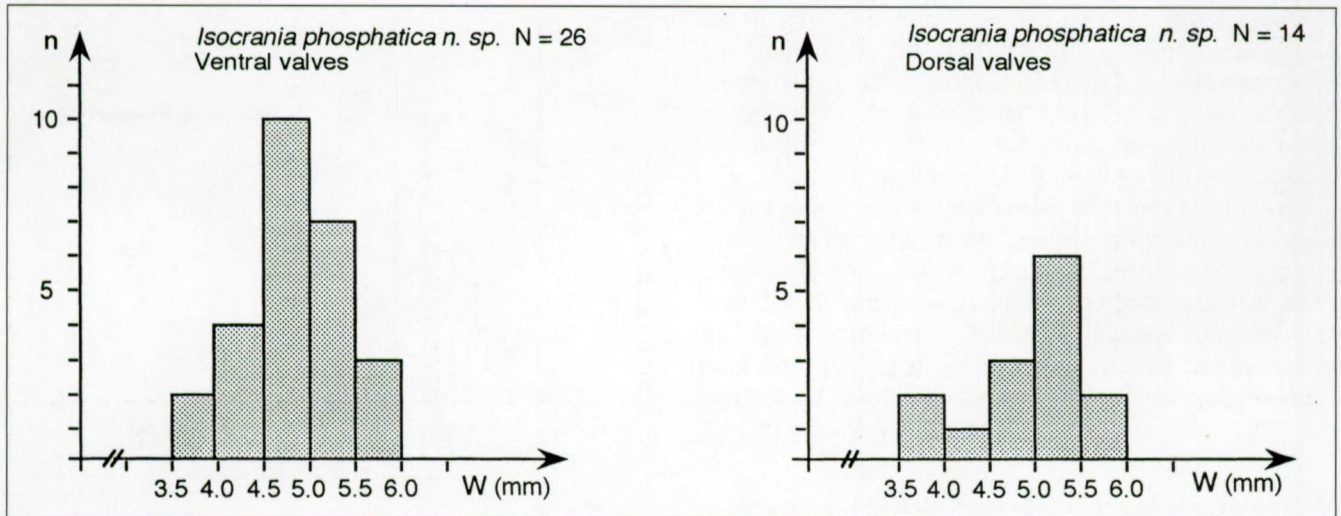
Fig. 7 – Size-frequency diagrams of *Isocrania* phosphatica n. sp. found in samples collected from the phosphatic chalk of Ciply (Van Damme quarry, Ciply, Hainaut, Belgium). N: total numbers of ventral or dorsal valves measured. n: number of individuals in the different size-classes. Abscissa is width (in mm) of individuals measured. The number of dorsal valves is lower than the number of ventral valves. The collected dorsal valves are not very well preserved due to selective transport which affected only dorsal valves. The ventral valves were fixed to small substrates and were better preserved *in situ*. The size-frequency distribution obtained for the dorsal valves cannot be taken into account due to selective transport.

fects could also explain the fact that no bivalved shells were found and that ventral valves and dorsal valves are found separately in different samples.

Isocrania praecostata ERNST, 1984 also occurs in samples similarly located in the section, but the very poor state of preservation of the specimens extracted, which are mostly fragments, indicate that these specimens were transported for a long time or over greater distances. Accordingly, *I. praecostata* was not included in the present assemblage together with *I. phosphatica* n. sp.

It is noteworthy that *Argyrotheca popielae* and *Isocrania phosphatica* n. sp. were also collected from the sediments infilling the cavities of the hardground which cover the phosphatic chalk.

A Lower Maastrichtian micromorph brachiopod-pectinid community

Some micromorphic brachiopods were found in the phosphatic chalk in a poor state of preservation and these species probably belong to an assemblage other than one of those described above in which micromorphic species were found well preserved. These micromorphic species were transported for a longer time and/or over greater distances.

Terebratulina chrysalis (VON SCHLOTTHEIM, 1813) is a tolerant species which was living directly fixed to the sediment (Group 1c of SURLYK, 1972, p. 1. See also same paper pp. 21-23). A few poorly preserved individuals of this species were collected in the phosphatic chalk. This was also the case for *Megathiris bidiscoidea* SIMON, 1992 and for some *Argyrotheca* species.

The fact that thousands of separated valves of *Microchlamys pulchella* were also repetitively transported,

raises the possibility of the existence of an allochtonous micromorph brachiopod-pectinid community in the phosphatic chalk of Ciply. The list below gives some idea of the species which may be included in this community.

Pectinid species found as isolated valves:
Microchlamys pulchella (NILSSON, 1827)
M. campaniensis (D'ORBIGNY, 1847)
? *Chlamys ternata* (G. VON MUENSTER in A. GOLDFUSS, 1833)
M. subarata (NILSSON, 1827)
Entolium membranaceum (NILSSON, 1827)
Syncyclonema hagenowi DHONDT, 1971

Other Bivalvia found as isolated valves
Limatula semisulcata (NILSSON, 1827)
Hypoxytoma tenuicostata (ROEMER, 1841)
Hyotissa semiplana (J. DE C. SOWERBY, 1825)

Tube worms
Sclerostyla mosae (BRONN, 1837
S. ciplyana (DE RYCKHOLT, 1852)

Micromorphic brachiopods which could be assigned to this community
Argyrotheca cf. *lacunosa* STEINICH, 1965
A. aff. *coniuncta* STEINICH, 1965
A. div. sp. (numerous undeterminable fragments)
Megathiris bidiscoidea SIMON, 1992
Terebratulina chrysalis (VON SCHLOTTHEIM, 1813)

BENIGNI & ROBBA (1996) described a brachiopod-pectinid community from the Pliocene of Rivarone (Piedmont,

Northern Italy) and there is a striking similarity in the biological composition of this Pliocene community and the Lower Maastrichtian brachiopod-pectinid community described herein from the chalk of Ciply. The species listed above can be compared with the species listed in BENIGNI & ROBBA (1996, p. 346, table 2).

Soon, the community from Ciply will be better known when the molluscs and others organisms from these samples will be studied. In previous studies, the phosphatic chalk was described as a relatively homogenous sediment that was investigated by wholesale sampling methods. To obtain more accurate results on the brachiopod-pectinid community, closer sampling methods should be applied.

Micromorphic brachiopods extracted in the cavities of the hardground

Micromorphic brachiopods from the contact zone between the top of the phosphatic chalk and the base of the overlying hardground: a possible "*subtilis*" Zone in Ciply

Three samples were collected at the base of the hardground where the contact with the top of the phosphatic chalk occurs. Soft sediment (15.1 kg) extracted from cavities in the hardground contained brachiopod species already found in the phosphatic chalk.

Hundreds of complete shells of *Argyrotheca popielae* were extracted. A size-frequency diagram showns (Figure 8) a left skewed distribution similar to that observed for this species in the phosphatic chalk samples (Figure 6).

Upper Maastrichtian species which are found mainly in the middle part of the hardground are also present in these three lower samples. They will be discussed below.

But, several species were exclusively found in these samples. These species are: *Terebratulina subtilis* STEINICH, 1965, *Dalligas nobilis* STEINICH, 1968, *Gisilina* aff. *jasmundi* STEINICH, 1965 and *Argyrotheca* cf. *coniuncta* STEINICH, 1965. Although material was transported and trapped in the cavities of the hardground, the specimens are well preserved. Well preserved specimens of *Terebratulina chrysalis* were also found.

In Rügen (Northern Germany), *D. nobilis* and *T. subtilis* are specifically found in the upper part of the Lower Maastrichtian (STEINICH, 1965). For SURLYK (1970b), *T. subtilis* is also an important stratigraphical marker diagnostic of the *subtilis - pulchellus* Zone in the Danish and the German white chalks. The presence of this brachiopod assemblage at this level suggests that a very feeble transgression probably occurred during the upper part of the Lower Maastrichtian in the area of Ciply.

Uppermost Maastrichtian small sized brachiopods found in the cavities of the hardground

Eleven samples of soft sediment (40.1 kg) were collected from numerous cavities in the middle part of the hard-
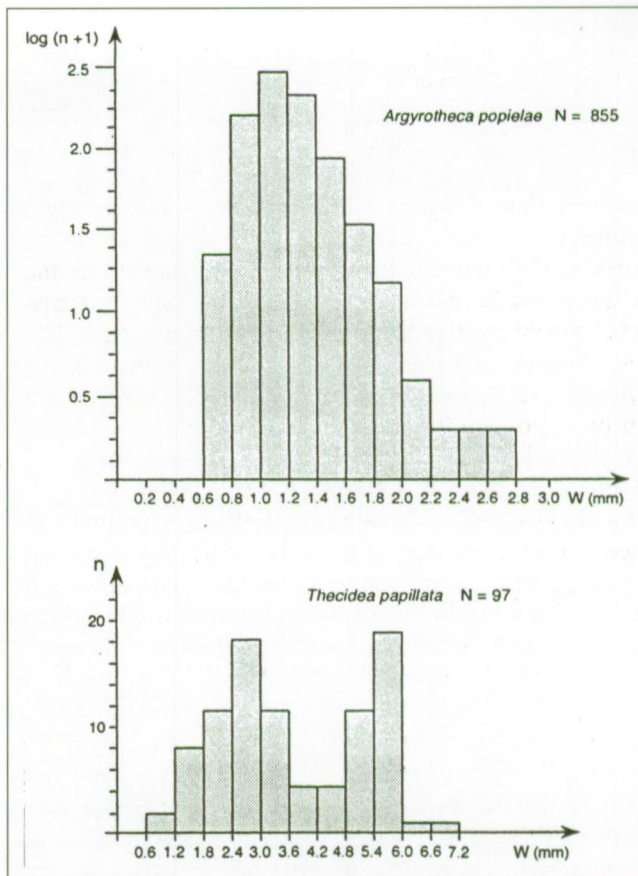

Fig. 8 – Size-frequency diagrams of *Argyrotheca popielae* SIMON, 1992 and of *Thecidea papillata* (VON SCHLOTTHEIM, 1813) found in samples collected from the cavities in the hard-ground overlying the phosphatic chalk of Ciply (Van Damme quarry, Ciply, Hainaut, Belgium). N: total numbers of ventral or dorsal valves measured. n: number of individuals in the different size-classes. Abscissa is width (in mm) of individuals measured. For *Argyrotheca popielae*, ordinate is logarithmic (log n+ 1) due to the large number of individuals present in some size-classes.

ground. The upper part, containing mainly Danian sediments, was excluded from this sampling.

Several Upper Maastrichtian micromorphic brachiopod species are found in these sediments. *Argyrotheca* cf. *microscopica* (VON SCHLOTTHEIM, 1813), is a species which occurs in large quantity in the uppermost Maastrichtian Chalk of Meersen from the Maastricht area. This material is not well preserved and is reworked.

A. stevensis (NIELSEN, 1928) which is known from the Upper Maastrichtian and Lower Danian from Denmark (JOHANSEN, 1987 a, p. 30 , text-fig. 21, pl. 12, figs. 6 A, B, pl. 13, figs. 1 - 4) is a rare species here in Ciply and has a stratigraphical interest.

A new species of *Terebratulina* was found and was also considered as an Upper Maastrichtian brachiopod. But the few number of specimens precludes a valid diagnosis. For this reason, this brachiopod remains in open nomenclature as *Terebratulina* n. sp.

The brachiopod which is fairly abundant in these sediments is *Thecidea papillata* (VON SCHLOTTHEIM, 1813). Its state of preservation is variable: some specimens are corroded and it is obvious that they were harshly transported. Other specimens are extremely well preserved: the ribs are intact with their small spines and the brachidium is completely preserved. A single origin is proposed for these two kinds of *T. papillata* because the matrix of both types is identical. It is envisaged that the cavities in the hardground were acting as traps for transported brachiopods when a transgression occurred. The specimens which were trapped immediatly in the cavities remained well preserved. Other specimens which were transported over a longer time interval and were trapped in the cavities much later suffered the effects of transport.

As the fissures and cavities of the hardground are much larger than the tiny shells of *T. papillata*, all size-categories represented in this transported population were trapped with an equal efficiency. A size-selective transport did not occur. Size-frequency distributions were investigated for *T. papillata* (Figure 8).

A typical bimodal distribution is observed for this secondary free-living brachiopod. Two peaks of mortality are registered; the first one corresponds to the fixed juvenile specimens and the second corresponds to the adult free living stage.

Specimens from the phosphatic chalk of Ciply (Lower Maastrichtian) were reported as the oldest representatives of this species (see BACKHAUS 1959, p. 27). This mention is doubtful. In all the samples investigated for the present paper, *T. papillata* has never been found in the phosphatic chalk of Ciply. Some specimens collected in the hardground were opened. They are filled with an original matrix which is identical to the matrix found in the specimens collected in the Tuffeau of Saint-Symphorien (uppermost Maastrichtian). For these reasons the specimens of *T. papillata* collected in the Van Damme quarry are definitely considered as uppermost Maastrichtian brachiopods.

It is not possible to certify that the Tuffeau of Saint-Symphorien was covering effectively the hardground in this part of the Mons basin. But as this "formation" is still covering the same hardground in other parts of the Mons basin (the Tuffeau of Saint-Symphorien was discovered 100 meters north of here), this possibility cannot be excluded. In the same way, sediments from the Tuffeau of Saint-Symphorien could have been transported and reworked during a transgression which occurred during the Lower or Middle Danian. However, more detailed sampling programme and other specific analyses must be made before this question can be resolved.

Discussion

The study of macromorphic and micromorphic brachiopods from the Lower Maastrichtian phosphatic chalk of

Ciply indicates the existence of three different assemblages in this sediment. Two of these brachiopod assemblages are considered to be autochtonous and thought to represent two distinct sets of palaeoecological conditions. The first assemblage, including macromorphic secondary free living brachiopods and species directly fixed to the subtrate and associated in their environment with micromorphic pedunculate brachiopods probably linked to bryozoa, is typical of the phosphatic chalk *sensu stricto*. This assemblage is adapted to a relatively quiet environment affected by a high sedimentation rate due to the continuous importation of a chalky calcarenite from the open ocean. This calcarenite was invaded by phosphatic ions due to centripetal phosphatisation (ROBASZYNSKI, personnal communication, 1997).

The second assemblage, only present at the base of the phosphatic chalk beds, is typical of a environment with a low sedimentation, affected by more energetic water conditions. Macromorphic brachiopods of this assemblage are relatively large species fixed to hard substrates by means of a well developed pedicle or brachiopods cemented to tiny subtrates and adapted to water currents. Micromorphic brachiopods are mainly represented by a species exhibiting a large foramen indicative of a fixation to the substrate by means of a strong and short pedicle.

A third allochtonous assemblage, consisting of a transported micromorphic brachiopod-pectinid community, is also evident. This area of the Mons basin was periodically submitted to strong storms from the open ocean for short periods. Harsh transportation of the representatives of this brachiopod-pectinid community occurred on these occasions and this material was often mixed with the autochtonous phosphatic chalk brachiopod assemblages.

The study of the brachiopods collected at the contact zone between the phosphatic chalk and the overlying hardground provides evidence of a possible weak transgression which occurred in this area during the upper part of the Lower Maastrichtian.

The brachiopods found in the cavities of the hardground itself are typical representatives of Upper Maastrichtian and uppermost Maastrichtian species. It has also been shown that the specimens of *Thecidea papillata* from Ciply must be related to the Tuffeau of Saint-Symphorien which is an uppermost Maastrichtian "formation".

The phosphatic chalk of Ciply represents a peculiar facies, quite distinct from the white chalk facies. The abundance of phosphates in an environment is generally considered as a disadvantage for the development of biological communities. The species involved in such communities must be tolerant to this factor. Endemism has occasionally been suggested for the fauna from the phosphatic chalk. It seems that this opinion must be treated with great care, as many of the species found in Ciply were already found in other places representing other types of sediments as white chalk or glauconitic chalk.

The species *Rugia curvirostris* n. sp. is possibly endemic to Ciply but it can be considered as a vicariant of *R.*

acutirostris STEINICH, 1965 which occurs in the white chalk of the same *Belemnella obtusa* Zone.

A stratigraphical correlation with the brachiopod zonation established by SURLYK (1982, 1983 and 1984) for the white chalk facies of Denmark and Northern Germany can be tentatively proposed. The phosphatic chalk of Ciply can be correlated with the acutirostris - spinosa Zone. The soft sediments collected in the cavities at the base of the overlying hardground are referred to the *subtilis - pulchellus* Zone. In part, the sediments filling the cavities of the middle part of the hardground can be correlated with the stevensis- chitoniformis Zone.

The study of the other faunal elements such as molluscs and echinoderms, collected in the same samples, will provide additional precision and an integrated study of the phosphatic chalk of Ciply is expected in the near future.

Systematic description

Phylum Brachiopoda DUMÉRIL, 1806
Subphylum Craniiformea WILLIAMS *et al.*, 1996
Order Craniida WAAGEN, 1885
Suborder Craniidina WAAGEN, 1885
Superfamily Cranioidea MENKE, 1828
Family Craniidae MENKE, 1828
Genus *Crania* RETZIUS, 1781
Type species: *Crania craniolaris* (LINNÉ, 1758)

Crania antiqua DEFRANCE, 1818
Text-Figure 2, Plate 1, Figures 1 a-b, 2 a-b.

* 1818   *Crania antiqua*, Def.- DEFRANCE, p. 312, vol. II, pl. 84, figs. 1, 1a,1b.
. 1819   *Crania antiqua* - DE LAMARCK, p. 239, n°4.
  1828   *Crania antiqua*, DEFRANCE. - HOENINGHAUS, p. 7, n° 6, fig. 6.
  1840   *Crania antiqua* Defr. - GOLDFUSS, p. 293, pl. 162, fig. 6 a-g.
. 1842   *Crania antiqua* - VON HAGENOW, n°2, p. 529.
. 1847   *Crania antiqua*, Defrance. - D'ORBIGNY, p. 143, pl. 525, figs. 11-15.
. 1847   *C. antiqua* Defrance. - MÜLLER, p. 43, n° 3.
. v 1859 *Crania antiqua* DEFR. 1818. - BOSQUET, p. 19, pl. 2, figs. 21-22.
  1859   *Crania antiqua*, Defr. - BINKHORST VAN DEN BINKHORST, pp. 70, 91, 140, 147.
  1860   *C. antiqua* Defr. - BOSQUET, n° 545.
  1866   *Crania antiqua* Defr. 1818 - SCHLOENBACH, p. 317.
  1879   *Crania antiqua* Defr. - VON HANSTEIN, p. 15.
  1879   *Crania antiqua* Defr. - UBAGHS, pp. 64, 127, 138, 215.
. 1885   *Crania antiqua* DEFRANCE - LUNDGREN, p. 28, pl. 1, fig. 7.
  1887   *Crania antiqua* - UBAGHS, p. 65.
. 1894   *Crania antiqua*, DEFRANCE - HENNIG, p. 511.
  1894   *Crania antiqua* Defrance - POSSELT, p. 22.
. 1909   *Crania antiqua* DEFRANCE. - BRÜNNICH NIELSEN, p. 154, pl. 1, figs. 16, 17.
  1910   *Crania antiqua* DEFR.- HENNIG, p. 661.
  1934   *Crania antiqua* DEFR.- LUNDEGREN, p. 246.
  1947   *Crania antiqua* Defrance - HÄGG, p. 99.
. 1947   *Crania antiqua*, Defr. - ZACHARIEVA - KOVACEVA, p. 267, pl. 4 fig. 16.
  1958   Crania craniolaris antiqua DEFRANCE 1818 - CARLSSON, p. 22, òpl. 2, figs. 10, 11.
. 1969   *Crania antiqua* Defrance 1818 - KRUYTZER, p. 12, fig. 2 a-b.

. 1972   *Crania antiqua* Defrance, 1818 - SURLYK, p. 17, fig. 5, p. 27.
  1979   *"Crania" antiqua* (Defrance) - BARBULESCU et al. , p. 2.
. 1979   *Crania antiqua* Defr. - BARBULESCU et al. , pl. 1, figs. 1-8.
. 1992   *Crania antiqua* (DEFRANCE, 1818) - POPIEL-BARCZYK, p. 9.

Stratigraphical range: Upper Campanian to Upper Maastrichtian.

Material: eight ventral valves, four fragments of ventral valves, no dorsal valves and one ventral valve, cemented on an intact shell of *Carneithyris carnea* (J. SOWERBY, 1812).

The specimens of *Crania antiqua* found in the present study are consistent with the descriptions of previous authors. The typical area of the ventral valve is always clearly visible. A detailed description of specimens from the phosphatic chalk of Ciply has already been provided by KRUYTZER (1969, p. 12).

Genus *Isocrania* JAEKEL, 1902
Type species: Crania Egnabergensis RETZIUS, 1781

Isocrania praecostata ERNST, 1984
Table 1, Text-Figure 5, Plate 1, Figures 3 a-b, 4 a-b.

* 1984   *Isocrania praecostata* n. sp. - ERNST, fig. 26, fig. 27, p. 64, pl. 5, fig. 3, pl. 6, figs. 1-2, p. 74.

Stratigraphical range: Lower Maastrichtian.

Material: All the specimens were collected in the phosphatic chalk of Ciply. No bivalved shells, eight dorsal valves, eight damaged dorsal valves, 19 ventral valves, two damaged ventral valves and nine small fragments.T Both dorsal and ventral valves are often eroded or broken, indicating this material has been transported.

Description
Ventral valve
This valve is quite large with strong ribs. The outline is subcircular to subquadrate. The valve is slightly wider than long. The ventral valve is very flat with a small attachment area located posteriorly: the ratio Lp/La reaches 0,504 (see Table 2 for explanation of Lp and La). The number of ribs is relatively low and varies from 16 to 27. A specimen, exceptionally, has only 11 ribs. The number of primary ribs varies from 9 to 12. The strong ribs protrude beyond the valve margin. The surface between the ribs is densely covered by coarse radially directed spines.

The posterior adductor scars are strong and close to each other. The strong anterior adductor scars are in the middle of the valve and they take the typical form of a small hatchet. They are separated by a well developed rostellum.

Dorsal valve
Few well preserved dorsal valves were collected. The dorsal valve is low conical in outline and its umbo is still

placed posteriorly. The anterior adductor scars are centrally placed in the valve floor and they have also a typical hatchet form. The small protractor scars are indistinct and anteriorly situated, not far from the anterior adductor scars.

This material is consistent with the original description given by ERNST (1984, p. 64-65).

Isocrania phosphatica n. sp.
Table 1, Table 2, Text-Figures 5, 7, 9, Plate 1,
Figures 5 a-d, 6 a-b, 7.

Diagnosis - Medium-sized Isocrania with subcircular outline. Both valves have an ornamentation of 23-38 ribs, the lateral ones slightly curved posteriorly. The shell surface between the ribs is always smooth. Ventral valve very flat with a small attachment surface located very posteriorly. Dorsal valve conical with its umbo also placed posteriorly. Anterior adductors of the ventral valve situated slightly posteriorly. Anterior adductors of the dorsal valve situated in a central position.

Derivatio nominis: ''phosphatica'' is an allusion to the phosphatic chalk of Ciply.

LOCUS TYPICUS: Van Damme quarry in Ciply, Hainaut, Belgium.
STRATUM TYPICUM: Phosphatic chalk of Ciply. Upper part of the lower Lower Maastrichtian.

Holotype.
Isocrania phosphatica n. sp. Plate 1, Figure 5 a-d. The holotype is an adult ventral valve preserved in the Institut royal des Sciences naturelles de Belgique in Brussels, IRScNB - IST n° 10681. It was collected in sample n°18 (Table 1) near the limit of two beds of phosphatic chalk at a depth of 200 cm below the base of the hardground. The morphological characters measured on the holotype are indicated in Table 2.

Material: no bivalved shells, 27 intact ventral valves, seven

Table 2 – Morphological characters measured on the holotype of Isocrania phosphatica n. sp. from the phosphatic chalk of Ciply. Van Damme quarry, Ciply (Hainaut, Belgium). IRScNB - IST n° 10681. L: length of the ventral valve, W: width of the ventral valve, Lp: distance from the protegular node to the posterior margin of the ventral valve, La: distance from the protegular node to the anterior margin of the ventral valve, NRp: number of primary ribs and NRT: total number of ribs.

	L mm	W mm	Lp mm	La mm	Lp/La	NRp	NRT
Isocrania phosphatica n. sp. Holotype IST N°10681	4.9	4.9	1.1	3.8	0.29	10	38

damaged ventral valves, 14 intact dorsal valves, eight damaged dorsal valves and six fragments collected from the phosphatic chalk of Ciply. These shells are well preserved. This material has not been transported over long distances.

Extracted from the soft sediment infilling the hardground cavities: no bivalved shells, seven intact ventral valves, 16 damaged ventral valves, 12 intact dorsal valves, 12 damaged dorsal valves and nine fragments.

Description
Ventral valve
The outline is subcircular but its posterior margin is clearly truncated. The valve is often slightly wider than long. The ventral valve is strikingly flat with a small attachment surface located very posteriorly: the ratio Lp/La has a mean value of 0.29 but it could be as low as 0.21 (Figure 9). On some specimens, fragments of the substrate used for fixation of the valve are still visible. The number of primary ribs varies between 9 and 12. New ribs are formed by intercalation and their number increases to 39. Generally, a number of 29-32 ribs is observed for adult shells. The ribs are relatively strong, the lateral ones curving posteriorly. They do not protude, or very few, beyond the valve margin. Between the ribs, the surface of the shell is always smooth.

The posterior adductor scars are close to each other and they are separated by a septum like extension of the limbus. The anterior adductor scars are small, oval, close together and separated from each other by a small rostellum. The anterior adductor scars are in a slight posterior position. The scars of the oblique lateral muscles are extremely small and sometimes indistinct. The limbus is pustulose: the pustules of the most external row are clearly smaller than the pustules from the internal rows. A free, smooth zone is visible between the external row of pustules and the valve margin.

Dorsal valve
The outline and sculpture are similar to the ventral valve but the dorsal valve is conical with a pointed umbo which is situated posteriorly. The ratio Lp/La has a mean value of 0.34 indicating that the umbo is slightly more central than the attachment area of the ventral valve (Figure 9). The posterior adductor scars, not far from each other, are separated by a triangular extension of the limbus. The anterior adductor scars are oval-reniform and converge towards the midline of the valve or slightly posteriorly. The small protractor scars, generally clearly visible, are situated quite anteriorly.

Discussion
From a taxonomical standpoint, Crania phosphatica n. sp. is intermediate between the borealis and the costata group as defined by ERNST (1984, p. 53). The relatively high number of quite fine, acutely limited ribs, the smooth shell surface between the ribs, the attachment surface of the ventral valve and the very low ratio Lp/La are typical features for the borealis group. The anterior position of the protractor scars of the dorsal valve also fit
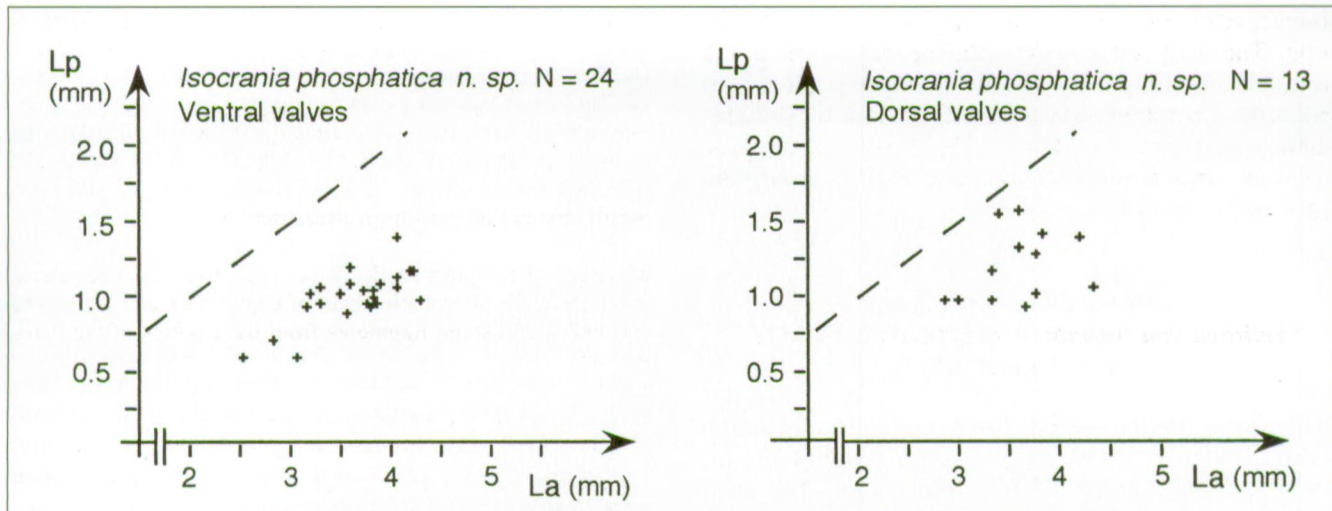
Fig. 9 – Relative position of the attachment surface in the ventral valves and relative position of the umbo in the dorsal valves of *Isocrania phosphatica* n. sp. collected in the phosphatic chalk of Ciply. La: distance from the attachment surface (or umbo) to the anterior margin. Lp: distance from the attachment surface (or umbo) to the posterior margin. For the ventral valves, the linear regression is y = 0.284x - 0.024 with r = 0.723.
Dashed lines indicate the ratio Lp/La = 0.5.

in with those observed in representatives of the *borealis* group.

However, the very small surface of the attachment area of the ventral valve is more typical of the *costata* group. The position of the anterior adductor scars of *C. phosphatica* is already more central than in the representatives of the borealis group. This brings *C. phosphatica* nearer the representatives of the costata group.

C. phosphatica differs from the other species of the costata group described by ERNST (1984) by its attachment surface (Lp/La very low) , by its extremely flat ventral valve, by its typical ribbing pattern and by its smooth surface between the ribs.

C. phosphatica differs from the other species of the *borealis* group described by ERNST (1984) by its smaller surface of attachment to the substrate and by the more central position of the anterior adductors scars in the ventral valve.

Subphylum Rhynchonelliformea WILLIAMS *et al.*, 1996
Class Rhynchonellata WILLIAMS *et al.*, 1996
Superfamily Rhynchonelloidea GRAY, 1848
Family Rhynchonellidae GRAY, 1848
Subfamily Cyclothyridinae MAKRIDIN, 1955 emended OWEN, 1962
Genus *Cyclothyris* M'COY, 1844
Type species: *Terebratula latissima* J. DE C. SOWERBY, 1829

Cyclothyris elegans (VON HANSTEIN, 1879)

*   1879   *Rhynchonella elegans sp. n.* - VON HANSTEIN, p. 40
. v   1996   *Cyclothyris elegans* (VON HANSTEIN, 1879) - SIMON, p. 98, fig. 1 and pl. 1, figs. 1-4.

Stratigraphical range: Lower Maastrichtian

Material: four intact specimens and one compressed specimen collected in the phosphatic chalk. One intact and four broken specimens collected in the hard rock from the hardground overlying the phosphatic chalk. All specimens are from the Lower Maastrichtian, Belemnella obtusa Zone.

The specimens collected correspond to the emended description published by SIMON (1996). *Cyclothyris elegans* is quite rare. Those extracted from the phosphatic chalk were always found near the base of the beds of chalk indicating that this species was probably able to develop when the sedimentation rate was lower and / or in a water current situation. The shape of the foramen, surrounded by cyclothyrid, well developed, deltidial plates and the coarse ribs of the external surface are adaptations to an energetic environment.

Genus *Cretirhynchia* PETTITT, 1950
Type species: *Terebratula plicatilis* J. SOWERBY, 1816

Cretirhynchia sp.
Plate 5, Figures 1, 2 a-b.

Material: Two fragments of the same ventral valve and one juvenile intact specimen from the phosphatic chalk.

It is not possible to recognize juvenile specimens of *Cretirhynchia* with certitude. The unique specimen found is not well preserved and it was opened during ultrasonic cleaning. The shell is smooth, oval and

pointed. The foramen at this stage of growth is still large. The teeth were broken. In the dorsal valve, the crura are strongly built and converge ventrally. This specimen may represent a juvenile form of *Cretirhynchia limbata* (VON SCHLOTTHEIM, 1813), which is the most common macromorphic brachiopod in the phosphatic chalk.

Cretirhynchia limbata (VON SCHLOTTHEIM, 1813)
Text-Figures 2-3.

(1798) Térébratules fossiles - FAUJAS DE SAINT-FOND, pl. XXVI, fig. 4p.

*   1813 *Terebratulites limbatus* - VON SCHLOTTHEIM, p. 113 (cit. FAUJAS, 1798).

      1820 *Terebratulit. Limbatus* - VON SCHLOTHEIM, p. 286.

      1841 *Terebratula subplicata* MANTELL - ROEMER, p. 38, Nr. 10.

      1842 *Terebratula subplicata* MANT. - VON HAGENOW, p. 534, Nr. 4

      1848 *Terebratula limbata* - BRONN, p. 1240.

      1871 *Terebratula octoplicata subplicata* - QUENSTEDT, p. 169, pl. 41, fig. 59.

.   1879 *Rhynchonella limbata* v. Schloth. sp. - VON HANSTEIN, p. 37.

      1894 *Rhynchonella limbata*, Schlotheim - POSSELT, p. 27, fig. 16.

p. p. 1909 *Rhynchonella limbata* SCHLATHEIM (sic) - BRÜNNICH NIELSEN, p. 157, pl. I, figs. 24 - 26.

. v   1938 *Rhynchonella limbata* SCHLOT. - POŻARYSKI, p. 20.

.   1953 *Cretirhynchia limbata* (SCHLOTHEIM) - PETTITT, p. 27, pl. I, fig. 1a-c, pl. II, fig. 12 a-c, text-figs. 7a-c, 8, 9.

¿   1961 *Cretirhynchia limbata* (Schlot.). - KOVALEVA, pp. 66, 70.

.   1965 *Cretirhynchia limbata* (Schlottheim, 1813) - STEINICH, pp. 24-27, pl. II, fig. 4a-d, text- fig. 13.

.   1966 *Cretirhynchia limbata* limbata (Schloth.) - MAKRIDIN & KATZ, p. 191, pl. I, fig. 6.

.   1972 *Cretirhynchia limbata* (Schlotheim) - SURLYK, p. 24, fig. 17.

      1974 *Cretirhynchia limbata* limbata (Schlotheim, 1813) - KATZ, p. 251, pl. 83, fig. 11.

? v   1984 *Cretirhynchia limbata* limbata (Schlottheim, 1813) - POPIEL- BARCZYK, p. 384, pl. CLI, figs. 5, 6.

? v   1988 *Cretirhynchia limbata* (Schlottheim, 1813) - POPIEL-BARCZYK, p. 6-8, figs. 3, 4, pl. 1, figs. 1-6.

.   1990 *Cretirhynchia limbata* (Schlotheim, 1813) - JOHANSEN & SURLYK, p. 838, pl. 2, figs. 3-5.

. v   1993 *Cretirhynchia limbata* (VON SCHLOTTHEIM, 1813) - SIMON, p. 83, text- fig. 8, pl. 3, fig. 4a-e, fig. 5a-b, pl. 4, fig. 1a-e, text-fig. 8.

Stratigraphical range: Upper Campanian to Upper Maastrichtian.

Material: 407 complete young, adult and gerontic shells, 113 ventral valves, 37 dorsal valves and numerous fragments, all collected in the phosphatic chalk.

This material is consistent with the description given by PETTITT (1950) and by STEINICH (1965). Comments on this material and measurements were already given by SIMON (1993). A cuneiform lateral profile, flat antero-lateral parts of the ventral valve, a V-shaped linguiform extension and a very thin umbo in lateral profile are typical characters for this smooth species of *Cretirhynchia*.

Cretirhynchia tenuicostata (VON HANSTEIN, 1879)
Text-Figure 2.

*v   1879 *Rhynchonella tenuicostata* sp. n. - VON HANSTEIN, p. 42.

. v   1996 *Cretirhynchia tenuicostata* (VON HANSTEIN, 1879) - SIMON, p. 102, fig. 2, pl. 2, figs. 1-6.

Stratigraphical range: Lower Maastrichtian.

Material: 15 complete shells, two dorsal valves and one ventral valve from the phosphatic chalk of Ciply. Two adult bivalved specimens and some fragments from the cavities of the hard-ground.

This material has been extensively described and illustrated by SIMON (1996). This *Cretirhynchia*, which is uncommon, seems to be related to an environment with low sedimentation and energetic water conditions. In the phosphatic chalk section investigated, this species is only found near the base of the beds of chalk.

Order Terebratulida WAAGEN, 1883
Suborder Terebratulidina WAAGEN, 1883
Superfamily Terebratuloidea GRAY, 1840
Family Terebratulidae GRAY, 184Y0
Subfamily Rectithyridinae MUIR-WOOD, 1965
Genus *Rectithyris* SAHNI, 1929
Type species: *Terebratula depressa* VALENCIENNES in LAMARCK, 1819.

Rectithyris ciplyensis (VON HANSTEIN, 1879)
Table 3, Plate 2, Figures 1 a-d, 2 a-c.

*   1879 *Terebratula Ciplyensis* sp. n. - VON HANSTEIN, p. 21.

?   1879 *T. biplicata* - UBAGHS, p. 216.

non   1885 *Terebratula ciplyensis* VON HANSTEIN - LUNDGREN, p. 57, pl. 3, fig. 6.

.   1894 *Terebratula Ciplyensis* von Hanstein. - PÉRON, p. 10, pl. 5, figs. 9- 11.

non   1909 *Terebratula ciplyensis* - BRÜNNICH NIELSEN, p. 167.

p. p. 1919 *Terebratula ciplyensis* v. HANST. - HADDING, p. 11, pl. 4, figs. 4, 6, non figs. 1, 2, 3, 5.

?   1930 *Terebratula ciplyensis* von Hanstein. - TZANKOV, pp. 34, 70.

Stratigraphical range: Lower Maastrichtian.

Material: two complete, young adults and one biplicate, gerontic specimen. All the material has been collected in the phosphatic chalk.

VON HANSTEIN designated, without illustration, this species with enough precision for the external characters. This designation, dated from 1879, remains valid. An emended description, with correct illustrations has been given by PÉRON (1894). He pointed out that the material of LUNDGREN (1885) was not similar to the species found in Ciply.

All the authors using this determination for different terebratulid brachiopods based their opinion on the external characters only. Even, HADDING (1919) to whom true specimens of "*Terebratula ciplyensis*" from Ciply

Table 3 – Morphological characters measured on the lectotype of *Rectithyris ciplyensis* (VON HANSTEIN, 1879) from the phosphatic chalk of Ciply. Collection of VON HANSTEIN preserved at the University of Bonn (G.P.I.B.O. - VON HANSTEIN: 1). L: Length of the specimen. LDV: length of the dorsal valve. W: width of the specimen. T: thickness of the specimen. L/W: ratio length (L) to width (W). LDV/W: ratio length of dorsal valve (LDV) to width (W). T/W: ratio thickness (T) to width (W).

	L mm	LDV mm	W mm	T mm	L/W	LDV/W	T/W	Apical angle °
Rectithyris ciplyensis (VON HANSTEIN, 1879) Lectotype G.P.I.B.O.-HANSTEIN :1	33.4	29.5	25.3	16.8	1.32	1.17	0.66	80

were available, did not inspect the interior of the shells. The Bulgarian material of TZANKOV (1930) is not available for revision (N. MOTCHUROVA-DEKOVA, personal communication) and it must be circumspectly considered.

Emended description
The shell is depressed and subpentagonal in outline with its largest width placed anteriorly to the middle of the valves. The shell is equally convex in lateral profile. The anterior commissure is gently biplicate in gerontic specimens. Young adults have a rectimarginate anterior commissure. The modification of the anterior commissure, related to the size of the specimen, is well illustrated by the lectotype (Plate 2, Figure1 a - d). The shell is smooth except for the sharp growth lines mainly visible in the anterior part of the shell. The beak is suberect, short, and truncated. The beak ridges are distinct. The permesothyridid foramen is quite large, attrite and slightly labiate. A convex symphytium is clearly visible.

The loop discovered in a slightly biplicate, young adult specimen from the Van Damme quarry enables inclusion of this species in the subfamily *Rectithyridinae*. The loop is narrowly triangular and its relative length is noteworthy. The cardinal process is flat, semi-circular and it exhibits a myophore plate surrounded by a low ridge. The moderately thick socket ridges are straight and inclined toward the narrow sockets. Posteriorly, the sockets are covered, for a short distance, by a plate starting from the cardinal process. This feature is typical of the genus *Rectithyris*, as stressed by COOPER (1983, p. 213). The wide, triangular outer hinge plates are dorsally attached to the crural bases. These outer hinge plates are very long and they taper anteriorly just before the short crural processes. The crural bases are thickened and they form a ridge on the inner sides of the outer hinge plates. This thickening of the crural bases must not be confused with inner hinge plates which do not exist in the loop investigated. The descending lamellae are very short and the transverse band which is relatively broad is folded and high. The crest of the transverse band is flat.

Comparison with other terebratulid brachiopods
In external appearance, *Rectithyris ciplyensis* is readily distinguishable from all other representatives of the genus. The specimens labelled as *Terebratula ciplyensis* and particularly those proposed by HADDING (1921, p. 11) should be examined again for the structure of their loop. The narrowly triangular, long loop observed in *Rectithyris ciplyensis* could be confused with that of the genus *Tanyoscapha* COOPER, 1983 (pl. 7, figs. 24, 25). However, in *Tanyoscapha*, the structure of the sockets is different, the outer hinge plates are still longer, tapering till the crural processess, and the transverse band is extremely low.

DESIGNATION OF A LECTOTYPE
VON HANSTEIN did not designate a type specimen. A lectotype is chosen among the four specimens of the type series of VON HANSTEIN kept in Bonn (reference: G.P.I.B.O.- HANSTEIN: 1). This lectotype is a perfectly preserved specimen corresponding to the original diagnosis. It is illustrated on Plate 2, Figures 1 a-d. The measurements of the lectotype are indicated on Table 3.

Genus *Neoliothyrina* SAHNI, 1925
Type species: *Terebratula obesa* DAVIDSON, 1852 non J. DE C. SOWERBY, 1823

Neoliothyrina obesa SAHNI, 1925

.	1841	*Terebratula obesa* Sow. - ROEMER, p. 43.
.	1842	*Terebratula Sowerbyi* n. - VON HAGENOW, p. 541.
	1846	*Terebratula Sowerbyi* v. Hg. - BOLL, p. 210.
	1850	*T. Sowerbyi* v. HAG. 1842 - GEINITZ, H. B., p. 214, n°34.
	1851	*T. Sowerbyi* v. HAG. - BOLL, p. 447.
	1852	*T. Sowerbyi* v. HAG. - BOLL, p. 62.
	1852	*Terebratula obesa* Sow. - DAVIDSON, p. 53, pl. V, figs. 13 - 15. [non fig. 16]
.	1856	*T. Sowerbyi* v. HAG. 1842 - BOLL, p. 43.
p. p.	1860	*T. Sowerbyi* v. Hagen. - BOSQUET, N° 584. [Gulpensch. non Maastrichtsch.].
.	1867	*Terebratula obesa* Sow. - SCHLOENBACH, pl. XXI (1), fig. 7.
.	1871	*T. Sowerbyi* - QUENSTEDT, p. 384, pl. 48, fig. 77 d.
.	1879	*Terebratula obesa* Sow. - VON HANSTEIN, p. 24.

1884   *Terebratula obesa* Sow. - Berendt, p. 873.
?   1885   *Terebratula obesa* Sowerby - Lundgren, p. 52.
1887   *Terebratula Sowerbyi*, von Hag. - Ubaghs, p. 64.
1888   *Terebratula obesa* Sow. - Geinitz, F. E., p. 742.
.   1907   *Terebratula obesa* Sow. var. *praelustris* Hag. - Deecke, pp. 105, 108, 112.
*   1925   *Neoliothyrina obesa* - Sahni, p. 375, pl. 23, fig. 8, pl. 26, fig. 10.
.   1929   *Neoliothyrina obesa* - Sahni - Sahni, p. 9, pl. 6, figs. 1-4, pl. 8, figs. 26-28, pl. 9, figs. 19-21.
.   1929   *Terebratula obesa* Sow. - Voigt, p. 150, pl. VII, fig. 7 (d).
.   1961   *Neoliothyrina sowerbyi* (Hagenow) - Asgaard, p. 461.
.   1965   *Neoliothyrina obesa* Sahni, 1925 - Steinich, p. 27, text-figs. , 14-22, pl. 1, figs. 1, 2a, b, pl. IV, fig. 1 a-d, pl. V, figs. 1, 2.
. v   1968   *Neoliothyrina obesa* (Davidson, 1852) - Popiel - Barczyk, p. 52, text-figs. 4, 17, 18, pl. XIII, figs. 1 - 5, pl. XIV, figs. 1 - 7, pl. XV, figs. 1 - 5, pl. XVI, fig. 7.
.   1972   *Neoliothyrina obesa* Sahni, 1925 - Surlyk, p. 17, fig. 5, p. 21, p. 36.
1982   *Terebratula obesa* Davidson, 1852 - Nechrikova, p. 44, pl. 5, figs. 1-4.
.   1983   *Neoliothyrina obesa* Sahni, 1925 - Cooper, p. 205, pl. 19, figs. 1-6, 7, pl. 67, figs. 16-18.
1989   *Neoliothyrina* aff. *obesa* (Davidson, 1852) - Popiel-Barczyk, p. 246, pl. CLIII, figs. 5, 6.
. v   1995   *Neoliothyrina obesa* Sahni, 1925 - Jagt et al., p. 11.
. v   1996   *Neoliothyrina* aff. *obesa* (Davidson, 1852) - Dhondt et al. , p. 57.

Stratigraphical range: Lower Maastrichtian to Upper Maastrichtian.

Material: One complete adult specimen and one posterior fragment of a ventral valve collected in the phosphatic chalk. No young or juvenile specimens.

This specimen collected in Ciply agrees with the descriptions of Sahni (1925) and of other authors including Steinich (1965) and Popiel-Barczyk (1968). Well developed outer and inner hinge plates are present. Large inner hinge plates, in adult specimens, are typical for this species. The surface of the shell is finely capillate. *Neoliothyrina obesa* is one of the rarest species in the phosphatic chalk.

Neoliothyrina fittoni (Hagenow, 1842)
Plate 3, Figures 1 a-b.

*   1842   *Terebratula Fittoni* n. - Hagenow, p. 542, n°16, pl. 9, fig. 6.
1846   *Terebratula Fittoni* v. Hg. - Boll, p. 210.
1860   *Terebratula Fittoni* v. Hagen. - Bosquet, n°583.
?   1894   *Terebratula Fittoni* von Haguenow. - Péron, p. 9, pl. 5, figs. 7-8.
1895   *Terebratula Fittoni* Hag. - Deecke, pp. 73, 74.
?   1909   *Terebratula Fittoni* v. Hag. - Brünnich Nielsen, p. 163, n°28, pl. 2, figs. 96-97.
.   1965   *Neoliothyrina fittoni* (Hagenow, 1842) - Steinich, pp. 35-37, text-fig. 23, pl. 5, fig. 3a-d.
.   1972   *Neoliothyrina fittoni* (Hagenow, 1842) - Asgaard, pp. 337 - 345.
.   1972   *Neoliothyrina fittoni* (Hagenow, 1842) - Surlyk, p. 17, text-fig. 5, p. 21, p. 29, text-fig. 13.
.   1988   *Neoliothyrina fittoni* (Hagenow, 1842) - Johansen, p. 44, text-fig. 2.
.   1989a   *Neoliothyrina fittoni* (Hagenow, 1842) - Johansen, p. 151, text-fig. 2, p. 161, Table 2.
.   1989b   *Neoliothyrina fittoni* (Hagenow, 1842) - Johansen, p. 246, text-fig. 2.

Stratigraphical range: Lower Maastrichtian.

Material: two specimens (posterior part) not well pres'erved from the phosphatic chalk of Ciply. One posterior part of a specimen extracted from the cavities in the hardground.

An unequivocal determination for these specimens is possible based on the cardinalia which are in a satisfactory state of preservation. A short, erect beak with a relatively large, subcircular foramen is observed.

The hinge is strongly constructed, with thick socket ridges. The cardinal process is well developed, bearing a flat, large, myophore plate. The concave crural bases are clearly visible and very narrow inner hinge plates are developed. Specimens fit in with the detailed illustrations given by Steinich (1965, p. 36).

Subfamily Carneithyridinae Muir-Wood, 1965
Genus *Carneithyris* Sahni, 1925
Type species: *Carneithyris subpentagonalis* Sahni, 1925

Carneithyris sp.
Table 1, Plate 5, Figures 3 a-b.

Stratigraphical range: Lower Maastrichtian

Material: one complete, juvenile specimen from the phosphatic chalk of Ciply.

This pointed shell is elongate-oval in outline. The maximum width is situated anteriorly, near midvalve. The shell is biconvex but the ventral valve is more convex than the dorsal valve. The anterior commissure is rectimarginate. The short beak is erect. The area is indistinct. The foramen is relatively small and hypothyridid. The deltidial plates are not well preserved. The shell is smooth and, under particular lighting conditions, punctae are visible on the anterior part of both valves. The internal characters have not been investigated due to the rarity of the material.

This shell is extremely similar to the specimen illustrated in Johansen (1987, pl. 1, figs. 2-4) and to the specimen illustrated in Johansen & Surlyk (1990, pl. 2, fig. 6). It is not possible to attribute this specimen to a species recognized in the phosphatic chalk such as *Carneithyris carnea* (J. Sowerby, 1812) or *Carneithyris cypliensis* (Sahni, 1929).

Carneithyris carnea (J. Sowerby, 1812)
Text-Figure 2, Plate 1, Figure2 a, Plate 3,
Figures 2 a-c, 3 a-c, 4 a-c, 5 a-c, Plate 4,
Figures 1 a-c, 2 a-c, 3 a-d; 4.

Note: Since the work of Asgaard (1975) who revised the numerous genera and species erected by Sahni (1925 and 1929) for the Campanian and Maastrichtian terebratulid brachiopods from England, the single genus *Carneithyris* remains valid. Only two species, *Carneithyris carnea* (J. Sowerby,

1812) and *Carneithyris subcardinalis* (SAHNI, 1925) are considered as valid by ASGAARD. The first one is a Campanian species whereas the second one is considered as a Maastrichtian representative of the genus.

All the species described under the genera *Pulchrithyris*, *Magnithyris*, *Ellipsothyris*, *Ornithothyris*, *Carneithyris* and *Chatwinothyris symphytica* in SAHNI (1925) pp. 353-385, pls. 23 -26 (corresponding figures) and all the species of *Carneithyris*, *Ellipsothyris* and *Magnithyris*, *Chatwinothyris symphytica* and *Ornithothyris carinata* in SAHNI (1929) pp. 30-37, 38-40, 42, 44, pl. 4, figs. 20-34, pl. 5, figs. 1-22 & figs. 26-31, pl. 6, fig. 19 & figs. 27-31, pl. 9, figs. 5-18 & figs. 22-26, pl. 10, figs. 6-9 & fig. 13 are considered as synonyms of *Carneithyris carnea* (J. SOWERBY, 1812). These species are not indicated in the synonymy list below.

*   1812   *Terebratula carnea.* - J. SOWERBY, p. 47, pl. 15, figs. 5-68.
      1819   *Terebratula carnea* - DE LAMARCK, vol. 6, p. 248, n°14.
.   1823   *Terebratula elongata.* - J. DE C. SOWERBY, p. 49, pl. 435, figs. 1-2.
      1828   *Terebratula carnea*, Sow. - DEFRANCE, vol. 53, p. 148.
.   1847   *Terebratula carnea* Sow. - D'ORBIGNY, vol. IV, p. 103.
.   1851   *Terebratula carnea* Sow. - D'ORBIGNY, Atlas, vol. IV, pl. 513, figs. 5- 8.
.   1852   *Terebratula carnea*, Sowerby. - DAVIDSON, p. 67, pl. 8, figs. 1-3.
.   1852   *Terebratula carnea*, Sowerby *var. circular* - DAVIDSON, p. 67, pl. 8, figs. 4, 4a, 5, 5a.
      1854   *Terebratula carnea*, Sow. - MORRIS, p. 158.
      1859   *Terebratula carnea*, Sow. - BINKHORST VAN DEN BINKHORST, pp. 93, 140, 151.
p. p. 1879   *Terebratula carnea*, Sow. - VON HANSTEIN, p. 19.
      1885   *Terebratula carnea* SOWERBY - LUNDGREN, p. 54, pl. 2, fig. 23.
non 1894   *Terebratula carnea* Sowerby. - PÉRON, p. 4, pl. 4, figs. 1, 2, 3.
.   1894   *Terebratula* aff. *carnea* - PÉRON, p. 5, pl. 4, figs. 5, 6.
      1919   *Terebratula carnea* Sow. - HADDING, p. 5, pl. 1, figs. 3-5.
      1919   *Terebratula carnea* Sow. *var. elongata* Sow. - HADDING, pl. 2, figs. 5-6.
. v   1935   *Terebratula carnea* Sow. - KONGIEL, p. 41, pl. 5, figs. 10 a-c, 11.
. v   1935   *Terebratula subrotunda* Hadding - KONGIEL, p. 42, pl. 6, fig. 9a-c, pl. 7, fig. 1a-c.
. v   1935   *Terebratula elongata* Sowerby - KONGIEL, p. 42, pl. 6, figs. 7a, 7b, 8 a-c.
?   1947   *Terebratula (Carneithyris) carnea* Sow. - ZAKHARIEVA-KOVACHEVA, p. 249, pl. 5, figs 1-3.
?   1947   *Terebratula circularis* Sahni - ZAKHARIEVA-KOVACHEVA, p. 255, pl. 6, figs. 10-12.
.   958   *Carneithyris carnea* (J. Sowerby) - SAHNI, p. 17, pl. 6, figs. 8-10.
      1959   *Carneithyris carnea* (Sowerby) - ASTAFIEVA, p. 228, pl. 2, figs. 5 a-g, 7.
      1959   Carneithyris circularis Sahni - ASTAFIEVA, p. 228, pl. 2, fig. 6.
.   1965   *Carneithyris carnea* (J. Sowerby) - MUIR-WOOD in MOORE, p. 799, fig. 668, 1a-c, fig. 669, 1, a-l.
. v   1968   Carneithyris subpentagonalis Sahni, 1925 - POPIEL-BARCZYK, p. 31, text-figs. 5, 6, pl. 2, figs. 1-8, pl. 3, figs. 3, 5, 6.
. v   1968   *Carneithyris carnea* (Sowerby, 1812) - POPIEL-BARCZYK, p. 35, text-figs. 7, 8, pl. 4, figs. 1-6, pl. 5, figs. 4-8.
. v   1968   *Carneithyris circularis* Sahni, 1925 - POPIEL-BARCZYK, p. 39, text-figs. 9, 10, pl. 6, figs. 1-8, pl. 7, figs. 1-7.
. v   1968   *Carneithyris elongata* (Sowerby, 1823) - POPIEL-BARCZYK, p. 41, text-fig. 11, pl. 5, figs. 1-3.
      1974   *Carneithyris circularis* Sahni, 1925 - KATZ, p. 261, pl. 86, fig. 4 a-c.
      1974   *Carneithyris carnea carnea* (Sowerby, 1813) - KATZ, p. 262, pl. 86, fig. 7 a-c.
      1982   *Carneithyris carnea* (Sowerby, 1812) - NECHRIKOVA, p. 45, pl. 5, figs. 5-8.
.   1982   *Carneithyris circularis* Sahni, 1925- NECHRIKOVA, p. 45, pl. 5, figs. 9-11.
.   1983   *Carneithyris carnea* (Sowerby) - COOPER, p. 181, pl. 25, fig s. 26, 30, 33-35, pl. 26, figs. 3, 7-8, 16-18.
      1983   *Carneithyris subpentagonalis* Sahni - COOPER, pl. 25, figs. 20, 22,
.   1983   *Carneithyris rotunda* Sahni - COOPER, pl. 25, figs. 23, 25.
.   1983   *Carneithyris circularis* Sahni - COOPER, pl. 25, figs. 25-29, 31, 32.
.   1983   *Carneithyris* cf. *elongata* (J. DE C. SOWERBY) - COOPER, pl. 27, figs. 1-7.
      1989   *Carneithyris carnea* (J. Sowerby, 1812) - POPIEL-BARCZYK, p. 248, pl. CLIII, figs. 2-3.
      1992   *Carneithyris carnea* (J. Sowerby, 1812) - POPIEL-BARCZYK, p. 22.

Stratigraphical range: Upper Campanian to Lower Maastrichtian.

Material: 192 bivalved shells, complete or with damaged anterior part, 52 dorsal valves, 48 ventral valves and numerous fragments, all from the phosphatic chalk.

Specimens exhibit a wide variation in outline, in thickness, and in the shape of the foramen. Younger specimens appear subcircular to oval in outline and are gently biconvex. The beak is suberect and the foramen is sometimes relatively large, sometimes relatively small. The foramen is circular but some specimens possess a slightly labiate foramen. These external differences are not correlated with any particular structure of the cardinalia. Larger, and supposedly older, specimens are much more variable: they can be oval , oval-elongate or subpentagonal in outline. The same range of variation occurs for their thickness, some of them remaining gently biconvex whereas others become strongly biconvex. In gerontic specimens, great variation is found in the form and the shape of the foramen. Even, but rarely, specimens are found with a quite large and labiate foramen which is reminiscent of the foramen observed in certain species of *Neoliothyrina*. However, the observation of the cardinalia and of the loop of such specimens confirms that they are true representatives of the genus *Carneithyris*. Significant variation in the internal characters is also visible in our specimens. Strong thickening of the hinge area, related to the age of the specimens, is well observed.

The structure of the cardinalia in this population is very similar to those represented by ASGAARD (1975, p. 341). The size of the cardinal knob increases with the age of the specimen and the myophore plate evolves from a semicircular structure with distinctly raised lateral margins in young individuals to a lobate pit divided by a low median ridge in gerontic specimens. A bi-tubular structure for the myophore as seen in specimens studied by POPIEL-BARCZYK (1968, pl. 5, fig. 6) is not found in Ciply specimens. The V-shaped crural bases, clearly visible in young specimens, are covered by secondary shell-deposits in older individuals, but their traces remain observable as ridges running toward the cardinal process (sometimes faintly) in all specimens investigated.

The loop of *Carneithyris carnea* was studied and illustrated by COOPER (ß1983, p. 180). The loops, excavated from our specimens, fit in correctly with his description

although the transverse band is not always strongly arched. This character seems to be quite variable in *C. carnea* as do all the other parameters.

The variations, for all the characters investigated, are so wide that it is impossible to establish any specific diagnosis for the specimens from the phosphatic chalk of Ciply. Although this material is of Lower Maastrichtian age, it is not possible to distinguish it clearly from the Campanian forms of *C. carnea* studied by ASGAARD (1975) in England.

Carneithyris ciplyensis (SAHNI, 1929)

Text-Figure 2, Plate 3, Figures 6-9, Plate 4, Figures 5-10.

non	1879	*Terebratula Ciplyensis sp. n.* - VON HANSTEIN, p. 21.
.	1894	*Terebratula carnea* Sowerby - PÉRON, p. 4, pl. 4, figs. 1-3.
*	1929	*Chatwinothyris ciplyensis* sp. nov. - SAHNI, p. 41, n°2, pl. 6, figs. 16- 18, pl. 10, fig. 5.
.	1975	*Chatwinothyris ciplyensis* - ASGAARD, p. 322.
non	1983	*Chatwinothyris ciplyensis* - COOPER, p. 183, pl. 20, figs. 1-3.
.	1983	*Chatwinothyris ciplyensis* - COOPER, pl. 20, figs. 4-6.

Stratigraphical range: Lower Maastrichtian.

Material: 58 bivalved shells often complete (36), the other being damaged in their anterior part. This material was collected exclusively in the phosphatic chalk.

In 1929 SAHNI erected this new species placed by him in the genus *Chatwinothyris*. SAHNI (1929) gave a rather laconic diagnosis of his species and as "distinction", he wrote: "Its shape and more obtuse beak distinguish it from the other species of *Chatwinothyris*".

The illustrated holotype has been opened to show the loop (SAHNI, 1929: pl. 10, fig. 5). This brachidium exhibits a strong thickening of the cardinalia and the details of the crural bases are not visible.

COOPER illustrated (1983, plate 20, figs. 1-3) *Carneithyris ciplyensis* with a shell exhibiting a clearly truncated beak, a character not observed by SAHNI. Such shells were not found in the Van Damme quarry and they will not be taken into account in this paper. But, in the collections of the Institut royal des Sciences naturelles de Belgique in Brussels, specimens from the phosphatic chalk of Ciply which are virtually identical to the specimen of COOPER are not uncommon. These specimens with a truncated beak, are very faintly capillate on the anterolateral parts of their valves. This character, only seen in special lighting conditions, can be easily overlooked. The specimen of COOPER (plate 20, figs. 1-3) should be checked for it. Moreover, the foramen of these brachiopods is slightly to clearly labiate. As the representatives of the genus *Carneithyris* are always smooth, the capillate ornamentation and the labiate foramen suggest that the specimen illustrated by COOPER (plate 20, figs. 1-3) could be related to the genus *Neoliothyrina*.

The second specimen illustrated by COOPER (pl. 20, figs 4-6) is considered here as a representative of *Carneithyris ciplyensis*.

Under the name *Terebratula carnea* Sowerby, PÉRON (1894) described and illustrated specimens which fit better with the diagnosis of *Carneithyris ciplyensis*.

Emended description

Specimens described in this paper as *Carneithyris ciplyensis* (SAHNI, 1929) are clearly elongate-subpentagonal in outline, oval-lenticular in lateral profile and oval-lenticular in frontal view. Young individuals are elongate-oval in outline and they are difficult to distinguish from similarly-sized specimens of *C. carnea* except for their foramen which is very small. The adults exhibit quite rapidly the subpentagonal outline which is typical for this species.

The shell is biconvex. The depth of the ventral valve is generally greater than the depth of the dorsal valve but equally convex valves are also seen in older specimens. Except for faint growth lines, the shell is smooth without capillae. The anterior commissure is rectimarginate. The curved beak is erect, never truncated and its apex appears pointed in lateral profile. The beak is never pressed against the dorsal umbo. The beak ridges are distinct. The permesothyridid foramen is circular, not labiate and not attrite. It is always small and sometimes reduced to a pinhole foramen. The symphytium is concealed.

An impressive thickening of the posterior part of the valves is observed and bivalved shells, in which the matrix has been removed, show a strong tendancy to orient themselves beak downwards.

Several specimens have been excavated for study of the internal characters. Thickening of the cardinalia is evident and this thickening occurs also in the youngest specimens investigated. Sockets ridges are massive and thickened. The cardinal process is well developed in the form of a massive cardinal knob supplied with a myophore plate divided by a relatively strong median ridge. In older and gerontic specimens, this ridge is impressively developed and a trifid cardinal process obstructs totally the canal of the pedicle. In the specimens investigated the canal of the pedicle is not filled with secondary callose substance.

The buried crural bases or their traces are not visible in all specimens investigated. The crural processes are acutely pointed and when intact, they are provided with needle sharp points. The anterior slope of the crural processes unite with a moderately to highly arched tranverse band.

A feature encountered in all excavated individuals is the presence of a recrystallized, bilobed, spiculate mantle, extending from the dorsal side of the loop to the border of the muscle scars of the dorsal valve floor. Often, the mantle of both valves was recrystallized. This indicates that these brachiopods were living in a quiet environment.

The heavy thickening of the posterior part of the valves and of the cardinalia, the very reduced size of the foramen and the obstruction of the canal of the pedicle indicate that this species was a secondary free living brachiopod.

The thickening of the posterior part of the valves must be interpreted as an adaptation for secondary free living. The heavy posterior part of the shell was giving an ideal orientation to the animal for feeding and for avoiding possibilities of burial by the sediment. A similar adaptation is observed for *Neothyris lenticularis* (DESHAYES, 1839), a Recent free living brachiopod (RICHARDSON 1979, p. 419-420).

Comparison with *Carneithyris carnea* (J. SOWERBY, 1812) from the phosphatic chalk

Specimens recognized here as *Carneithyris carnea*, are more oval in outline. Their foramen, which is very variable in size, is larger than the foramen of the specimens considered as *C. ciplyensis*. Although a subcircular foramen is easily found among specimens of *C. carnea*, a slightly labiate structure is sometimes observed. A labiate foramen is not observed in *C. ciplyensis*.

The thickening of the posterior part of the shell of *C. ciplyensis* is much more extensive than the thickening observed in *C. carnea*.

Crural bases are v-shaped and remain visible in *C. carnea*. However they are not v-shaped in *C. ciplyensis* and their inner side is sharply flat as seen on SEM illustrations on Plate 4, Figures 5-9.

The two species are also distinguished by their way of life: secondary free living for *C. ciplyensis* and anchored to the substrate for *C. carnea*.

Comparison with *Carneithyris subcardinalis* (SAHNI, 1925)

Carneithyris subcardinalis (SAHNI, 1925) was extensively studied by STEINICH (1965, p. 37), POPIEL-BARCZYK (1968, p. 44) and by ASGAARD (1975, p. 335). This species has a more oval-elliptical outline, is less elongate and adult specimens appear more biconvex than *C. ciplyensis*. A pinhole foramen is generally observed in *C. subcardinalis*. The beak of *C. subcardinalis* is firmly pressed against the dorsal umbo, a character which is not observed in *C. ciplyensis*.

Internally, the fusion of the cardinal process and the socket ridges is more advanced in *C. subcardinalis* but this character is variable with the age of the specimen investigated. The myophore plate of *C. ciplyensis* seems to be placed in a slightly more posterior position than the myophore plate of *C. subcardinalis*. The inner sides of the crural bases are not as flat and parallel in *C. subcardinalis* as they are in *C. ciplyensis* (see fig. 32 in STEINICH, 1965).

Discussion
Sufficient external and internal characters enable specimens of *Carneithyris ciplyensis* to be differentiated from *Carneithyris carnea*. The mode of life of *C. ciplyensis* is also highly distinct.

Distinctions with *Carneithyris subcardinalis* are more subtle. Slight differences in the aspect of the crural bases, swollen cardinalia and position of the myophore plate could also be attributed to intraspecific variation and to the age, although these differences were systematically observed in the specimens investigated.

The pinhole foramen and the pressed beak of *C. subcardinalis* are permanent features for this species. On the contrary, the beak of *C. ciplyensis* is never pressed against the umbo of the dorsal valve. The outline of *C. ciplyensis* is also very distinctive.

Family Cancellothyrididae THOMSON, 1926
Subfamily Cancellothyridinae THOMSON, 1926
Genus *Terebratulina* D'ORBIGNY, 1847
Type species: *Anomia retusa* LINNÉ, 1758

Nomenclative note:
Since 1970, the accepted type species for the genus Terebratulina is now *Anomia retusa* LINNÉ, 1758 and not *Anomia caput-serpentis* LINNÉ, 1767. This follows the Opinion 924 in the Bulletin of Zoological Nomenclature, **27** (2).

Terebratulina chrysalis (VON SCHLOTTHEIM, 1813)
Table 1, Text-Figure 5, Plate 5, Figures 4, 5 a-b, 6 a-f.

	1798	*Térébratules Fossiles* - FAUJAS DE SAINT-FOND, pl. XXVI, fig. 9.
*	1813	*Terebratulites chrysalis* - VON SCHLOTTHEIM, p. 113.
.	1820	*Terebratulites chrysalis* - VON SCHLOTHEIM, p. 272, n° 39.
.	1835	*Terebratula chrysalis* Schloth. - VON BUCH, p. 227.
p. p.	1841	*T. striatula* MANTELL - ROEMER, p. 39 , p. 144.
p. p.	1841	*T. chrysalis* v. Schl. - ROEMER, p. 40, p. 145.
.	1842	*T. striatula* Mant. - VON HAGENOW, p. 538.
p. p.	1847	*Terebratulina striata* d'Orb., 1847 - D'ORBIGNY, p. 65, Atlas (1851), pl. 504, figs. 9-13.
p. p.	1852	*Terebratulina striata* Wahlenberg sp. - DAVIDSON, Part II, p. 35, pl. II, figs. 18-20 (non figs. 21 - 28).
p. p.	1866	*Terebratulina chrysalis* Schloth. sp. 1813 - SCHLOENBACH, p. 277 (non pl. 38, fig. 4).
.	1871	*Terebratula striatula* - QUENSTEDT, p. 247, pl. 44, figs. 29, 30.
?	1879	*Terebratulina chrysalis* v. Schloth. sp. - VON HANSTEIN, p. 26.
p. p.	1909	*Terebratulina striata* Wahlenberg. - BRÜNNICH NIELSEN, p. 159, pl. I, figs. 28 -32.
.	1938	*Terebratulina striata* Wahl. - POŻARYSKI, p. 19.
.	1965	*Terebratulina chrysalis* (SCHLOTTHEIM, 1813) - STEINICH, p. 53, text- figs. 44 - 61; pl. VIII, fig. 1 a - d; pl. IX, figs. 1 - 5, 9a, b, 10a, b.
.	1968	*Terebratulina chrysalis* (Schlottheim, 1813) - POPIEL - BARCZYK, p. 63, pl. XVII, figs. 1-3, text-fig. 25.
.	1972	*Terebratulina chrysalis* (Schlotheim) - SURLYK, p. 21, pl. 4, fig. 5 - 8, text-figs. 12-1Í8.
.	1979	*Terebratulina chrysalis* (Schlotheim) - BITNER & PISERA, p. 73, pl. 3, figs. 12-15.
.	1987a	*Terebratulina chrysalis* (Schlottheim 1813) - JOHANSEN, p. 14, pl. 4, figs. 1-5, text-figs. 14 A - D.
.	1988	*Terebratulina chrysalis* (Schlotheim, 1813) - JOHANSEN, pl. II, figs. 7-10.
.	1989	*Terebratulina chrysalis* (Schlottheim, 1813) - POPIEL-BARCZYK, p. 248, pl. CL, fig. 5.
.	1990	*Terebratulina chrysalis* (Schlotheim, 1813) - JOHANSEN & SURLYK, p. 841, pl. 3, figs. 1-5.
.	1992	*Terebratulina chrysalis* (Schlottheim 1813) - POPIEL-BARCZYK, p. 27.
.	1995	*Terebratulina chrysalis* (von Schlottheim, 1813) - SIMON, p. 11.

A more complete synonymy list can be found in STEINICH (1965, pp. 53-54).

Stratigraphical range: Upper Campanian to Upper Maastrichtian and Lower Danian.

Material: thirteen ventral valves, five dorsal valves and 12 fragments collected in the phosphatic chalk. Two complete shells, 19 ventral valves, 22 dorsal valves and 22 fragments were found in the sediment infilling the cavities of the hardground.

Seven complete shells were collected at the contact zone between the phosphatic chalk and the hardground.

STEINICH (1965, pp. 53-66) has given an accurate description of this species and a detailed explanation of its ontogenetic development. JOHANSEN (1987, p. 15) has confirmed the comments of STEINICH for specimens from the Danish chalk.

The specimens from Ciply, which are mostly juvenile specimens, are consistent with the descriptions of these authors.

The specimens collected from the base of the hardground are yound individuals which exhibit a slightly more elongate outline.

Terebratulina carinata VON HANSTEIN, 1879
Plate 2, Figures 3 a-e, 4 a-b, 5 a-b, 6.

*   1879   *Terebratulina carinata* sp. n. - VON HANSTEIN, p. 27.
.   1965   *Terebratulina carinata* v. HANSTEIN - STEINICH, p. 55.
.   1996   *Terebratulina carinata* VON HANSTEIN - SIMON, p. 97.

LOCUS TYPICUS: Ciply, Hainaut, Belgium.
STRATUM TYPICUM: Phosphatic chalk of Ciply, Lower Maastrichtian.

Designation of a lectotype
VON HANSTEIN did not designate any type specimen. A lectotype is herein formally designated from the three specimens of the type series of VON HANSTEIN kept in Bonn (reference: G.P.I.B.O - HANSTEIN -2). The shell of the lectotype has a length of 44.6 mm, a width of 32.2 mm and a thickness of 21.8 mm. The dorsal valve is 42.9 mm long. The apical angle is 74°. The lectotype is illustrated in Plate 2, Figures 3 a-e.

Material: one broken bivalved specimen found at the base of the hardground. One juvenile specimen also found in the sediment from the cavities at the base of the hardground.

The external morphological features of this large species of *Terebratulina* were precisely described by VON HANSTEIN (1879, p. 27). A specimen from the collection of the Institut royal des Sciences naturelles de Belgique in Brussels was opened for study of the brachidium. This specimen was collected in Ciply, in the phosphatic chalk. The loop was broken but slight reconstruction allowed the loop to be restored to its original structure (Plate 2, Figures 4 a-b).

In the ventral valve, the teeth are long and narrow. In the dorsal valve, a cardinal process is developed as a transverse subcircular area. The sockets are elongate and the inner socket ridges are moderately low. The crura are quite long and thin, and they converge midventrally. The crural processes are moderately wide and they unite dorsally in a bridge. The crural processes and the descending branches form a ring-loop which shows a strong fold in its dorsal part.

In outline, the juvenile specimen collected at the base of the hardground is already very similar to the adult (Plate 2, Figures 5 a-b). The dorsal valve is strongly convex and the form of the beak is typical for this species. The ribs are coarse and they are roughly knobbed. At this stage of growth, the anterior commissure is not biplicate.

Comparison with other species
The strongly biplicate anterior commissure of *Terebratulina carinata* avoid any confusion with all the other large species of *Terebratulina*.

T. carinata is extremely different from *T. chrysalis*. *T. carinata* is much larger, has a biplicate anterior commissure and possess more numerous and finer ribs. The dorsal valve of *T. carinata* is also more convex than the dorsal valve of *T. chrysalis*. The beak of *T. carinata* has a more pointed outline. The ring-loop of *T. carinata* is much more delicate than the loop of *T. chrysalis* which is more tubular and more strongly built.

Terebratulina subtilis STEINICH, 1965
Plate 5, Figures 7 a-b.

*   1965   *Terebratulina subtilis* sp. n. - STEINICH, pp. 93-99, text-figs. 115-129, pl. XI, figs. 2 a-d.
.   1970a *Terebratulina subtilis* Steinich - SURLYK, p. 160, table 1.
.   1970b *Terebratulina subtilis* Steinich - SURLYK, p. 12, fig. 2, p. 13, fig. 3.
.   1972   *Terebratulina subtilis* Steinich, 1965 - SURLYK, p. 18, figs. 2, 5, 6.
.   1982   *Terebratulina subtilis* Steinich, 1965 - SURLYK, fig. 1.
.   1988   *Terebratulina subtilis* Steinich, 1965 - JOHANSEN, fig. 2.
     1990   *Terebratulina subtilis* Steinich, 1965 - JOHANSEN & SURLYK, p. 848, pl. 6, figs. 1, 2.

Stratigraphical range: upper part of Lower Maastrichtian to Upper Maastrichtian

Material: one bivalved shell and one fragmented dorsal valve collected at the boundary between the phosphatic chalk and the hardground.

The unique bivalved specimen investigated here is quite small (length: 2.6 mm). The outline is subtriangular. The shell is plano-convex; the ventral valve is slightly convex whereas the dorsal valve is flat, except umbonally. The anterior commissure is straight. The ornamentation of the shell consists of numerous radial ribs bearing a fine granulation coarser on the ventral valve. Forty-six ribs are observed on the dorsal valve. During growth, new ribs are formed by intercalation. The beak, which is slightly different from the beak of the type specimen (STEINICH 1965, pl. XI, fig. 2), is relatively long, truncated and suberect. The cardinal area is narrow. The foramen mostly hypothyridid is limited by two narrow deltidial plates.

The internal characters have not been investigated due to the scarcity of the material.

Confusion between *Tereratulina subtilis* STEINICH, 1965 and *Rugia tenuicostata* STEINICH, 1963 is possible. But, *R. tenuicostata* has a more pointed beak and a lower number of serrate ribs. The dorsal valve of *R. tenuicostata* is also more convex.

As indicated by SURLYK (1990, p. 833, fig. 4), in Kronsmoor, *T. subtilis* is a brachiopod of significant stratigraphical value. It indicates the limit between the *Belemnella obtusa* and the *Belemnella sumensis* Zones. In Belgium, the complete stratigraphical range for this species is still unknown. The results obtained in Kronsmoor must be taken into account here with care. Nevertheless, it is noteworthy that *Terebratulina subtilis* has only been found at the boundary between the phosphatic chalk and the hardground. This fact could be stratigraphically significant.

Terebratulina (?) n. sp.
Plate 5, Figures 8 a-d.

The stratigraphical position of this specimen is unknown. The matrix is made of phosphatic chalk and could indicate a Lower Maastrichtian origin. But the position of this specimen in the hardground speaks for an Upper Maastrichtian origin.

Material: one intact bivalved shell and one ventral valve found in the soft sediment infilling the cavities of the hardground overlying the phosphatic chalk of Ciply.

This *Terebratulina* (?) n. sp. has a clear subtriangular outline in dorsal view. The ratio WH/W (= 0.44) is relatively low resulting in a shell appearing constricted at the base of the beak. This induces a pyriform shape in dorsal view. In ventral view, the shell appears very elongate. The ornamentation of the outer surface is made of coarse, simple ribs; no new ribs appear by intercalation. The ribs are roughly knobbed. The knobs are not annular. There are 26 knobs on the median dorsal rib. The beak is obtuse and suberect. The beak-ridges are not distinct. The foramen is relatively large and submesothyridid. The auricles are quite small but well defined. The auricles are not ribbed, but a row of two knobs was added at each growth stage. This gives the illusion that the auricles are radially ribbed. During growth, the auricles were righting themselves dorsally and the variation of the ratio LDV/W indicates that the width of the shell was increasing during growth. The ratio L/W was increasing slightly during growth, indicating an increase of the length of the beak.

Comparison with other species
The internal structure of *Terebratulina* (?) n. sp. remains unknown. A confusion with the genus *Gisilina* STEINICH, 1963 is still possible. As only one specimen is now available, it is preferable to leave this species in open nomenclature.

Terebratulina (?) n. sp. cannot be confused with *T.*

chrysalis (VON SCHLOTTHEIM, 1813) which developed a number of new ribs by intercalation. Moreover, the ribs of *Terebratulina* (?) n. sp. are much coarser than the ribs of *T. chrysalis*. The ratio T/W is higher in *Terebratulina* (?) n. sp.

Terebratulina (?) n. sp. is distinguished from *T. faujasii* (ROEMER, 1841) by its subtriangular-elongate outline. *T. faujasii* is more subcircular. The number of ribs is higher in *Terebratulina* (?) n. sp. and the knobs on the ribs are not annular as they are in *T. faujasii*.

Subfamily Chlidonophorinae MUIR-WOOD, 1959
Genus *Gisilina* STEINICH, 1963
Type species: *Gisilina gisii* (ROEMER, 1841)

Gisilina aff. jasmundi STEINICH, 1965
Plate 6, Figures 1 a-e.

Stratigraphical range: upper part of Lower Maastrichtian.

Material: one bivalved shell, perfectly preserved and collected at the limit between the phosphatic chalk and the hardground.

For this brachiopod, a similarity with *Gisilina jasmundi* STEINICH, 1965 is observed: the general outline of the shell, the type and the number of ribs and the shape of the beak are identical to the holotype of STEINICH (1965, pl. 16, figs. 1a-d, 2).

The ornamentation of the single radial ribs consists of annular knobs similar to those observed in the holotype of *G. jasmundi*.

This specimen has a length of 6.1 mm, a width of 4.7 mm and a thickness of 2.8 mm. The hinge line is 3.7 mm long and the area is 1.4 mmm high.

However, this specimen has a higher ratio L/W (1.36), a higher ratio WH/W (0.81) and a higher ratio T/W (0.63) than the holotype. In *G. jasmundi* the anterior commissure is slightly plicate. This is not the case for our specimen. The auricles of *G. jasmundi* are quite small. The auricles of the specimen from Ciply are more developed; this gives a subrectangular outline to the shell when it is seen in dorsal view.

This shell from Ciply may be a gerontic specimen of *G. jasmundi*. From a stratigraphical point of view, it is noteworthy that this shell has been found together with *Dalligas nobilis* STEINICH, 1968.

Genus *Rugia* STEINICH, 1963
Type species: *Rugia tenuicostata STEINICH, 1963*

Rugia curvirostris n. sp.
Tables 1, 4, Text-Figure 5, 6, 10, Plate 6,
Figures 2 a-d, 3-7.

Diagnosis - A species of *Rugia* with a subtriangular outline and possessing a curved beak with a minute foramen. The droplet form is typical of adult representatives of this

Table 4 – Morphological characters measured on the holotype of *Rugia curvirostris* n. sp. from the phosphatic chalk of Ciply. Specimen collected in the Van Damme quarry in Ciply (Hainaut, Belgium). IRScNB. - IST. n° 10709. L: Length of the specimen. LDV: length of the dorsal valve. W: width of the specimen. T: thickness of the specimen. WH: width of hinge line. HA: height of area. L/W: ratio length (L) to width (W). LDV/W: ratio length of dorsal valve (LDV) to width (W). T/W: ratio thickness (T) to width (W). NRVV: number of ribs on the ventral valve. NRVD: number of ribs on the dorsal valve. ß: apical angle. ØF: diameter of the foramen.

	L mm	LDV mm	W mm	T mm	L/W	LDV/W	T/W	WH mm	HA mm	ß degrees	NRVV	NRVD	ØF mm
Rugia curvirostris n. sp. Holotype IST-N°10709	1.8	1.4	1.6	0.8	1.13	0.88	0.50	0.8	0.4	75	28	27	0.23

species. Numerous radial ribs, which are sculptured by rows of densely spaced transverse scales, are observed on the shell surface.

Derivatio nominis: from the Latin *curvus* (curved) and *rostrum* (beak).

LOCUS TYPICUS: Van Damme quarry in Ciply, Hainaut, Belgium.
STRATUM TYPICUM: Phosphatic Chalk of Ciply. Upper part of the lower Lower Maastrichtian.

Holotype.
Rugia curvirostris n. sp. Plate 6, Figure 2 a-d. The holotype is conserved in the Institut royal des Sciences naturelles de Belgique in Brussels, IRScNB - IST n° 10709. The morphological characters measured on the holotype are indicated in Table 4.

Material: 36 complete bivalved shells, 43 ventral valves, 60 dorsal valves and many fragments. Most of the specimens were collected in the phosphatic chalk although some individuals were also found in the cavities at the base of the hardground.

Description
External characters

The shell is very small. Young specimens are oval-triangular in outline. Large specimens exhibit a typical "droplet" outline due to rapid increase of the width during ontogeny. The anterior commissure is rectimarginate. The maximum width of the shell is situated anteriorly in young specimens. Throughout ontogeny, the maximum width moves slightly around midlength of the shell. The ratio L/W perceptibly decreases during ontogeny as does the ratio LDV/W. The hinge line is oblique and the ratio WH/W decreases significantly during growth. The shell is moderately biconvex and the pedicle valve is often slightly more convex than the brachial valve. Some specimens with equal convexity have also been observed.

The shell surface is covered by 14-34 well developed ribs. They are straight in the median part of the shell but they are slightly curved on the lateral flanks of the shell. The ratio NR/W varies from 12.7 to 23.2. This ratio decreases slightly through ontogeny but this slope is not very significant. The rib sculpture, which is always sharply visible in the specimens investigated, consists of rows of numerous small scale's arranged across the ribs.

The beak is short, very pointed and always curved even for the smallest specimens. As seen in lateral profile, the cardinal area is apsacline. This cardinal area is small but well defined. The hypothyridid foramen is extremely small (minute foramen) through ontogeny and the ratio F/W varies from 0.05 to 0.13. The deltidial plates are narrow. A well developed pedicle collar is present. The morphological characters measured on the specimens are illustrated in Figure 10.

Internal characters

Very small, slightly elongate teeth are visible in the pedicle valve. There are no dental plates. The cardinal process is indistinct. The inner socket ridges are short and bent postero-laterally. A well exposed, intact brachidium, has not been observed among the opened specimens. Spicular skeletons are often found recrystallized.

The crura are thin, very long and they converge strongly antero-ventrally. In a specimen, some fragments of the loop indicate that the ascending branches are spoon-shaped, a feature typical of the genus *Rugia*.

Comparison with other species
Rugia curvirostris n. sp. cannot be confused with *Rugia tenuicostata* STEINICH, 1963 which has a more elongate-triangular outline, a beak which is never curved and a larger foramen.

R. curvirostris n. sp. is closely related to *Rugia acutirostris* STEINICH, 1965. This species has a similar curved beak and also a minute foramen. The first distinction between these species is the less elongate shell of *R. curvirostris* n. sp. and its droplet shape. *R. acutirostris* STEINICH, 1965 is typically oval-elongate or broad oval.
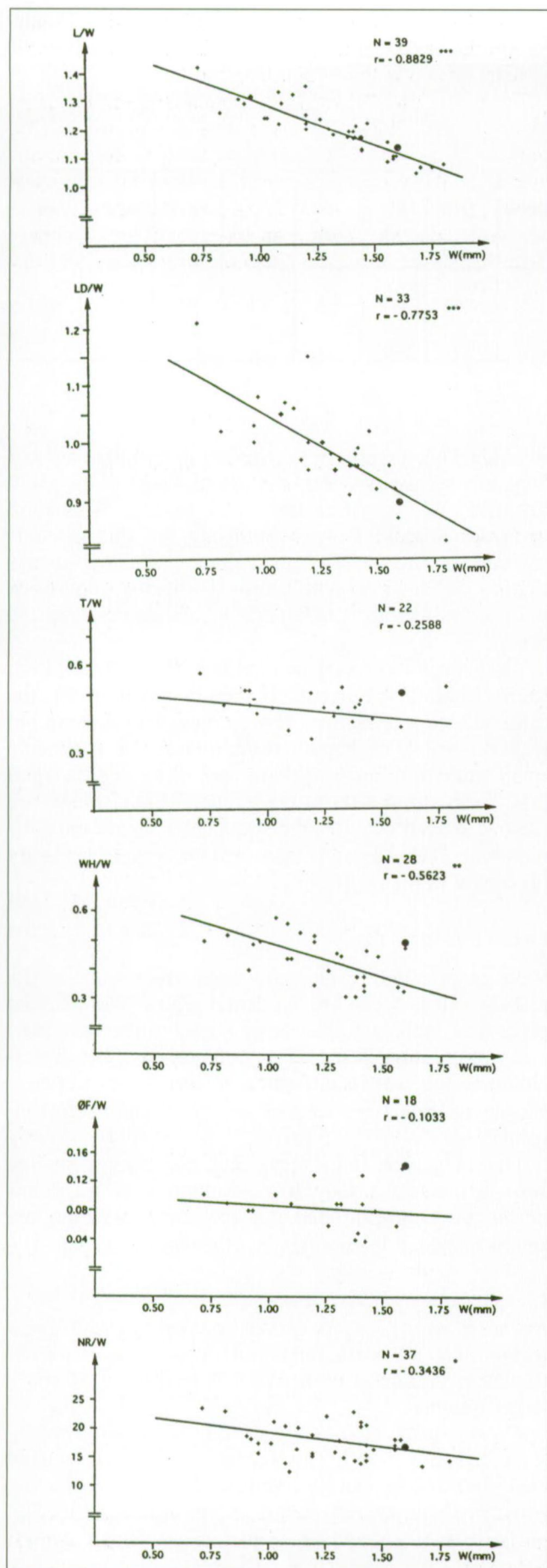
The decrease in the ratios L/W and LD/W during onto-geny is sharper for *R. curvirostris n. sp.* The number of ribs is lower for *R. curvirostris* n. sp. The rib sculpture is more developed on the shell surface of *R. curvirostris* n. sp. The ribs of *R. acutirostris* STEINICH, 1965 are not sharply decorated and they are often smooth.

Rugia alsenii JOHANSEN, 1987b from the Upper Campanian is more elongate in outline and cannot be confused with any species of *Rugia* discussed herein.

Suborder Terebratellidina MUIR-WOOD, 1955
Superfamily Terebratelloidea KING, 1850
Family Megathyrididae DALL, 1870
Genus *Megathiris* D'ORBIGNY, 1847
Type species: *Anomia detruncata* J. F. GMELIN, 1790

***Megathiris bidiscoidea* SIMON, 1992**
Table 1, Text-Figure 5, Plate 6, Figures 8 a-c.

*   1992   *Megathiris bidiscoidea n. sp.* - SIMON, p. 124, pl. 1, figs. 1-8, pl. 3, figs. 1-4.

Stratigraphical range: Lower Maastrichtian.

Material: no bivalved specimen, five dorsal valves, two fragmented ventral valves and some fragments from the phosphatic chalk of Ciply.

Extracted from the soft sediment infilling the cavities of the hardground: no bivalved shell, 13 dorsal valves, two ventral valves and 18 fragments.

The diagnosis, measurements and comments concerning this recently described species can be found in SIMON (1992). A better preserved dorsal valve has been found and is illustrated here.

The poor state of preservation of the specimens of *Megathiris bidiscoidea* indicates that they were transported. The relative abundance of this species in the hardground is another argument for this fact.

Genus Argyrotheca DALL, 1900
Type species: *Terebratula cuneata* RISSO, 1826

Argyrotheca cf. *microscopica* (VON SCHLOTTHEIM, 1813)
Plate 7, Figures 1 a-c, 2.

1798   Térébratulite inédite - FAUJAS DE SAINT FOND, p. 159, pl. XXVI, fig. 2.
*   1813   *Terebratulites microscopicus* - VON SCHLOTTHEIM (cit. FAUJAS, 1798), p. 113.

Fig. 10 – Scatter diagrams of *Rugia curvirostris* n. sp. from the phosphatic chalk of Ciply (Lower Maastrichtian, *Belemnella obtusa* Zone). The holotype is circled. L/W: ratio shell length to width. LD/W: ratio dorsal valve length to width. T/W: ratio thickness of the shell to width. WH/W: ratio hinge line width to width. ØF/W: ratio foramen width to width. NR/W: ratio number of ribs to width.

. 1820   *Terebratulites microscopicus* - VON SCHLOTTHEIM, p. 286.

. 1859   *Argiope microscopica* v. Schl. sp. - BOSQUET, p. 46, pl. V, figs. 10- 14.

. 1965   *Argyrotheca microscopica* v. SCHLOT. - STEINICH, p. 125.

Stratigraphical range: Upper Maastrichtian.

Material: No bivalved specimen, 15 dorsal valves, six ventral valves and some fragments. All this material has been collected from the sediments trapped in the cavities of the hardground

All specimens investigated were damaged by transportation. For this reason, a precise determination was not possible. The shell has an outline similar to those observed in BOSQUET (1859, pl. V, figs. 10-14). The ribs protrude from the anterior margin. The interspace between the two principal ribs is wider than the interspace between the secondary ribs. The ribs are strongly knobbed as in the specimen illustrated by BOSQUET. The lateral parts of the shell, near the posterior margin, are not ribbed. The shell is quite thick. This feature is also observed in representatives of this species from the Maastricht area.

The internal structures are not sufficiently preserved, but the high triangular septum seen in the dorsal valve corresponds to the detailed description given by BOSQUET (p. 47).

Argyrotheca stevensis (NIELSEN, 1928)
Plate 7, Figures 4 a-g.

* 1928   *Argiope stevensis n. sp.* - NIELSEN, p. 219, pl. 4, figs. 10 - 11.

. 1972   *Argyrotheca stevensis* (NIELSEN) - SURLYK, p. 20, text-figs. 2, 5, 13.

. 1984   *Argyrotheca stevensis* (NIELSEN) - SURLYK & JOHANSEN, fig. 1.

. 1987a   *Argyrotheca stevensis* (NIELSEN, 1928) - JOHANSEN, p. 30, text- figs. 21 A-F, pl. 12, fig. 6, pl. 13, figs. 1-4.

Stratigraphical range: uppermost Maastrichtian.

Material: one bivalved specimen and one fragmented dorsal valve collected from the sediment trapped in the cavities of the hardground.

The intact specimen found at Ciply accords with the detailed description of this species given by JOHANSEN (1987a, p. 30) for the Upper Maastrichtian material from Nye Kløv.

The Ciply specimen is subpentagonal in outline with nearly parallel lateral edges to its shell. The shell is biconvex and the ventral valve is more convex than the dorsal one. The ribs are arranged in two distinct bundles separated by a median sulcus.

The internal characters are well preserved. The two hinge plates are concave and disc shaped. The dorsal median septum is quite high and has a truncated triangular outline in lateral view. Its posterior part slopes very sharply. The dorsal septum of the specimen from Ciply

has an identical shape to the septum illustrated in JOHANSEN for the same species (1987, pl. 12, fig. 6). The ventral median septum is thin, quite long but low.

The distinction between the Danian *Argyrotheca dorsata* (NIELSEN, 1928) and *Argyrotheca stevensis* is difficult. But, the internal structures of our specimen are not similar to those observed for *A. dorsata* by JOHANSEN (1987a, p. 34, pl. 15, figs. 2, 3). *Argyrotheca stevensis* is considered in Denmark as an index fossil for the uppermost Maastrichtian *stevensis-chitoniformis* Zone of SURLYK (1982, 1984).

Argyrotheca cf. *lacunosa* STEINICH, 1965
Table 1, Plate 7, Figures7 a-c.

* 1965   *Argyrotheca lacunosa sp. n.* - STEINICH, pp. 134-137, text-figs. 197- 199, pl. XVIII, fig. 1 a-d.

Stratigraphical range: Lower Maastrichtian.

Material: two complete bivalved shells and numerous small fragments, all collected in the phosphatic chalk of Ciply.

Due to transport, most of the specimens are poorly preserved, except two individuals. In outline, they are very similar to *Argyrotheca lacunosa* STEINICH, 1965. The interarea in the Ciply specimens is as high as the interarea developed in *Argyrotheca lacunosa*. A large foramen is also present. The faint ribs and the growth lines observed in the specimens from Ciply agree with those illustrated by STEINICH (1965, pl. 18, fig. 1 a-d). It was not possible to open the two intact specimens found in Ciply. As the internal characters are not known, it is preferable to leave these specimens in open nomenclature.

Argyrotheca cf. *coniuncta* STEINICH, 1965
Plate 7, Figures 5 a-b.

* 1965   *Argyrotheca coniuncta n. sp.* - STEINICH, pp. 138-144, text-figs. 200 - 206, pl. 18, fig. 2 a-d.

. 1969   *Argyrotheca coniuncta* Steinich - SURLYK, pp. 194-199, text-figs. 206-212, pl. 20, figs. 1-3.

. 1972   *Argyrotheca coniuncta* Steinich - SURLYK, p. 20, text-figs. 5-12.

. 1979   *Argyrotheca coniuncta* Steinich, 1965 - BITNER & PISERA, p. 79, pl. 5, figs. 5-7.

. 1984   *Argyrotheca coniuncta* Steinich, 1965 - SURLYK & JOHANSEN, fig. 1.

. 1987   *Argyrotheca coniuncta* Steinich, 1965 - JOHANSEN, p. 28, pl. 12, fig. 5 A, B.

. 1990   *Argyrotheca coniuncta* Steinich, 1965 - JOHANSEN & SURLYK, p. 857, pl. 8, figs. 5, 6, 8, 9.

Stratigraphical range: Lower Maastrichtian to uppermost Maastrichtian.

Material: one poorly preserved dorsal valve from the sediments situated at the boundary between the phosphatic chalk and the hardground.

Detailed descriptions of this species were given by STEI-NICH and JOHANSEN (see synonymy list). The dorsal valve from Ciply exhibits the external characters of the species: its typical semicircular outline and similar ribs, separated by a median sinus, are clearly visible. Internally, a strong median septum is developed: it is typically curved. Nevertheless, it is difficult to determine wether or not the hinge plates are fused in this specimen. As this feature is a very important feature for this species, the specimen is left in open nomenclature.

Argyrotheca aff. coniuncta STEINICH, 1965
Table 1, Plate 7, Figures 6 a-b.

Material: one dorsal valve collected in the phosphatic chalk of Ciply.

The outline of this specimen is similar to the outline of *Argyrotheca coniuncta* STEINICH, 1965: it is semicircular and the hinge line is prolonged into wing-like extensions. But the median septum is neither as strong nor as curved as it is in *Argyrotheca coniuncta*. Moreover, the hinge plates in this specimen are not fused but totally indepen-dent from each other. The state of preservation of this specimen is not very good.

Argyrotheca popielae SIMON, 1992
Table 1, Text-Figures 5, 6, 8.

* 1992 *Argyrotheca popielae* n. sp. - SIMON, p. 126, text-figs. 5-8, pl. 2, figs. 1-13.
. v 1992 *Argyrotheca popielae* SIMON 1992 - POPIEL-BARCZYK, p. 29.

Stratigraphical range: Lower Maastrichtian.

Material: 156 bivalved shells, 166 dorsal valves, 240 ventral valves and numerous fragments from the phosphatic chalk of Ciply.
From the soft sediment extracted from the cavities of the hardground: 851 intact bivalved shells, 623 dorsal valves, 702 ventral valves and fragments.

A detailed description and illustrations were given re-cently by SIMON (1992). This paper can be consulted for more information.

Family Platidiidae THOMSON, 1927
Subfamily Platidiinae THOMSON, 1927
Genus *Aemula* STEINICH, 1968
Type species: *Aemula inusitata* STEINICH, 1968

Aemula inusitata STEINICH, 1968
Table 1, Plate 8 Figures 1 a-b, 2.

* 1968a *Aemula inusitata* sp. n. - STEINICH, pp. 193 - 199, text-figs. 1-5, pl. 1, fig. 1.

. 1972 *Aemula inusitata* Steinich, 1968 - SURLYK, pp. 20, 35, 40, text- figs. 5, 12, 13, 15-18, pl. 3, figs. e, f, h.
. 1974 *Aemula inusitata* Steinich, 1968 - SURLYK, pp. 185-203, text-figs. 1, 3, 6, 7, pl. 2, figs. A, C - F.
. v 1979 *Aemula inusitata* Steinich, 1968 - BITNER & PISERA, pp. 79-80, pl. 5, fig. 4 a, b.
. 1984 *Aemula inusitata* Steinich, 1968 - SURLYK & JOHANSEN, fig. 1.
. 1987a *Aemula inusitata* Steinich, 1968 - JOHANSEN, pp. 39-40, pl. 18, figs. 1-5.
. 1988 *Aemula inusitata* Steinich, 1968 - JOHANSEN, text-fig. 2, pl. 3, figs. 4a, b, 5, 6.
. 1990 *Aemula inusitata* Steinich, 1968 - JOHANSEN & SURLYK, pp. 864- 865, pl. 9, figs. 1-4.

Stratigraphical range: Upper Campanian to Lower Danian.

Material: two complete shells collected in the phosphatic chalk of Ciply.

The specimens are subcircular in outline. They are plano-convex to concavo-convex. The ventral valve is covered with small tubercles regularly spaced. The dorsal valve is smooth, except for some growth lines. The beak is very short and suberect. The foramen is typically amphithyrid and irregular. Internally, a septal pillar bearing septal flanges is visible. Socket ridges and low outer hinge plates are present. Dental plates and crura are not devel-oped.

Family Dallinidae BEECHER, 1893
Genus *Dalligas* STEINICH, 1968
Type species: *Dalligas nobilis* STEINICH, 1968

Nomenclative note
The fact that the genus *Dalligas* belongs to the Dallinidae is doubtful. Strong dental plates and the development of septal flanges on the septal pillar are indicative of affinity with the family Laqueidae. The absence of crura in *Dalligas* (and of a complete loop) makes precise taxonomic determination difficult.

Dalligas nobilis STEINICH, 1968
Plate 8, Figures 5 a-c, 6 a-b, 7 a-b.

* 1968b *Dalligas nobilis gen. et sp. nov.* - STEINICH, pp. 336-347, text-figs. 1-3, pl. 1, figs. 1-2.
. 1987a *Dalligas nobilis* Steinich, 1968 - JOHANSEN, p. 43, pl. 18, figs. 6-7.

Stratigraphical range: upper part of the Lower Maastrichtian.

Material: one bivalved juvenile specimen, one well preserved, adult, ventral valve, two fragmented ventral valves and one dorsal valve. All the specimens were collected at the boundary between the phosphatic chalk of Ciply and the base of the overlying hardground.

The intact ventral valve is slightly elongate and possesses a typical ornamentation of the adult shell as described by STEINICH (1968, p. 339) consisting of 30 to 40 weak radial ribs. Strong dental plates and a well developed pedicle collar are observed. The fragmented dorsal valve exhibits a septal pillar which is broken. The septal flanges occur-ing on the septal pillar cannot be seen. Weak hinge plates,

fused with the posterior part of the septal pillar, are present.

It is noteworthy that this material is found together with *Gisilina* aff. *jasmundi*.

Subfamily Gemmarculinae ELLIOTT, 1947
Genus *Ruegenella* OWEN, 1977
Type species: *Ruegenella ciplyensis* OWEN, 1977

Ruegenella ciplyensis OWEN, 1977

* 1977 *Ruegenella ciplyensis sp. nov.* - OWEN, p. 227, text-fig. 11, pl. 1, fig. 5a-c.

Stratigraphical range: Lower Maastrichtian.

Material: one broken dorsal valve and a fragment found in the phosphatic chalk at the boundary with the overlying hard-ground.

This fairly rare brachiopod has been placed in the genus *Ruegenella*, mainly because its cardinal process is massive and bilobed, a feature always absent in representatives of the genus *Gemmarcula* ELLIOTT, 1947. A detailed description can be found in OWEN (1977, p. 227).

OWEN associated this species with the larger *Ruegenella corneti* (VON HANSTEIN, 1879). This latter species is not found, in fact, in the phosphatic of Ciply but it is a typical brachiopod from the boundary between the hard-ground overlying the phosphatic chalk and the Tuffeau of Saint-Symphorien (Uppermost Maastrichtian). Other very large brachiopods including *"Terebratula" dessaillyi* PÉRON, 1894 were collected from the same situation. They cannot be attributed to the Lower Maastrichtian. In the Van Damme quarry, the Tuffeau of Saint-Symphorien is not visible and such large brachiopods were never found.

Family Laqueidae HATAI, 1965 emended RICHARDSON, 1975
Subfamily Kingeninae ELLIOTT, 1948 emended by RICHARDSON, 1975
Genus *Kingena* DAVIDSON, 1852
Type species: *Terebratula lima* DEFRANCE, 1828

Kingena sp.
Table 1, Plate 8, Figure 8.

Material: one damaged dorsal valve and one fragment collected in the phosphatic chalk.

This material is not well preserved and a more precise determination cannot be given for this small shell. Its ornamentation, made of regularly spaced pustules, and the structure of the cardinalia allows only an identification at the genus level.

Subfamily Trigonoseminae ELLIOTT, 1965
Genus *Trigonosemus* KOENIG, 1825
Type species: *Trigonosemus elegans* KOENIG, 1825

Nomenclative note

The representatives of this genus are in need of revision. The genus *Trigonosemus* includes several species which exhibit very different outline and cardinalia. The trifid structure of the cardinal process, which is observed in the type species, is not found in the other species (see also OWEN, 1977, pp. 240 - 244). Moreover, dental plates are present in the type species and in some other species including *T. pulchellus* (NILSSON, 1827) but they are absent in *"T. pectiniformis"* (VON BUCH, 1835). *T. uralicus* (RENNGARTEN, 1953) should also be investigated for its internal features.

The genus *Trigonosemus* is tentatively placed here in the family Laqueidae according to RICHARDSON (1975, p. 310) who took into account the ontogenetic development of the loop in *T. pulchellus* (NILSSON, 1827) studied in STEINICH (1965, pp. 170 - 183, text-figs. 269 - 278).

Trigonosemus elegans KOENIG, 1825

*	1825	*Trigonosemus elegans* n. - KOENIG, p. 3, pl. VI, fig. 73 a-e.
.	1847	*Fissurirostra recurva* d'Orb. - D'ORBIGNY, n° 1156, p. 133, pl. 520, figs. 1-8
.	1847	*Fissurirostra elegans* d'Orb. - D'ORBIGNY, n° 1157, p. 134, pl. 520, figs. 9-13.
.	1847	*Fissurirostra pectita* d'Orb. - D'ORBIGNY, n° 1158, p. 136, pl. 520, figs. 14-18.
?	1852	*Trigonosemus elegans* Koenig. - DAVIDSON, p. 29, pl. IV, fig. 3.
?	1860	*T. elegans* Sowerb. sp. - BOSQUET, n° 565.
	1866	*Fissurirostra pectita* d'Orb. - CORNET & BRIART, p. 151.
.	1879	*Trigonosema pectitum* d'Orb. sp. - VON HANSTEIN, pp. 32-33.
?	1974	*Trigonosemus elegans* Koenig, 1825 - KATZ, p. 267, pl. 87, fig. 17 a-c.
.	1977	*Trigonosemus elegans* Koenig 1825 - OWEN, pp. 241-244, text-figs. 23-24, pl. 3, fig. 2 a-c.
	1992	*Trigonosemus elegans* KOENIG, 1825 - POPIEL-BARCZYK, p. 33.

Stratigraphical range: Upper Campanian to Upper Maastrichtian.

Material: one bivalved small individual and a fragment of a dorsal valve. This material was collected at the boundary between the phosphatic chalk and the overlying hardground.

This species was described in detail by OWEN in 1977 and a specimen from Ciply is illustrated in his paper (pl. 3, fig. 2 a-c). The specimens found in the Van Damme quarry are identical to the specimen illustrated by OWEN. The fragment of dorsal valve exhibits the typical cardinal process with trifid lobes and a big sphaeroidal bulge. *Trigonosemus elegans* is a fairly rare brachiopod in the phosphatic chalk of Ciply.

Trigonosemus palissii WOODWARD, 1854
Table 1, Text-Figures 2, 4, 5, 6, 11, Plate 9,
Figures 1 a-b, 2 a-c, 3 a-c, 4 a-b, 5, 6 a-c,
7 a-c, Plate 10, Figures 1-3, 4 a-b.

* 1854 *Trigonosemus Palissii* - WOODWARD, part II, p. 217, pl. XV, fig. 8.
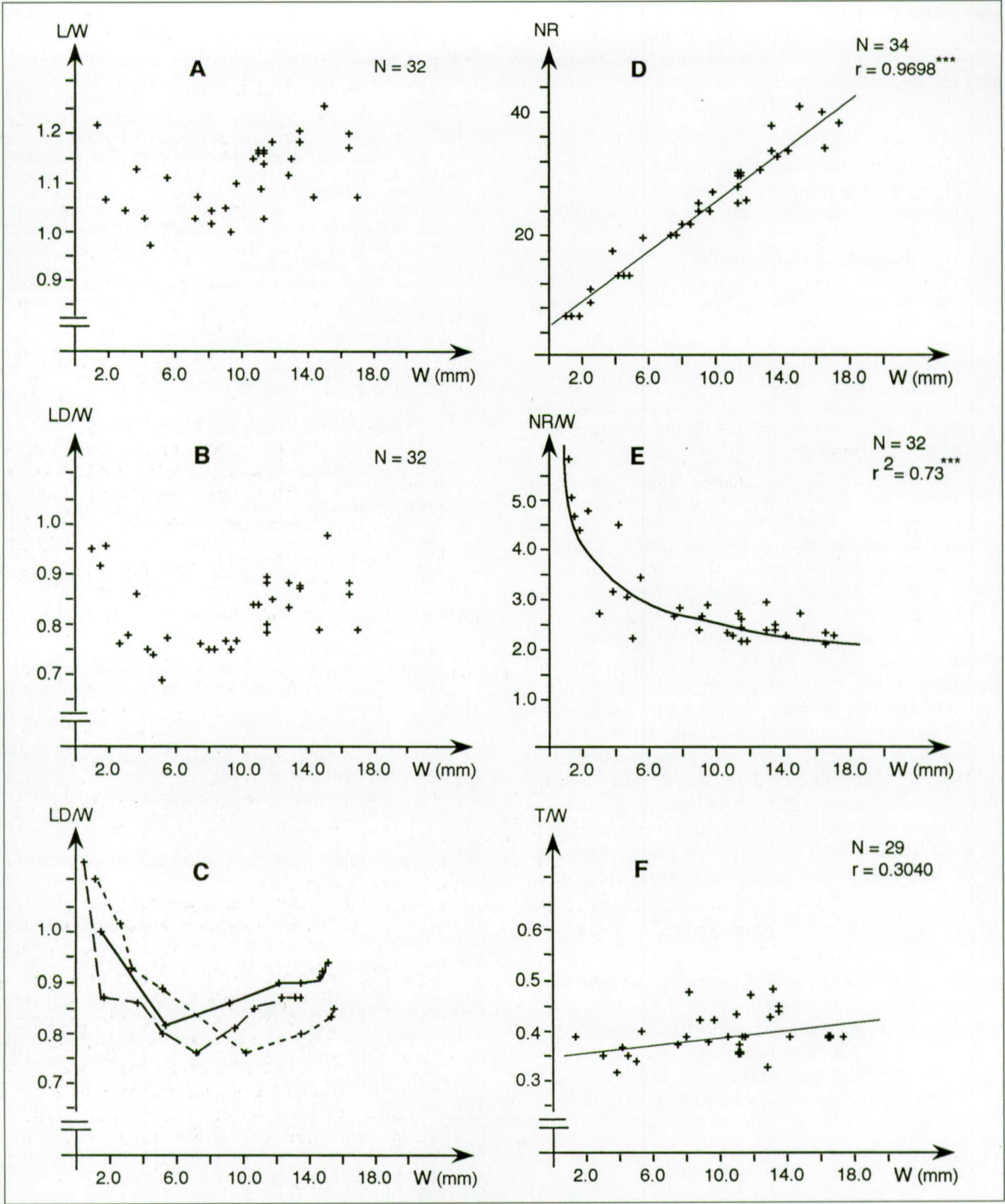
Fig. 11 – Scatter diagrams of *Trigonosemus palissii* Woodward, 1864 from the phosphatic chalk of Ciply (Lower Maastrichtian, *Belemnella obtusa* Zone). N: number of specimens measured. r: coefficient of correlation. r^2: coefficient of regression. A: ratio shell length (in mm) to width (in mm). B: ratio dorsal valve length (in mm) to width (in mm). C: variation of the ratio dorsal valve length to width for three specimens. The value of this ratio decreases during the first phase of growth. Then the value of this ratio increases till the adult stage of growth is reached. This variation indicates an elongation of the shell during the last growth stages. This is also visible in the ratio shell length to width. D: relation between the number of ribs (NR) and the shell width (in mm). E: ratio number of ribs to shell width (in mm). F: ratio shell thickness (in mm) to shell width (in mm).

. 1860   *Terebratella palissei* Woodw. sp. - Bosquet, N° 564.
. 1870   *Trigonosemus Palissii* - Woodward translated by Humbert, p. 378.
. 1870   *Trigonosemus Palissyi* - Woodward translated by Humbert, pl. XV, fig. 8.
p. p. 1871   *Terebratula pectiniformis* - Quenstedt, p. 265, pl. 44, figs. 96, 98, 102 , non figs. 97, 99, 100, 101, 103.
p. p. 1879   *Trigonosema pectiniforme* v. Schloth. sp. - von Hanstein, pp. 30 -32.
. 1879   *Terebratella Palissei* Bosq. - Ubaghs, pp. 138, 216.
. 1927   *Trigonosemus Palissyi* - Cornet, pp. 242, 282.
. 1965   *Trigonosemus palissii* Woodward - Steinich, pp. 171, 182.
? 1967   *Trigonosemus palissii* - Wood, p. 283.
. 1977   *T. palissyi Woodward* - Owen, p. 242.
. 1977   *Trigonosemus palissi* (Woodward) - Owen, p. 243, text-fig. 26.
. 1992   *Trigonosemus palissi* Woodward, 1831 - Popiel- Barczyk, p. 33.

Stratigraphical range: Lower Maastrichtian.

Material: 129 adult bivalved shells, 39 adult dorsal valves, 43 adult ventral valves and numerous fragments from the phosphatic chalk of Ciply. Young and juveniles specimens extracted from the phosphatic chalk: four bivalved shells, three dorsal valves, seven ventral valves and some fragments.

Emended description

External characters

The shell is medium-sized with an outline changing from subcircular in the young adult stage to elongate oval in more gerontic forms. The maximum width is at the mid-length of the dorsal valve. The anterior commissure is generally rectimarginate but it is slightly sulcate in some specimens. Except for the beak, the shell is plano-convex in lateral profile, the dorsal valve being extremely flat. The shell surface possesses numerous radial ribs (Fig. 11), the lateral ones being slightly reflexed. New ribs are formed by intercalation. The ribs interspaces are as wide as the ribs or slightly wider. The essential morphological ratios are illustrated on Figure 11. On the external ventral valve surface, a narrow sulcus is visible in the median posterior part of the valve. The hinge line is straight. The beak is curved, long, acute and erect. The very well defined interarea is wide, triangular, concave and smooth. The symphytium is high, concave and triangularly shaped. A pinhole foramen is visible.

Internal characters

Ventral valve

Ribbing sculpture is visible internally, on the valve floor. A pseudo-septum or ridge, moderately elevated, is visible in the posterior part of the valve. It extends till the mid-length of the ventral valve. It corresponds to the narrow sulcus, externally visible, on this valve. The posterior part of this valve is strongly thickened. The canal of the pedicle is obstructed with callose substance resulting in the fact that *Trigonosemus palissii* is a secondary free living species. Strong dental plates are

visible which support small, robust teeth. The teeth are placed very near each other, in the median part of the hinge line.

Dorsal valve

The outer socket ridges are very low. The inner socket ridges are very strong, high and extend posteriorly beyond the hinge line. The inner sides of the inner socket ridges are fused with the cardinal process. The cardinal process consists of a posterior extension of the rim of the hinge trough. A small bulge is visible anteriorly and two small, distinct, muscle scars are visible in its posterior part. Outer hinge plates are not developed. A median septum extends till the mid-length of the dorsal valve: it is very thin and not very elevated. The crura arise directly from the anterior part of the inner socket ridges. They are very short and diverge anteriorly. The crural processes are short, triangular and acutely pointed. The adult loop reaches a typical trabecular stage, the lateral connecting bands being well developed. The adult loop of *Trigonosemus palissii* is similar to the loop described by Steinich (1965, text-figs. 268 - 278) for *T. pulchellus* (Nilsson, 1827). The ontogenetic development of the loop is not precisely known because juvenile specimens are extremely rare in the phosphatic chalk of Ciply but it is considered to be similar to the development observed in *T. pulchellus*.

Comparison with other species.

No confusion is possible between *Trigonosemus palissii* and the larger *T. elegans* Koenig, 1825 which has a biconvex shell, ornamented with more numerous and finer ribs. The cardinal process of *T. elegans* is highly developed with trifid lobes and a big hemisphaeroidal bulge.

On the contrary, *T. palissii* is very similar to *T. pulchellus* (Nilsson, 1827). When the material is not well preserved, confusion between these two species is easily possible (Wood, 1967, p. 283).

Adults specimens of *T. palissii* are generally larger and they possess a higher number or ribs. The anterior commissure of *T. pulchellus* is more clearly sulcate.

The beak of *T. pulchellus* is more curved than the beak of *T. palissii*. In dorsal view, the interarea is elongate and clearly visible in all specimens of *T. palissii*. In *T. pulchellus*, the strongly curved beak obscures the interarea. In *T. palissii*, the ratio of dorsal valve length to width decreases during growth until the width of the specimens reaches 6.0 or 7.0 mm. This ratio increases later, because an elongation of the shell occurs during the growth of adult specimens. This typical elongation during growth, which is interpreted here as a morphological adaptation, does not occur in *T. pulchellus* (Fig. 4 and Fig. 11, B, C, D).

The early juvenile individuals of these two species are extremely similar and it is nearly impossible to distinguish them.

Family uncertain
Genus *Kingenella* POPIEL-BARCZYK, 1968
Type species: *Kingenella pseudohebertiana* (PÉRON, 1894)

Nomenclative note
The genus Kingenella is removed from the family Terebratellidae because the cardinalia observed in this genus are never found in representatives of this family. Further studies are needed to understand the taxonomical position of Kingenella and other brachiopods which possess fused, outer and inner hinge plates, forming a platform.

Kingenella pseudohebertiana (PÉRON, 1894)

	1874	*Terebratula Hebertiana* d'Orb. - CORNET, p. 576
*	1894	*Terebratula (Kingena) pseudohebertiana* - PÉRON, p. 14, pl. 5, figs. 16 - 22.
. v	1935	*Kingena lima* Defr. - KONGIEL, p. 41, pl. V(VIII), figs. 7 a-c, 8 a-c, 9 a-c.
.	1938	*Kingena lima* Defr. - POŻARYSKI, p. 20.
. v	1965	*Pseudomagas nilssoni* - MAKRIDIN & KATZ, p. 105 [*nomen nudum*]
. v	1968	*Kingenella kongieli sp. nov.* - POPIEL-BARCZYK, p. 73, pl. XIX, figs. 1-4 and figs. 6 - 9, pl. XX, fig. 6 a - b. non pl. XIX, fig. 5.
. v	1974	*Kingenella nilssoni* (Lundgren, 1885) - KATZ, p. 267, pl. 87, fig. 16 a-c.
. v	1984	*Kingenella kongieli* Popiel-Barczyk - POPIEL-BARCZYK, p. 250, pl. CLII, figs. 3-4
. v	1992	*Kingenella kongieli* Popiel-Barczyk, 1968 - POPIEL-BARCZYK, p. 34.
. v	1994	*Kingenella pseudohebertiana* (PÉRON, 1984) - SIMON, p. 162, text-figs. 3-5, pl. 1, figs. 1-6, pl. 2, figs. 1-6, pl. 3, figs. 1, 2, 6, 7, pl. 4, figs. 1-6.

Stratigraphical range: Lower Maastrichtian to Upper Maastrichtian.

Material: two adult bivalved specimens found in the phosphatic chalk.

This material was investigated and illustrated by SIMON (1994). That paper can be consulted for more information.

Superfamily uncertain
Family uncertain
Genus *Leptothyrellopsis* BITNER & PISERA, 1979
Type species: *Leptothyrellopsis polonicus* BITNER & PISERA, 1979

Leptothytellopsis polonicus BITNER & PISERA, 1979
Table 1, Text-Figure 5, 6, Plate 8,
Figures 3 a-c, 4 a-c.

* v	1979	*Leptothyrellopsis polonicus sp. n.* - BITNER & PISERA, pp. 82-83, text-fig. 5, pl. 7, figs. 1-4.
.	1982	*Leptothyrellopsis polonicus* Bitner and Pisera - SURLYK, fig. 1, pl. 3, figs. c-e.
.	1988	*Leptothyrellopsis polonicus* Bitner and Pisera - JOHANSEN, fig. 2
.	1990	*Leptothyrellopsis polonicus* Bitner and Pisera, 1979 - JOHANSEN & SURLYK, pp. 868-869, pl. 11, figs. 1-4.
. v	1995	*Leptothyrellopsis polonicus* Bitner and Pisera, 1979 - SIMON in JAGT et al., p. 12.

Material: 35 bivalved specimens, 11 ventral valves, two dorsal valves and some fragments, mostly collected in the phosphatic chalk of Ciply. Some specimens were found in the cavities at the base of the hardground.

A revision of this species has recently been completed by MACKINNON, SIMON & BITNER (this volume, p. 175-180). The material collected in Ciply is especially well preserved for observing the small crural plates, a typical feature for this genus. On the contrary, the crura are destroyed in all specimens investigated. Their traces of attachment to the socket ridges are visible in some specimens. *Leptothyrellopsis polonicus* was probably associated with small bryozoa. It is not very abundant but it is constantly present in samples of phosphatic chalk.

Order uncertain
Suborder Thecideidina ELLIOTT, 1958
Superfamily Thecideacea GRAY, 1840
Family Thecideidae GRAY, 1840
Genus *Thecidea* DEFRANCE, 1822
Type species: *Terebratulites papillatus*
VON SCHLOTTHEIM, 1813.

Thecidea papillata (VON SCHLOTTHEIM, 1813)
Text-Figure 8, Plate 10, Figures 5-6, 7 a-c, 8 a-b, 9 a-b, 10-11.

	1798	Jolie Térébratulite - FAUJAS DE SAINT-FOND, p. 116, pl. XXVII, fig. 8 a-f.
*	1813	*Terebratulites papillatus* - VON SCHLOTTHEIM, p. 113 (cit. FAUJAS).
	1819	*Terebratula pumila* - LAMARCK, VI (1), p. 257.
	1819	*Terebratula radians* - LAMARCK, VI (1), p. 257.
.	1828	*Thecidea radiata* DEFR. - DEFRANCE, p. 434 (cit. FAUJAS), pl. XI, 80, fig. 1 a-e.
.	1837	*Thecidea papillata* - BRONN, p. 663, pl. XXX, fig. 3.
.	1847	*Thecidea papillata* BRONN - D'ORBIGNY, p. 154, n° 1168, pl. 523, figs. 1-8.
.	1854	*Thecidium radiatum* DEFR. - DAVIDSON, 1, p. 77, pl. VI, figs. 35-38.
.	1871	*Thecidea papillata* SCHL. - QUENSTEDT, p. 694, pl. 61, figs. 115- 121.
.	1879	*Thecidea papillata* SCHL. - VON HANSTEIN, p. 18.
.	1886	*Thecidea papillata* SCHLOT. - RUTOT & VAN DEN BROECK," p. 331.
.	1887	*Thecidium papillatum* SCHL. - UBAGHS, pp. 60, 61, 64.
.	1897	*Thecidea radiata* - BEECHER, , p. 109.
.	1929	*Thecidea papillata* SCHLOT. - LERICHE, p. 298.
.	1953	*Thecidea papillata* (SCHLOT.) - ELLIOTT, p. 695, pl. XVIII, fig. 5.
.	1959	*Thecidea papillata* (VON SCHLOTTHEIM, 1813) - BACKHAUS, pp. 21- 27, text-figs. 6-7, pl. 1, figs. 1-4.
.	1992	*Thecidea papillata* (SCHLOTTHEIM, 1813) - POPIEL-BARCZYK, p. 34.

A more complete synonymy can be found in BACKHAUS (1959, p. 21-23).

Stratigraphical range: Upper Maastrichtian.

Material: 51 complete bivalved shells, 71 dorsal valves, 80 ventral valves and 76 fragments. This transported material was exclusively collected from the cavities, filled with soft sediments, in the hardground overlying the phosphatic chalk.

This secondyary free living species was studied extensively by BACKHAUS (1959, pp. 21-27). Specially well preserved and juvenile individuals are illustrated here. Complete brachidia with intact *jugum, apparatus ascendens, apparatus descendens, laminae* etc. are visible in Plate 10.

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PLATE 1

All illustrated specimens are preserved at the Institut royal des Sciences naturelles de Belgique in Brussels

Crania antiqua DEFRANCE, 1818
All specimens were collected from the phosphatic chalk of Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
Lower Maastrichtian. *Belemnella obtusa* Zone.

Fig. 1 – Adult ventral valve cemented on a tube of *Sclerostyla mosae* (BRONN, 1837). Length of the specimen: 13.1 mm. Magnification: 4 x. 1a- ventral view. 1b- dorsal view. (IRScNB - IST n° 10677).

Fig. 2 – Young specimen cemented on the margin of the dorsal valve of a specimen of *Carneithyris carnea* (J. SOWERBY, 1812). 2a-general view (magnification: 1.45 x). 2b-detail showing the development of a small pseudointerarea. Magnification: 5.65 x. (IRScNB - IST n° 10678).

Isocrania praecostata ERNST , 1984.
All specimens were collected from the phosphatic chalk of Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
Lower Maastrichtian. *Belemnella obtusa* Zone.

Fig. 3 – Adult dorsal valve ornamented with a low number of ribs. 3a- general dorsal view (magnification: x 6.5). 3b- A detail of the posterior part of this dorsal valve: the surface between the ribs is densely covered by coarse radially directed spines. Magnification: 16.4 x. (IRScNB - IST n° 10679).

Fig. 4 – Adult ventral valve ornamented with a low number of ribs. 4a- general ventral view (magnification: 6.5 x). 4b- A detail of the lateral part of this valve. Magnification: 16.4 x. (IRScNB - IST n° 10680).

Isocrania phosphatica n. sp.
All the specimens were collected from the phosphatic chalk of Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium) or from the cavities within the overlying hard-ground. Lower Maastrichtian. *Belemnella obtusa* Zone.

Fig. 5 – Holotype: adult ventral valve from the phosphatic chalk. 5a- ventral view showing the attachment surface situated near the posterior margin of the shell (magnification: 12 x). 5b- dorsal view showing the relative position of the muscle scars (magnification: 12 x). 5c- lateral view: note that the attachment surface is situated below the top of the valve (magnification: 12 x). 5d- A detail of the attachment surface. Magnification: 32.1 x. (IRScNB - IST n° 10681).

Fig. 6 – Adult dorsal valve. 6a- dorsal view showing the position of the pointed umbo (magnification: 10.2 x). 6b- ventral view showing the relative position of the muscle scars. Note the protractor scars which are situated very anteriorly. Magnification: 10.2 x. (IRScNB - IST n°10682).

Fig. 7 – An eroded dorsal valve which suggests that this species was living in energetic water conditions. Magnification: 10.2 x. (IRScNB - IST n° 10683).

PLATE 2

Fig. 1 – *Rectithyris ciplyensis* (VON HANSTEIN, 1879). Lectotype from Ciply preserved in the collection of the University of Bonn (reference: G.P.I.B.O. - Hanstein-1). Phosphatic chalk of Ciply: Lower Maastrichtian, *Belemnella obtusa* Zone. 1a- dorsal view. 1b- ventral view. 1c- lateral view. 1d- anterior view. The morphological measurements are indicated in Table 3.

Fig. 2 – *Rectithyris ciplyensis* (VON HANSTEIN, 1879). Specimen collected from the phosphatic chalk of Ciply, Van Damme quarry (Ciply, Mons Basin, Hainaut, Belgium). Lower Maastrichtian, *Belemnella obtusa* Zone. 2a- Complete loop in ventral view. 2b- Complete loop in oblique lateral view. 2c- Detail of the cardinal process and of the crural bases. Scale bar: 1mm. This specimen is preserved at the Institut royal des Sciences naturelles de Belgique in Brussels (IRScNB - IST n° 10684).

Fig. 3 – *Terebratulina carinata* (VON HANSTEIN, 1879). Lectotype from Ciply preserved in the collection of the University of Bonn (reference: G.P.I.B.O. - Hanstein-2). Phosphatic chalk of Ciply. Lower Maastrichtian, *Belemnella obtusa* Zone. 3a- dorsal view. 3b- ventral view. 3c- slightly oblique lateral view: the structure of the beak is clearly visible. 3d- anterior view. 3e- posterior view. Magnification: 1.45 x.

Fig. 4 – *Terebratulina carinata* (VON HANSTEIN, 1879). Specimen collected from Ciply (without precision) in the phosphatic chalk and opened for the study of the brachidium. 4a- restored loop in oblique lateral view. 4b- the same specimen in anterior view. Magnification: 5.2 x. This specimen is preserved at the Institut royal des Sciences naturelles de Belgique in Brussels (IRScNB - IST n°10685).

Fig. 5 – Juvenile specimen of *Terebratulina carinata* (VON HANSTEIN, 1879) collected from the sediment infilling the cavities in the hard-ground. Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). 5a- dorsal view. 5b- lateral view. Magnification: 7 x. This specimen is preserved at the Institut royal des Sciences naturelles de Belgique in Brussels (IRScNB - IST n° 10686).

Fig. 6 – Same juvenile specimen as in Fig. 5 presented in anterior view. The strong convexity of the dorsal valve is visible. Note that the juveniles of *Terebratulina carinata* are not biplicate (Magnification: 12 x).

PLATE 3

All specimens illustrated are preserved at the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – *Neoliothyrina fittoni* (VON HAGENOW, 1842). Cardinalia observed in a broken bivalved specimen collected from the phosphatic chalk of Ciply. Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). The flat cardinal process and the very narrow hinge plates are visible. 1a- oblique ventral view. 1b- anterior view. Scale bar: 1mm. (IRScNB - IST n° 10687).

Fig. 2 – *Carneithyris carnea* (J. SOWERBY, 1812). Young specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). 2a- dorsal view. 2b- ventral view. 2c- lateral view. Magnification: 1.35 x. (IRScNB - IST n°10688).

Fig. 3 – *Carneithyris carnea* (J. SOWERBY, 1812). Fully adult specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons Basin,Hainaut, Belgium). 3a- dorsal view. 3b- ventral view. 3c- lateral view. Magnification: 1.35 x. (IRScNB - IST n° 10689).

Fig. 4 – *Carneithyris carnea* (J. SOWERBY, 1812). Larger adult specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Hainaut, Belgium).
4a- dorsal view. 4b- ventral view. 4c- lateral view. Magnification: 1.35 x. (IRScNB - IST n° 10690).

Fig. 5 – *Carneithyris carnea* (J. SOWERBY, 1812). Gerontic specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from Ciply (Hainaut, Belgium). Collection of the Institut royal des Sciences naturelles de Belgique in Brussels (ex Ach. Piret I.G. 9694). 5a- dorsal view. 5b- ventral view. 5c- lateral view. Magnification: 1.35 x. (IRScNB - IST n° 10691).

Fig. 6 – *Carneithyris ciplyensis* (SAHNI, 1929). Small specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). 6a- dorsal view. 6b- ventral view. 6c- lateral view. Magnification: 1.35 x. (IRScNB - IST n°10692).

Fig. 7 – *Carneithyris ciplyensis* (SAHNI, 1929). Adult specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons basin, Hainaut, Belgium). 7a- dorsal view. 7b- ventral view. 7c- lateral view. Magnification: 1.35 x. (IRScNB - IST n°10693).

Fig. 8 – *Carneithyris ciplyensis* (SAHNI, 1929). Larger adult specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). 8a- dorsal view. 8b- ventral view. 8c- lateral view. Magnification: 1.35 x. (IRScNB - IST n°10694).

Fig. 9 – *Carneithyris ciplyensis* (SAHNI, 1929). Gerontic specimen from the phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian, collected from the Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium).
9a- dorsal view. 9b- ventral view. 9c- lateral view. Magnification: 1.35 x. (IRScNB - IST n° 10695).

PLATE 4

All specimens illustrated were collected from the phosphatic chalk of Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
Lower Maastrichtian, *Belemnella obtusa* Zone.
They are preserved in the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – *Carneithyris carnea* (J. SOWERBY, 1812). SEM microphotograph of the cardinalia of the specimen illustrated Pl. 3, Fig. 3. 1a- ventral view, 1b- posterior view and 1c- oblique lateral view. The cardinalia are thickened by secondary shell deposits but the V-shaped crural bases remain visible. Scale bar: 1 mm. (IRScNB - IST n° 10689).

Fig. 2 – *Carneithyris carnea* (J. SOWERBY, 1812). SEM microphotograph of the brachidium of a young specimen. The thickening of the cardinalia is not as extensive as in fully adult shells. 2a- ventral view, 2b- oblique lateral view and 2c- oblique anterior view. The V-shaped crural bases are clearly visible and the cardinal process is moderately developed. Scale bar: 1 mm. (IRScNB - IST n° 10696).

Fig. 3 – *Carneithyris carnea* (J. SOWERBY, 1812). SEM microphotograph of the brachidium of a gerontic specimen illustrated on Pl. 3, Fig. 5. (ex collection IRScNB, Ach. PIRET, I.G. 9694). 3a- ventral view (scale bar: 1 cm), 3b- oblique lateral view (Scale bar: 1 mm), 3c- anterior view (scale bar: 1 mm) and 3d- posterior view (scale bar: 1 mm). The cardinal process is strongly developed as a thick bulge but it remains independant from the socket ridges. The V-shaped crural bases remain visible. (IRScNB - IST n° 10691).

Fig. 4 – *Carneithyris carnea* (J. SOWERBY, 1812). SEM microphotograph of the cardinalia of a young specimen illustrated on Pl. 3, Fig. 2. The crural bases are already thickened by secondary shell deposits but the V-shaped crural bases are visible. Scale bar: 1 cm. (IRScNB - IST n° 10688).

Fig. 5 – *Carneithyris ciplyensis* (SAHNI, 1929). SEM microphotograph of the brachidium of the specimen illustrated on Pl. 3, Fig. 8. 5a- ventral view (scale bar: 1 cm), 5b- anterior view (scale bar: 1 mm). (IRScNB - IST n°10694).

Fig. 6 – *Carneithyris ciplyensis* (SAHNI, 1929). SEM microphotograph of the brachidium of the specimen illustrated on Pl. 3, Fig. 9. 6a- oblique ventral view (scale bar: 1 cm), 6b- anterior view (scale bar: 1 mm). (IRScNB - IST n°10695).

Fig. 7 – *Carneithyris ciplyensis* (SAHNI, 1929). SEM microphotograph of the brachidium in ventral view of an adult specimen illustrated on Pl. 3, Fig. 7. The crura and the descending branches are extremely short in this specimen. Magnification: 3.8 x. (IRScNB - IST n°10693).

Fig. 8 – *Carneithyris ciplyensis* (SAHNI, 1929). Brachidium in ventral view of a relatively young specimen. The crural bases appear not V-shaped and the cardinal process is well developed. Scale bar: 1 cm. (IRScNB - IST n° 10697).

Fig. 9 – *Carneithyris ciplyensis* (SAHNI, 1929). Oblique anterior view of a complete brachidium in a bivalved specimen. Significant shell thickening of the ventral valve is visible. Scale bar 1 cm. (IRScNB - IST n° 10698).

Fig. 10 – *Carneithyris ciplyensis* (SAHNI, 1929). Anterior view of the cardinalia of a gerontic specimen. The cardinal process is trifid and obstructs the pedicle canal. Scale bar: 1 cm. (IRScNB - IST n° 10699).

PLATE 5

All illustrated specimens were collected from Van Damme quarry, Ciply (Hainaut, Belgium).
They are preserved in the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – *Cretirhynchia sp.* A broken ventral valve in dorsal view collected from the phosphatic chalk of Ciply (sample n°36), *Belemnella obtusa* Zone, Lower Maastrichtian. Magnification: 21 x. (IRScNB - IST n°10700).

Fig. 2 – *Cretirhynchia sp.* An opened bivalved specimen collected from the phosphatic chalk of Ciply (sample n°14), *Belemnella obtusa* Zone, Lower Maastrichtian. 2a- ventral valve in dorsal view, 2b- dorsal valve in ventral view. Magnification: 17.2 x. (IRScNB - IST n° 10701).

Fig. 3 – *Carneithyris sp.* A complete juvenile specimen found in the phosphatic chalk of Ciply (sample n°10), *Belemnella obtusa* Zone, Lower Maastrichtian. 3a- dorsal view (magnification: 18.5 x), 3b- ventral view (magnification: 19.5 x). (IRScNB - IST n° 10702).

Fig. 4 – *Terebratulina chrysalis* (VON SCHLOTTHEIM, 1813). A complete juvenile specimen collected from the sediment trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 32). Dorsal view. Magnification: 31 x. (IRScNB - IST n° 10703).

Fig. 5 – *Terebratulina chrysalis* (VON SCHLOTTHEIM, 1813). 5a- A juvenile ventral valve collected from the phosphatic chalk of Ciply (sample n°16), *Belemnella obtusa* Zone, Lower Maastrichtian. Ventral view. Magnification: 26.5 x. 5b- A detail of the knobbed ribs of the anterior part of the valve. Magnification: 90 x. (IRScNB - IST n° 10704).

Fig. 6 – *Terebratulina chrysalis* (VON SCHLOTTHEIM, 1813). A young specimen with an elongate shape collected at the boundary between the base of the hard-ground and the phosphatic chalk of Ciply (sample n° 12). This specimen was found at the same level as *Dalligas nobilis*, *Gisilina* aff. *jasmundi* and *Terebratulina subtilis*. Probable stratigraphy: upper part of the Lower Maastrichtian.
6a- dorsal view (magnification: 9 x), 6b- ventral view (magnification: 9.6 x), 6c- lateral view (magnification: 9.6 x), 6d- brachidium in general ventral view (magnification: 9.6 x), 6e- brachidium in anterior view (magnification: 9.6 x) and 6f- brachidium in oblique lateral view (magnification: 22 x). (IRScNB - IST n° 10705).

Fig. 7 – *Terebratulina subtilis* STEINICH, 1965. A bivalved specimen collected at the boundary between the base of the hard-ground and the phosphatic chalk of Ciply (sample n° 12). Stratigraphy: probably upper part of the Lower Maastrichtian (*Belemnella sumensis* Zone?). 7a- dorsal view; the deltidial plates are broken. 7b- ventral view; the posterior part of the ventral valve has been broken. Magnification: 20 x. (IRScNB - IST n° 10706).

Fig. 8 – *Terebratulina (?)* n. sp. A complete specimen collected in the sediments trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 1). 8a- dorsal view (magnification: 8 x), 8b- ventral view (magnification: 11 x), 8c- lateral view (magnification: 9 x) and 8d- a detail of the ornamentation of the ribs from the middle part of the dorsal valve (magnification: 23 x). (IRScNB - IST n°10707).

PLATE 6

All illustrated specimens are preserved in the collection of the Institut royal des Sciences naturelles
de Belgique in Brussels.

Fig. 1 – *Gisilina aff. jasmundi* STEINICH, 1965. A complete specimen from Van Damme quarry in Ciply (Hainaut, Belgium),
collected at the boundary between the base of the hard-ground and the phosphatic chalk of Ciply (sample n° 12). It was
found together with *Terebratulina subtilis* STEINICH, 1965. Probable stratigraphy: upper part of the Lower Maastrichtian
(*subtilis - pulchellus* Zone of SURLYK). 1a- dorsal view (magnification: 8.5 x), 1b- ventral view (magnification: 8.5 x), 1c-
lateral view (magnification: 8.5 x), 1d- a detail of the ribs on the dorsal valve and of the ornamentation of the auricles
(Scale bar: 1 mm), 1e- a detail of the ribs on the ventral valve (Scale bar: 1 mm). The position of the scale bar indicates the
direction of the umbo. (IRScNB - IST n°10708).

Fig. 2 – *Rugia curvirostris* n. sp. Holotype from the phosphatic chalk of Ciply, (sample n°24), *Belemnella obtusa* Zone, Lower
Maastrichtian. Van Damme quarry in Ciply (Hainaut, Belgium). 2a- dorsal view, 2b- ventral view, 2c- lateral view
(magnification: 26.5 x), 2d- anterior view (magnification: 31.5 x). The measurements of the morphological characters are
indicated in Table 4. (IRScNB - IST n°10709).

Fig. 3 – *Rugia curvirostris* n. sp. Complete specimen in dorsal view from the phosphatic chalk of Ciply (sample n°45), *Belemnella
obtusa* Zone, Lower Maastrichtian. Underground La Malogne quarry in Cuesmes (Mons Basin, Hainaut, Belgium), 12
meters below the base of the hard-ground overlying the phosphatic chalk of Ciply. Magnification: 28.3 x. (IRScNB - IST
n° 10710).

Fig. 4 – *Rugia curvirostris* n. sp. Complete specimen in ventral view from the phosphatic chalk of Ciply (sample n°45), *Belemnella
obtusa* Zone, Lower Maastrichtian. Underground La Malogne quarry in Cuesmes (Mons Basin, Hainaut, Belgium), 12
meters below the base of the hard-ground overlying the phosphatic chalk of Ciply. Magnification: 28.3 x. (IRScNB - IST
n° 10711).

Fig. 5 – *Rugia curvirostris* n. sp. Another complete specimen in dorsal view from the phosphatic chalk of Ciply (sample n°14),
Belemnella obtusa Zone, Lower Maastrichtian. Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). Magnifica-
tion: 28.3 x. (IRScNB - IST n° 10712).

Fig. 6 – *Rugia curvirostris* n. sp. An isolated ventral valve in dorsal view from the phosphatic chalk of Ciply (sample n°14),
Belemnella obtusa Zone, Lower Maastrichtian. Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). Magnifica-
tion: 28.3 x. (IRScNB - IST n° 10713).

Fig. 7 – *Rugia curvirostris* n. sp. An opened bivalved specimen from the phosphatic chalk of Ciply (sample n°14), *Belemnella
obtusa* Zone, Lower Maastrichtian. Van Damme quarry in Ciply (Mons Basin, Hainaut, Belgium). The recrystallized
spicular skeleton is visible in the dorsal valve and a crus covered with calcite crystals is shown. The beak is broken.
Magnification: 35 x. (IRScNB - IST n° 10714).

Fig. 8 – *Megathiris bidiscoidea* SIMON, 1992. An adult dorsal valve collected from the sediments trapped in the cavities of the base
of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 15). Van Damme quarry in Ciply (Mons Basin,
Hainaut, Belgium). This specimen exhibits a papillate inner margin and the lateral septa are well preserved as are the very
large hinge plates. 8a- dorsal view, 8b- ventral view (magnification: 17 x), 8c- a detail of the typical secondary septum in
oblique lateral view (magnification: 62 x). (IRScNB - IST n° 10715).

PLATE 7

All illustrated specimens were collected from Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
They are preserved in the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – *Argyrotheca* cf. *microscopica* (VON SCHLOTTHEIM, 1813). A dorsal valve collected from the sediments trapped in the
cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 15). Stratigraphy: Upper Maastrichtian,
stevensis - chitoniformis Zone of SURLYK. 1a- dorsal view (magnification: 9 x), 1b- ventral view (magnification: 9 x) and
1c- oblique lateral view (magnification: 11 x). (IRScNB - IST n° 10716).

Fig. 2 – *Argyrotheca* cfmicroscopica (VON SCHLOTTHEIM, 1813). A ventral valve of a young specimen from dorsal view collected from the sediments trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 11). Stratigraphy: Upper Maastrichtian, *stevensis - chitoniformis* Zone of SURLYK. Magnification: 30 x. (IRScNB - IST n° 10717).

Fig. 3 – *Argyrotheca* cf.   microscopica (VON SCHLOTTHEIM, 1813). A dorsal valve in dorsal view collected from the sediments trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 11). Stratigraphy: Upper Maastrichtian, *stevensis - chitoniformis* Zone of SURLYK. Magnification: 24 x. (IRScNB - IST n° 10718).

Fig. 4 – *Argyrotheca stevensis* (NIELSEN, 1928). Complete, bivalved specimen from the sediments trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 32). Stratigraphy: Upper Maastrichtian, *stevensis - chitoniformis* Zone of SURLYK. 4a- dorsal view (magnification: 20 x), 4b- ventral view (magnification: 19 x), 4c- lateral view (magnification: 19 x), 4d- opened specimen in oblique lateral view (magnification: 17.2 x), 4e- opened specimen in oblique ventral view (magnification: 17.2 x), 4f- opened specimen in anterior view (magnification: 17.2 x) and 4g- a detail of the *punctae* on the external surface of the ventral valve (scale bar: 1 mm). The scale bar is placed on the side of the anterior commissure. (IRScNB - IST n° 10719).

Fig. 5 – *Argyrotheca* cf. *coniuncta* STEINICH, 1965. A dorsal valve from the sediments trapped in the cavities of the base of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 15). Probable stratigraphy: upper part of the Lower Maastrichtian, *subtilis - pulchellus* Zone of SURLYK. 5a- dorsal view and 5b- ventral view. Magnification: 18.5 x. (IRScNB - IST n° 10720).

Fig. 6 – *Argyrotheca* aff. *coniuncta* STEINICH, 1965. A poorly preserved dorsal valve collected from the phosphatic chalk of Ciply (sample n° 19), *Belemnella obtusa* Zone, Lower Maastrichtian. 6a- dorsal view and 6b- ventral view. Magnification: 21.5 x. (IRScNB - IST n° 10721).

Fig. 7 – *Argyrotheca* cf. *lacunosa* STEINICH, 1965. A complete specimen from the phosphatic chalk of Ciply (sample n° 28), *Belemnella obtusa* Zone, Lower Maastrichtian.
7a- dorsal view, 7b- lateral view and 7c- posterior view. Magnification: 19.8 x. (IRScNB - IST n° 10722).

PLATE 8

All illustrated specimens were collected from Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium)
and preserved in the collection of the Institut des Sciences naturelles de Belgique in Brussels.

Fig. 1 – *Aemula inusitata* STEINICH, 1968. A complete specimen collected from the phosphatic chalk of Ciply (sample n° 30), *Belemnella obtusa* Zone, Lower Maastrichtian. 1a- dorsal view showing the amphythyridid foramen, 1b- lateral view. Magnification: 18 x. (IRScNB - IST n° 10723).

Fig. 2 – *Aemula inusitata* STEINICH, 1968. Another complete specimen collected from the phosphatic chalk of Ciply (sample n° 9), *Belemnella obtusa* Zone, Lower Maastrichtian. Ventral view showing the typical pustules ornementing the surface of this valve. Magnification: 18 x. (IRScNB - IST n° 10724).

Fig. 3 – *Leptothyrellopsis polonicus* BITNER & PISERA, 1979. A complete specimen collected from the phosphatic chalk of Ciply (sample n° 18), *Belemnella obtusa* Zone, Lower Maastrichtian. This is the largest specimen found in the phosphatic chalk. 3a- dorsal view , 3b- ventral view and 3c- lateral view. Magnification: 14 x. (IRScNB - IST n° 10725).

Fig. 4 – *Leptothyrellopsis polonicus* BITNER & PISERA, 1979. A complete opened specimen collected from the phosphatic chalk of Ciply (sample n° 9), *Belemnella obtusa* Zone, Lower Maastrichtian. 4a- ventral valve in dorsal view (magnification: 22 x), 4b- dorsal valve in ventral view (magnification: 28.5 x) and 4c- dorsal valve in oblique lateral view: the small crural plates are visible (magnification: 28.5 x). (IRScNB - IST n°10726).

Fig. 5 – *Dalligas nobilis* STEINICH, 1968. A well preserved, adult ventral valve collected from the sediments trapped in the cavities of the base of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 12). This specimen was collected together with *Terebratulina subtilis* STEINICH, 1965. Probable stratigraphy: upper part of the Lower Maastrichtian (*subtilis - pulchellus* Zone of SURLYK). 5a- ventral view showing the typical ornementation for this species, 5b- dorsal view and 5c- a detail of the dental plates, well developed pedicle collar and teeth. Magnification: 17.2 x. (IRScNB - IST n° 10727).

Fig. 6 – *Dalligas nobilis* STEINICH, 1968. An adult dorsal valve collected from the sediments trapped in the cavities of the base of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 15). Probable stratigraphy: upper part of the Lower Maastrichtian (*subtilis - pulchellus* Zone of SURLYK, 1970). 6a- dorsal view, 6b- ventral view; the septal pillar was broken. Magnification: 20 x. (IRScNB - IST n° 10728).

Fig. 7 – *Dalligas nobilis* STEINICH, 1968. A juvenile complete specimen collected from the sediments trapped in the cavities of the base of the hard-ground overlying the phosphatic chalk of Ciply (sample n° 15). Probable stratigraphy: upper part of the Lower Maastrichtian (*subtilis - pulchellus* Zone of SURLYK, 1970). 7a- dorsal view, 7b- lateral view. Magnification: 35.4 x. (IRScNB - IST n° 10729).

Fig. 8 – *Kingena* sp. A damaged dorsal valve in ventral view, collected from the phosphatic chalk of Ciply (sample n° 25), *Belemnella obtusa* Zone, Lower Maastrichtian. Magnification: 15 x. (IRScNB - IST n° 10730).

PLATE 9

Trigonosemus palissii WOODWARD, 1854

All illustrated specimens were collected from Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
Phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian. The specimens are preserved in
the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – Early juvenile dorsal valve from sample n° 18. The emergence of the septal pillar is visible (Axial phase). 1a- ventral view, 1b- oblique lateral view. Magnification: 32 x. (IRScNB - IST n° 10731).

Fig. 2 – A complete juvenile specimen collected from sample n°43. The foramen is relatively large and the beak is flat. 2a- dorsal view, 2b- ventral view and 2c- lateral view. Magnification: 28 x. (IRScNB - IST n° 10732).

Fig. 3 – A complete juvenile specimen from sample n°30. The foramen is reduced in size but it was still functionnal and the beak is slightly curved. 3a- dorsal view (magnification: 15 x), 3b- ventral view (magnification: 14.5 x) and 3c- lateral view (magnification: 14.5 x). (IRScNB - IST n° 10733).

Fig. 4 – A complete young specimen at the beginning of its secondary free living stage of growth (sample n°30). The foramen is totally reduced to a pin-hole foramen. 4a- dorsal view and 4b- ventral view. Magnification: 11 x. (IRScNB - IST n° 10734).

Fig. 5 – An isolated ventral valve of a young specimen in oblique anterior view (sample n° 42). The dental plates are visible. Magnification: 12.5 x. (IRScNB - IST n° 10735).

Fig. 6 – A fully adult specimen showing an elongate outline. 6a- dorsal view, 6b- ventral view and 6c- lateral view. Magnification: 4.5 x. (IRScNB - IST n° 10736).

Fig. 7 – A fully adult specimen showing a more subcircular outline. 7a- dorsal view, 7b- ventral view and 7c- lateral view. Magnification: 4.5 x. (IRScNB - IST n° 10737).

PLATE 10

Trigonosemus palissii WOODWARD, 1854

All illustrated specimens were collected from Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
Phosphatic chalk of Ciply, *Belemnella obtusa* Zone, Lower Maastrichtian. The specimens are preserved in
the collection of the Institut royal des Sciences naturelles de Belgique in Brussels.

Fig. 1 – An opened adult specimen showing the crural bases, the crural processes, the descending branches, the lateral connecting bands and a part of the ascending branches. Magnification: 3.9 x. (IRScNB - IST n°10738).

Fig. 2 – Same specimen as in Fig. 1. A detail of the brachidium in ventral view. Scale bar: 1 mm. (IRScNB - IST n° 10738).

Fig. 3 – Same specimen as in Fig. 1. A detail of the brachidium in oblique lateral view. Scale bar: 1 mm. (IRScNB - IST n° 10738).

Fig. 4 – SEM microphotograph of a partly cleaned, complete brachidium of a fully adult specimen. 4a- ventral view: the ascending branches (upper part) and the transverse band are visible. 4b- The same specimen in oblique lateral view. the crural process, the descending and the ascending branches and the transverse band are seen. Scale bar: 1 mm. (IRScNB - IST n° 10739).

Thecidea papillata (VON SCHLOTTHEIM, 1813)

All illustrated specimens were collected from Van Damme quarry, Ciply (Mons Basin, Hainaut, Belgium).
All the specimens were collected from the sediments trapped in the cavities of the hard-ground overlying the phosphatic chalk of Ciply. Stratigraphy: Upper Maastrichtian, *stevensis - chitoniformis* Zone of SURLYK.

Fig. 5 – An adult dorsal valve, in ventral view, showing fine preservation of the *apparatus ascendens*, *apparatus descendens* and of the *transversarium*. Sample 7. Magnification: 10.5 x. (IRScNB - IST n° 10740).

Fig. 6 – An adult ventral valve, in dorsal view, showing the intact hemispondylium. Magnification: 10.5 x. Sample 7. (IRScNB - IST n° 10741).

Fig. 7 – An adult dorsal valve showing a well developed *apparatus ascendens*. 7a- ventral view, 7b- anterior view and 7c- lateral view. Magnification: 9 x. (IRScNB - IST n° 10742).

Fig. 8 – A phosphatic internal mould of an adult specimen. 8a- dorsal view (magnification: x 11), 8b- ventral view (magnification: x 10). Sample 12. (IRScNB - IST n° 10743).

Fig. 9 – A juvenile specimen (sample 8) showing the attachment surface to the subtrate. 9a- ventral view (magnification: 24 x), 9b- a detail of the attachment surface Magnification: 33 x. (IRScNB - IST n° 10744).

Fig. 10 – A juvenile specimen in ventral view showing its ventral valve with several gastropod (Muricid?) borings. Sample 17. Magnification: 28.5 x. (IRScNB - IST n° 10745).

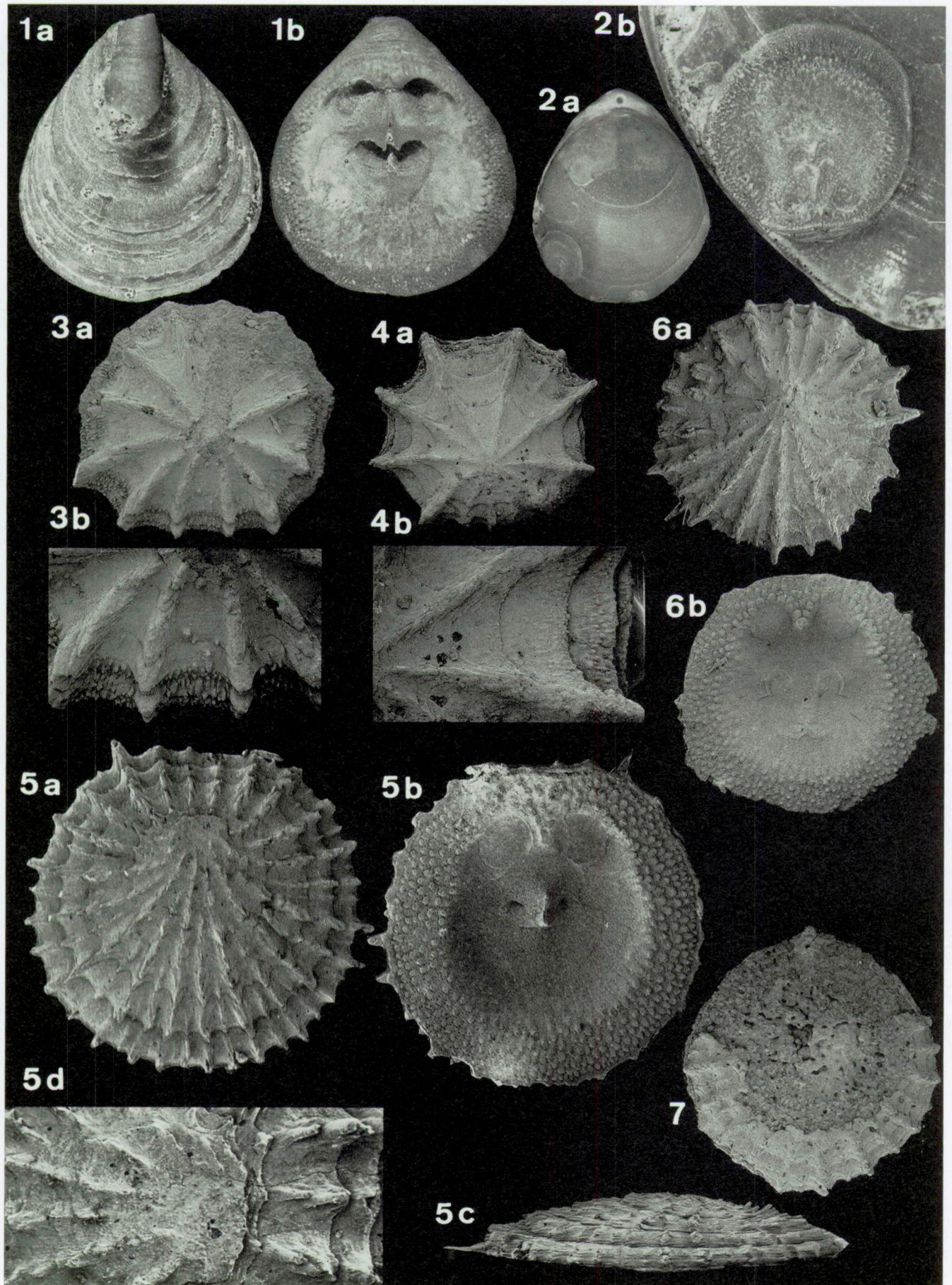Fig. 11 – Another adult dorsal valve showing a well preserved *apparatus descendens*. Sample 15. Magnification: 10.5 x. (IRScNB - IST n°10746).
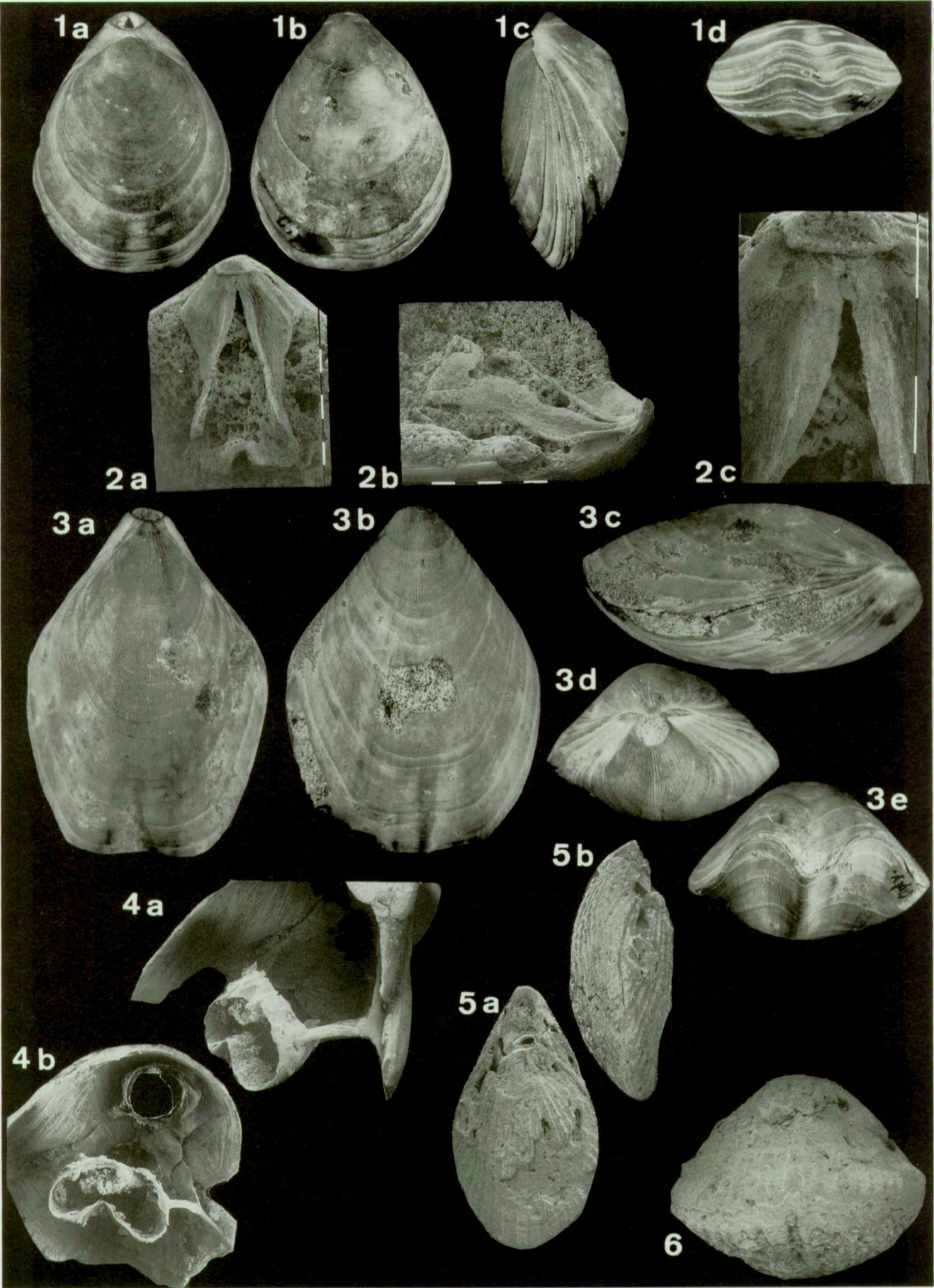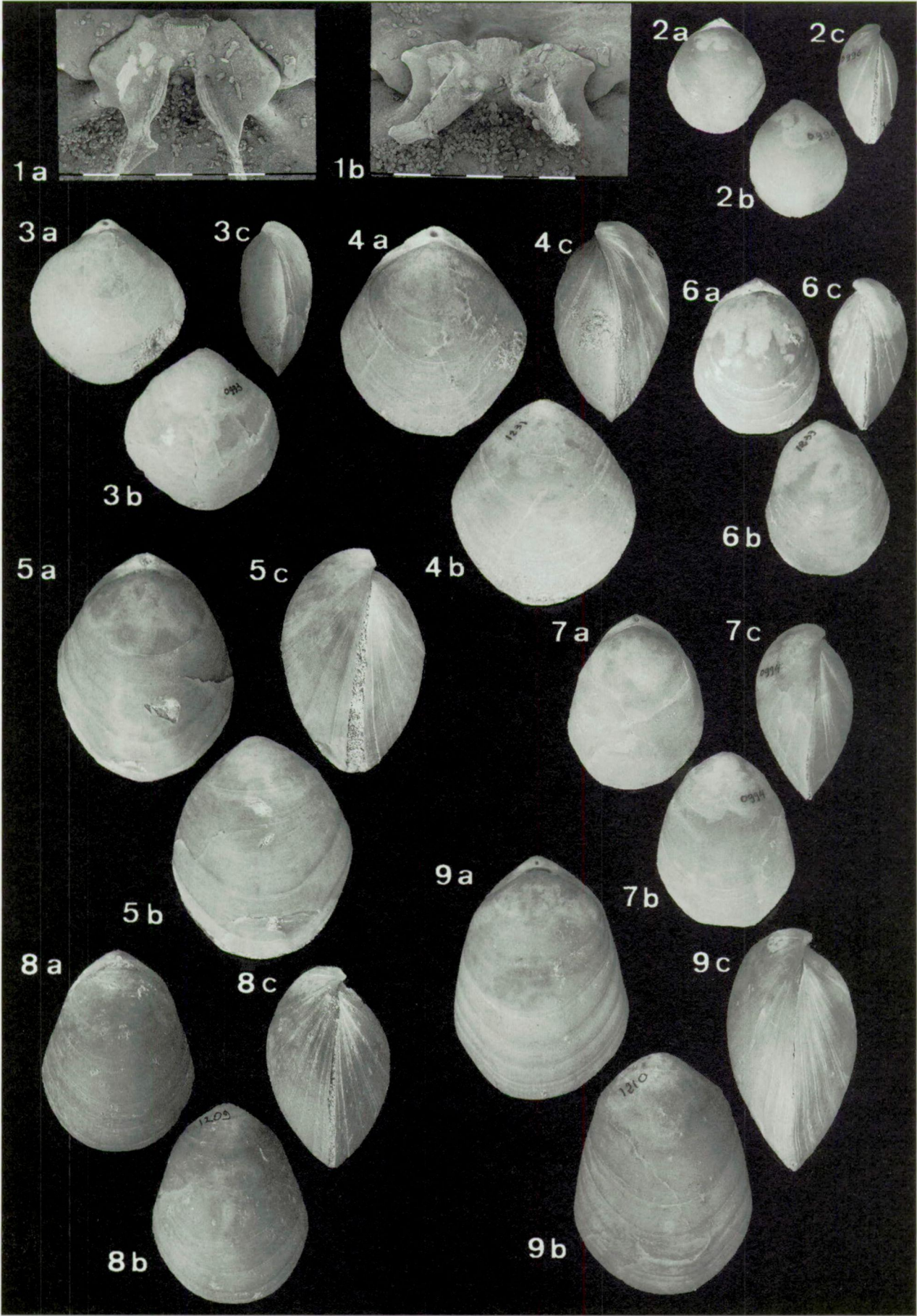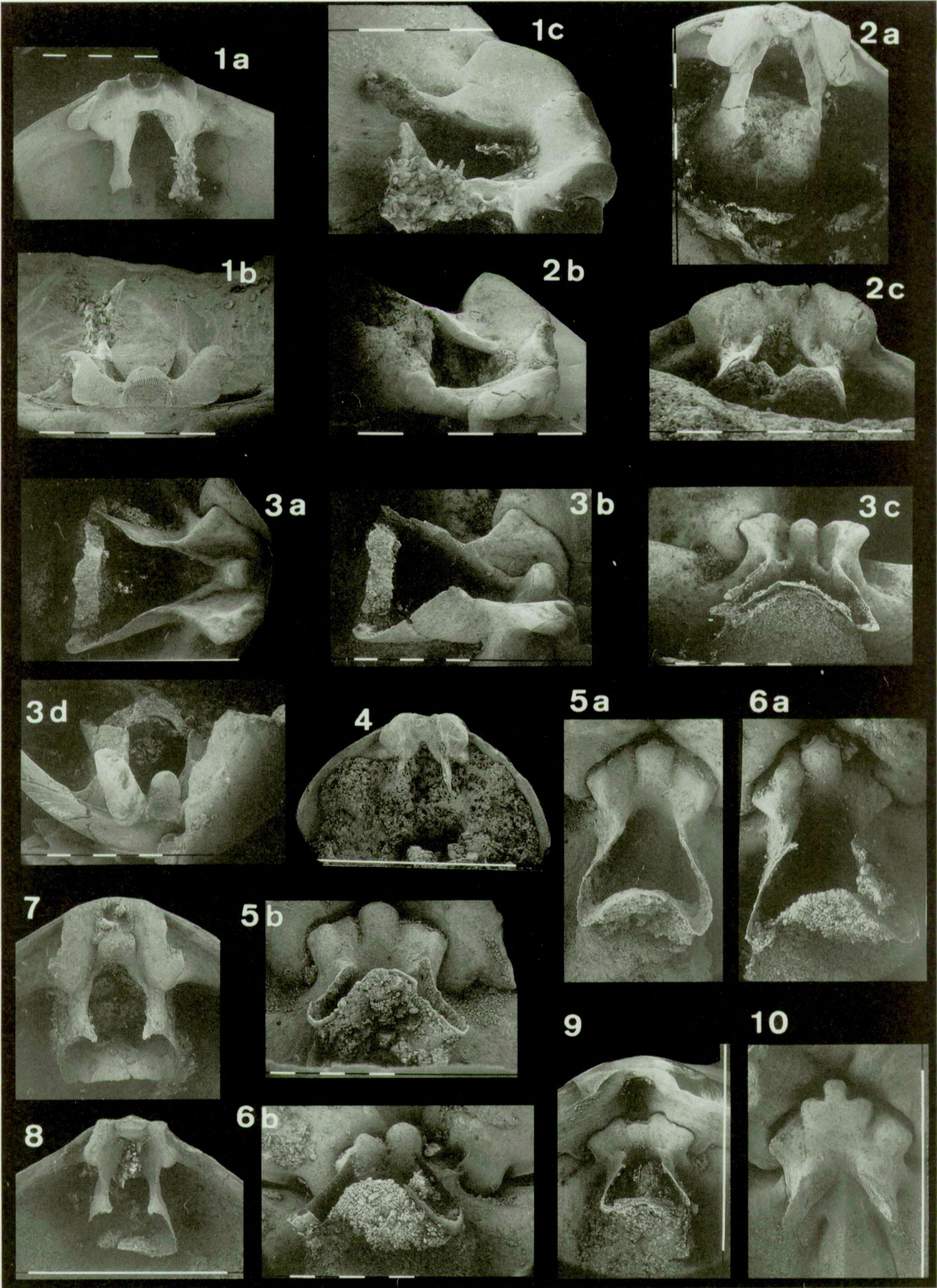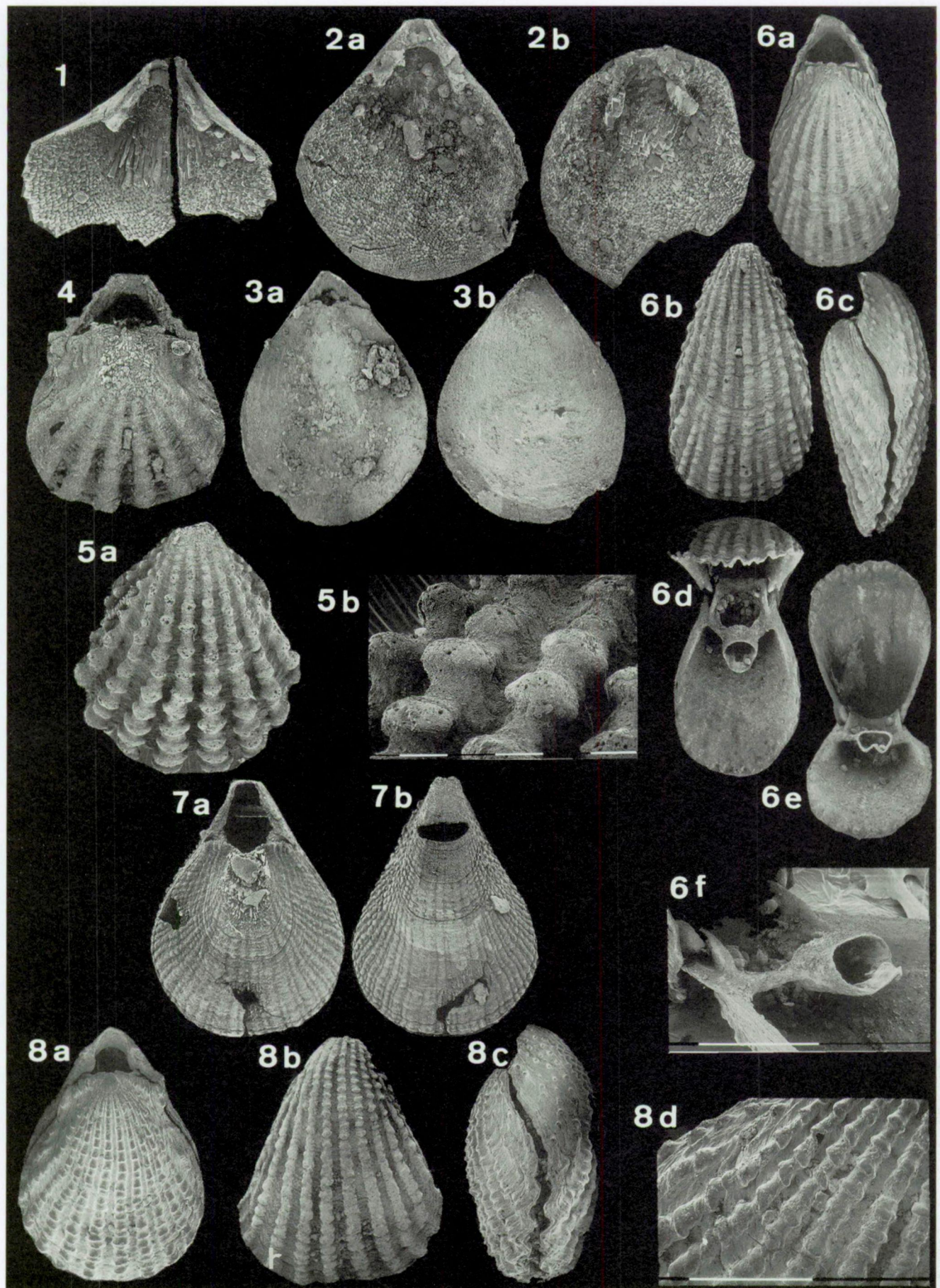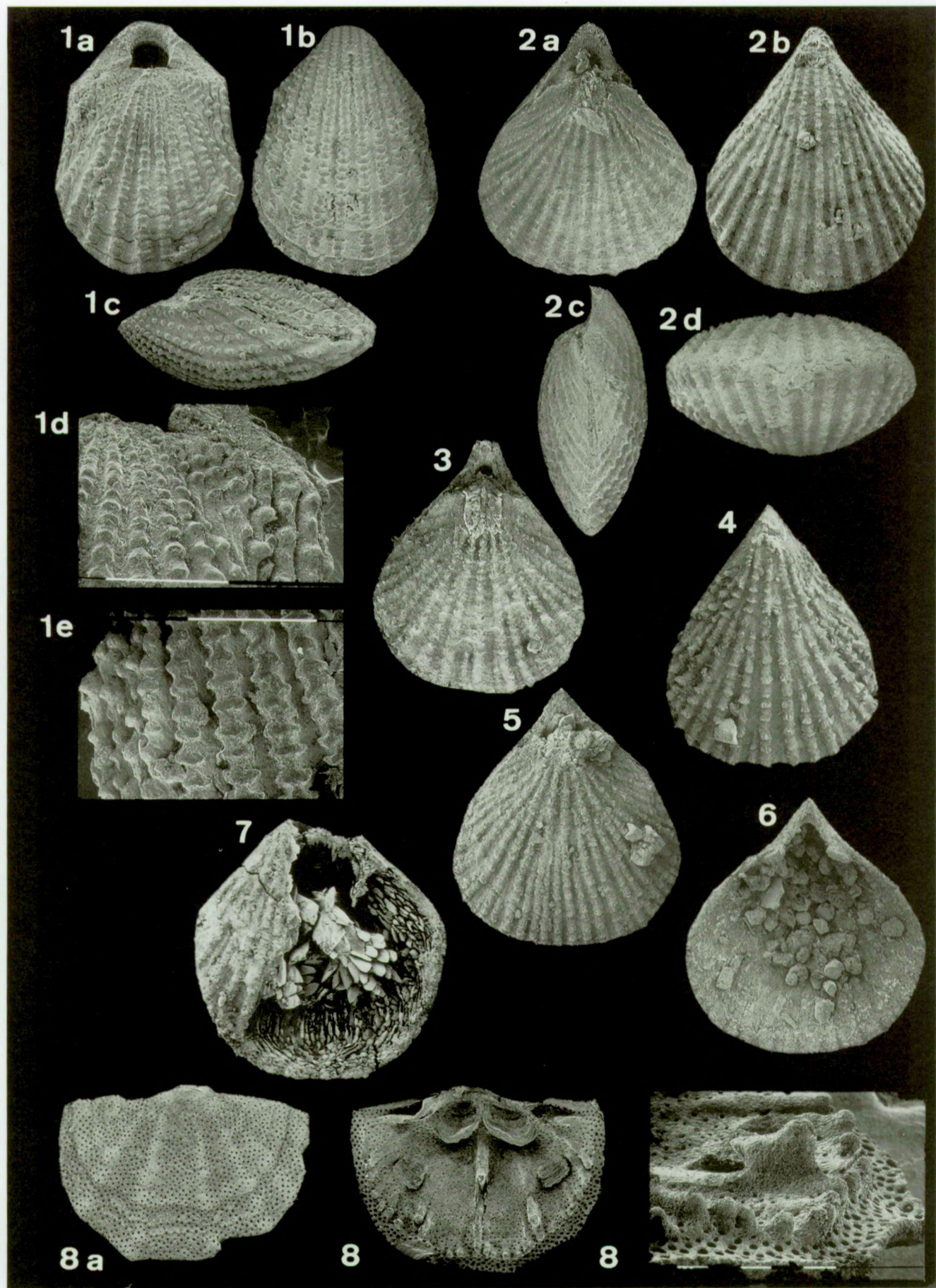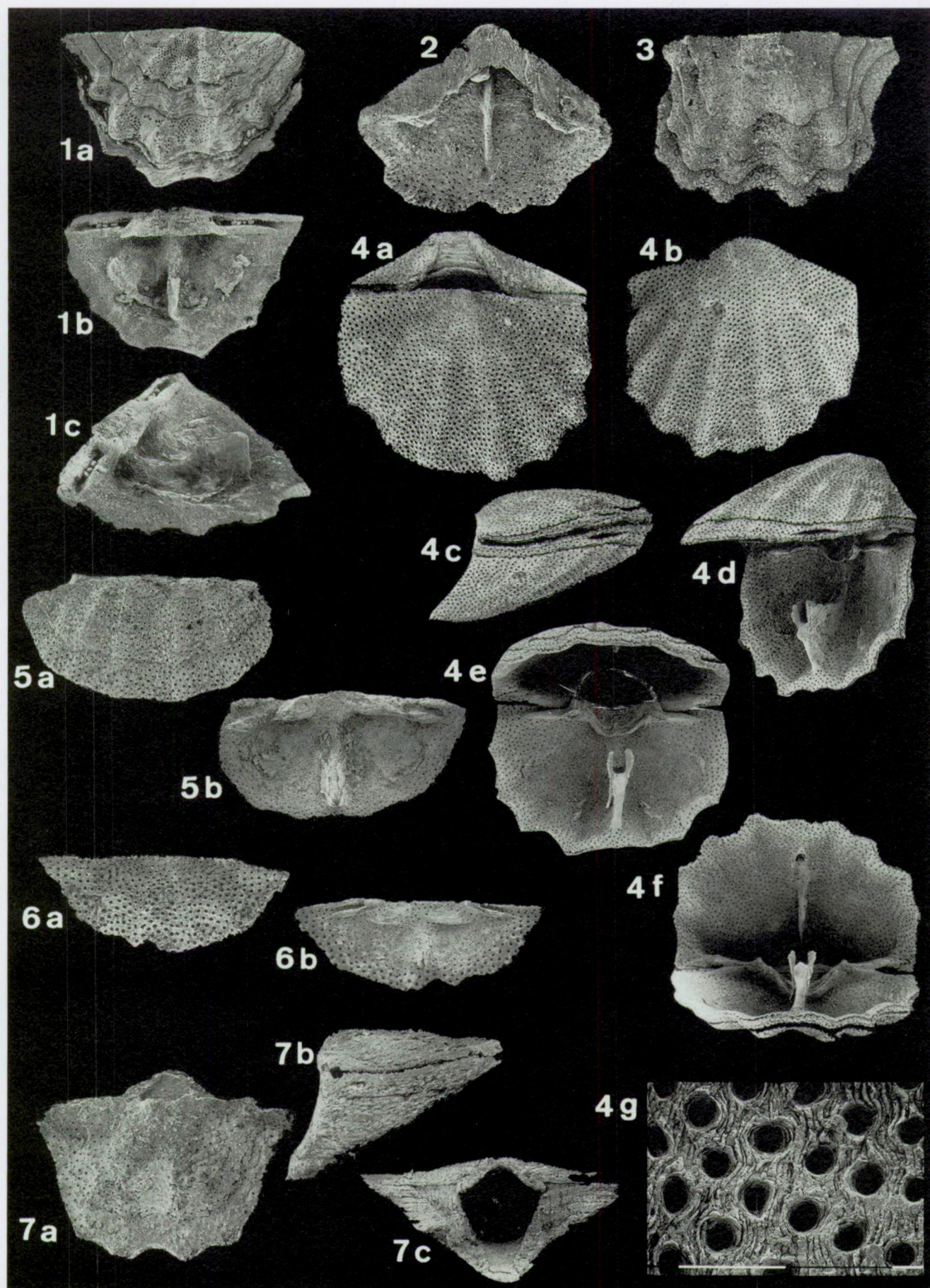
PLATE 1

PLATE 2

PLATE 3

PLATE 4

PLATE 5

PLATE 6

PLATE 7

PLATE 8

PLATE 9

PLATE 10