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54	SCIENCES DE LA TERRE - AARDWETENSCHAPPEN	5

LIMATULA SPECIES (LIMIDAE, BIVALVIA, MOLLUSCA)  
FROM THE MAASTRICHTIAN IN BELGIUM  
AND IN THE NETHERLANDS

BY

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(With one plate and four textfigures)

ABSTRACT

In palaeontological literature *Limatula semisulcata* (NILSSON, 1827) is mentioned from localities of Maastrichtian (Upper Cretaceous) age in Limburg (N. E. Belgium and S. E. Netherlands) and in Hainaut (S. W. Belgium). The specimens from Kunrade and some of those from directly around Maastricht show characteristics which differ strongly from the specimens from the Swedish type locality and from other localities in which the species has been found. It can be shown biometrically that these differences may be partly due to the age-composition of the population but some are not related to age, such as rib number, rib shape and size ratios.

The specimens from Kunrade and Maastricht are herein described as a new species: *Limatula kunradensis* n. sp.

RESUME

Dans la littérature paléontologique *Limatula semisulcata* (NILSSON, 1827) est mentionnée de différentes localités maastrichtiennes du Limbourg (Belgique, N. E., Pays Bas, S. E.) et du Hainaut (Belgique, S. O.). Les spécimens de Kunrade et certains exemplaires des environs de Maastricht ont des caractères fortement différents de ceux de la localité-type en

Suède. Par la biométrie on a pu démontrer que certaines de ces différences sont dues à la structure de la population, mais d'autres telles que le nombre de côtes, la forme de celles-ci et les proportions des dimensions, en sont indépendantes. Les exemplaires de Kunrade et de Maastricht sont décrits comme appartenant à une espèce nouvelle : *Limatula kunradensis* n. sp.

#### INTRODUCTION

*Limatula semisulcata* (NILSSON, 1827) was originally described from the Swedish Upper Campanian. In Belgium and in the Netherlands the species has been mentioned from Ciply, Spiennes, Saint Symphorien (Hainaut), Maastricht and Kunrade (Limburg), all of Maastrichtian age.

VOGEL, 1895 already mentioned that specimens from Kunrade and Maastricht seemed different from the Swedish specimens of *Limatula semisulcata*. Differences in rib form- and number are indeed obvious when comparing specimens from Ciply, Spiennes and Saint Symphorien with those from Kunrade and Maastricht. A biometrical analysis has been made to check whether these differences are merely due to intraspecific variation or whether they are statistically significant.

#### SYSTEMATICS AND BIOMETRY

##### Material and methods

All the material previously considered to belong to *Limatula semisulcata*, with populations from Spiennes, Ciply, Saint Symphorien, Kunrade and Maastricht, was analysed biometrically. The specimens studied belong to different museum collections (list p. 17 and 21). The 220 specimens used for the biometrical studies come exclusively from the collection of the K. B. I. N. because it was sampled more randomly.

The following measurements were taken : (Fig. 1).

- a. the number of ribs;
- b. the distance from the tip of the auricle to the first rib, on the anterior side of the shell (2);
- c. the same on the posterior side (3);
- d. the maximum height of the valve (5);
- e. the maximum length of the valve (4);
- f. the length of the ribbed zone, measured along the inferior margin (6);
- g. the distance between auricle tips (7) ;
- h, j. on specimens with clearly indicated growth lines, the length of different growthstages (9);
- i, k. on the same specimens the height of different growthstages (8).

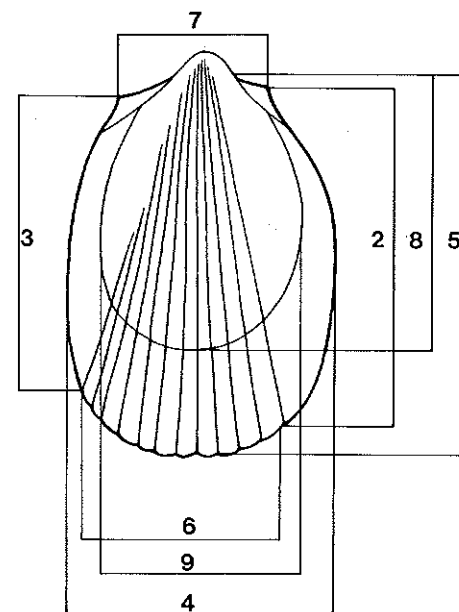


Fig. 1. — Measurements taken on the shell (see in text, under « material and methods » for the explanation of the different numbers on the figure).

Some « obvious » measurements could not be taken because of the condition of the specimens : the umbonal angle, because the umbo is nearly always damaged; the length of the auricular margin and the convexity of the shell because the specimens are embedded in matrix.

The following ratios were calculated :

1.  $b : c$  quantifies the asymmetry of the rib position : the higher the ratio, the closer the ornamentation lies to the posterior side;
2. the height : length ratio, with measurements d and e and eventually h and i gives an idea of the shell shape;
3. the ratio  $d : f$ ;
4. the ratio  $d : g$ ;
5. the ratio  $b : e$ ;
6. the ratio  $a : f$ .

For the means and standard deviations from the different populations for measurements a to g, see appendix B table 1.

Statistically significant differences between the populations were traced by means of an F — test; a Student — Newman — Keuls test was used to localise these differences, as explained in SOKAL & ROHLF, 1969 : see appendix B table 2a.

Furthermore a canonical analysis was performed following BLACKITH & REYMENT, 1971 and HEBRANT, 1974. For this analysis, a to g were used, but only on the complete specimens from Kunrade, Spiennes, Ciplly and St. Symphorien.

### Results

Table 1 shows that the population from Kunrade differs from the others. However, the differences in b to i are solely a measure of the size of the shell. The shells from Kunrade are on the average smaller than those from the other populations. The origin of this difference could be :

- a group consisting of younger (i.e. smaller) individuals;
- a non-optimum environment;
- a separate species that has smaller adults.

The rib number is independent of size and is consistently higher in Kunrade (fig. 2).

The ratio d : e is also not dependent on size (fig. 3). The growth is clearly linear.

**Conclusion.** — Kunrade specimens are distinct

- in H/L ratio
- in the asymmetric position of the ribbed zone
- the ribbed zone is narrower, although the rib number is higher : the individual ribs are narrower.

In the height : length ratio, there is mathematically a significant difference between Spiennes and St. Symphorien, but from this last locality the material is too scant to be reliable. This applies also to the Maastricht material.

The Kunrade population differs also in other characteristics, which are not measurable. The ribs are triangular in cross-section rather than rounded, as in most of the other populations. At Maastricht however, specimens with both rib forms are found, probably both groups occurred there; this is also demonstrated by the rib number and by the ratios 1, 2 and 6 from that locality, which do not differ from those from Kunrade.

To solve the problem of the Maastricht specimens, a canonical analysis was performed. It was found that :

- the groups from Ciplly, Spiennes and St. Symphorien occupy the same region in the diagram of the first and second canonical variates;
- the Kunrade group is separated by the first canonical variate from the others, except for a few specimens from Spiennes, which seem to occupy an aberrant position and lie completely within the same range as the Kunrade group. They have also 17 triangular ribs.

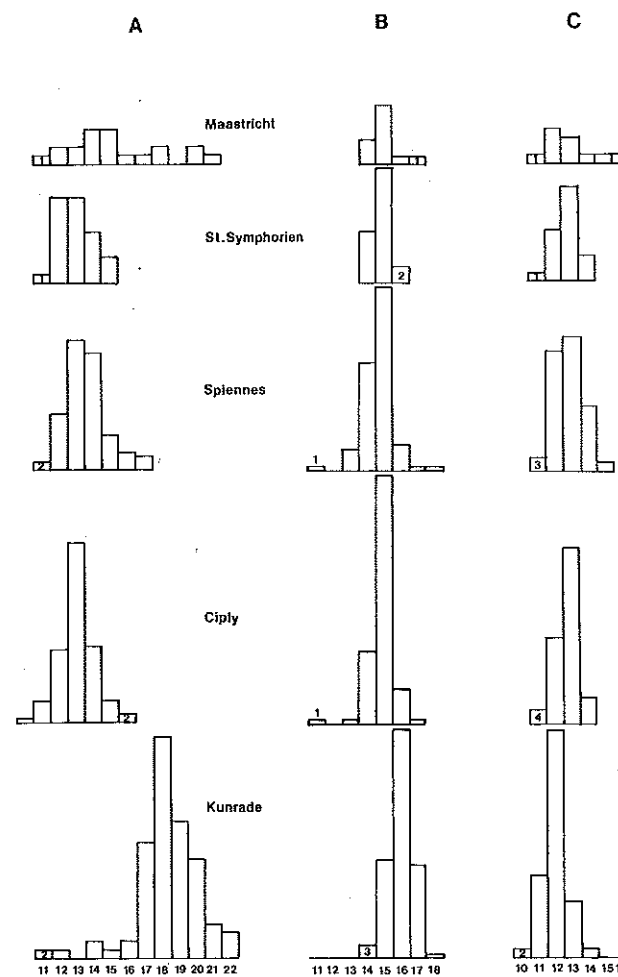


Fig. 2. — 2A : Histograms of measurement 1, the rib number;  
2B : Histograms of ratio b, height/length;  
2C : Histograms of ratio c, maximum height/length of ribbed zone.

Those specimens, and a few others which are strongly worn, influence the variance within the groups. A second analysis was therefore necessary, excluding those five shells and leaving 215 to analyse. The diagram for the first and second canonical variates is given on fig. 4. The Kunrade group is clearly separated from the three others by the first canonical variate. This is also shown by the mean vectors of the canonical variates (appendix B table 2 b).

By plotting the second and third canonical variates we only get one undivided pointmass.

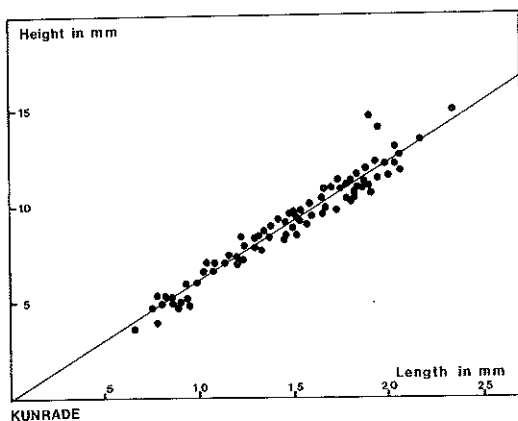
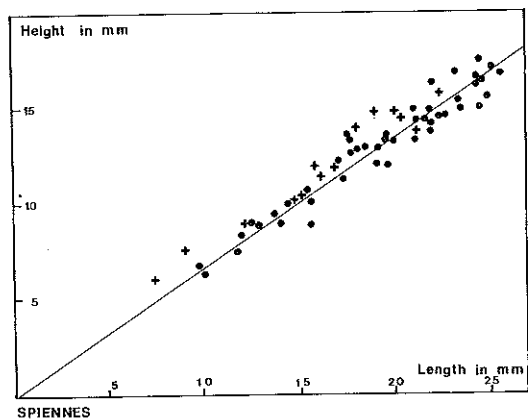


Fig. 3. — Height plotted against length, populations from Spiennes and Kunrade (● measured along the edge of the shell; + measured along growth lines).

The specimens from the Ciplly — Spiennes — St. Symphorien group which, when plotted, lie closest to those from Kunrade, are relatively small; however, they are not the smallest specimens known in those groups. The specimens which on the diagram lie closest to those from Kunrade are characterised by relatively high rib numbers. For the specimens from Kunrade the contrary applies: the specimens plotted near to those from the other group have relatively low rib numbers.

Thus the factor dividing the groups is not primarily the size of the specimens, but their rib-number, which can safely be assumed to be independent of age. The first and second canonical variates were calculated

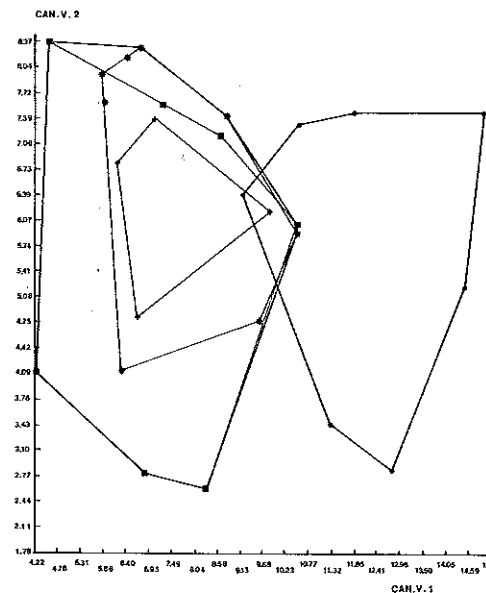


Fig. 4. — Canonical analysis. The thin lines show the different populations of *Limatula semisulcata* (NILSSON, 1827); the thick lines limit the two species: on the left: *Limatula semisulcata* (NILSSON, 1827), on the right: *Limatula kunradensis* n. sp. ● = specimens from Kunrade; ■ = specimens from Ciplly; + = specimens from Saint Symphorien; \* = specimens from Spiennes.

for those specimens which were not used in the second analysis and for those of Maastricht, to check where they belong among the different groups: one specimen with 22 ribs belongs to the Kunrade-group, one with 15 in the other. Two specimens from Jandrain (12 and 13 ribs) fall within the Spiennes — Ciplly — St. Symphorien group; one from Eisdén (21) falls in the Kunrade-group; two with 14 and 15 ribs come near the edge of the group.

The two specimens from Spiennes with 17 ribs belong to the Kunrade group.

The eigenvectors for the canonical transformation are given in appendix B table 2 c.

**Conclusion.** — The shells from Kunrade, some of those from Maastricht, those from Eisdén and two from Spiennes differ strongly from the other specimens studied, not only for size-dependent measurements, but also for size-independent measurements, such as the number of ribs and their shape. These differences can only be explained by the existence of a species that is not *Limatula semisulcata*, and for which we propose the name *Limatula kunradensis* n. sp.

## Description of the species

Phylum MOLLUSCA

Classis BIVALVIA

Subclassis PTERIOMORPHIA BEURLÉN 1944

Ordo PTERIOIDEA NEWELL 1965

Superfamilia LIMACEA RAFINESQUE 1815

Familia LIMIDAE RAFINESQUE 1815

Genus LIMATULA WOOD 1839

Type species *Pecten subauriculatus* MONTAGU, 1808 (S. D. GRAY, 1847).a. *Limatula semisulcata* (S. NILSSON, 1827)

(Pl. 1, figs 2 a-c)

- ? 1799 — « Lime » B. FAUJAS ST. FOND, p. 163-164, pl. 27, fig. 2.
- ? 1821 — *Ostracites decussatus* G. WAHLENBERG, p. 59-60, pl. 4, fig. 7, 8, 9.
- . 1827 — *Plagiostoma semisulcatum* S. NILSSON, p. 25, pl. 9, fig. 3.
- . 1837 — *Lima semisulcata* Deshayes F. DUJARDIN, p. 226, pl. 16, fig. 2.
- . 1841 — *Lima semisulcata* Nilss. F. A. ROEMER, p. 55.
- 1842 — *Lima semisulcata* Desh. F. VON HAGENOW, p. 555.
- ? 1845 — *Lima semisulcata* Deshayes A. REUSS, p. 32.
- 1845 — *Lima semisulcata* Nilsson H. B. GEINITZ, p. 188.
- ? 1873 — *Lima semisulcata* Nilsson H. B. GEINITZ, p. 53, pl. 16, fig. 14.
- . 1875 — *Limatula semisulcata* (Nilsson) D. BRAUNS, p. 387-388.
- ? 1877 — *Lima semisulcata* Nilss. A. FRITSCH, p. 132, fig. 15.
- ? 1883 — *Lima semisulcata* Nilss. A. FRITSCH, p. 112.
- 1887 — *Lima (Limatula) semisulcata* (Nilsson) G. MUELLER, p. 405-406.
- ? 1889 — *Lima semisulcata* Nilss. A. FRITSCH, p. 84.
- ? 1893 — *Lima semisulcata* Nilss. A. FRITSCH, p. 100.
- . 1895 — *Lima (Limatula) semisulcata* (Nilss.) F. VOGEL, p. 19 (p.p.).
- ? 1897 — *Lima semisulcata* Nilss. A. FRITSCH, p. 67.
- . 1897 — *Lima semisulcata* Nilss. A. HENNIG, p. 43, pl. 2, fig. 14-15.
- ? 1898 — *Lima semisulcata* (Nilss.) G. MUELLER, p. 26-27, textfig. 7.

- 1901 — *Lima semisulcata* Nilss. F. STURM, p. 91.
- ? 1903 — *Lima semisulcata* Nilsson sp. J. P. J. RAVN, p. 96, pl. 2, fig. 10.
- 1918 — *Lima (Limatula) cf. semisulcata* Nilss. J. P. J. RAVN, p. 25.
- 1923 — *Lima (Limatula) semisulcata* Nilss. A. JESSEN & H. ØDUM, p. 33.
- 1926 — *Lima (Limatula) semisulcata* Nilss. H. ØDUM, p. 176.
- 1929 — *Lima (Limatula) semisulcata* Nilsson R. HÄGG, p. 34.
- 1934 — *Lima (Limatula) semisulcata* (Nilsson) R. HÄGG, p. 32.
- . 1934 — *Lima semisulcata* Nilss. sp. H. ANDERT, p. 152, pl. 8, fig. 10-11.
- . 1938 — *Lima semisulcata* Nilsson J. G. CARLSSON, p. 7.
- 1954 — *Lima (Limatula) semisulcata* (Nilsson) R. HÄGG, p. 265-266-267.
- 1959 — *Limatula semisulcata* (Nilsson) S. FRENEIX, p. 225.
- v 1973 — *Limatula semisulcata* Nilsson 1827 M. GLIBERT & L. VAN DE POEL, p. 52.
- non 1836 — *Lima semisulcata* J. SOWERBY in FITTON, p. 336, pl. 11, fig. 10 = *L. fittoni* d'ORB.
- non 1847 — *Lima semisulcata* Deshayes J. MUELLER, p. 33-34 = *L. decussata* GOLDFUSS.
- non 1850 — *Lima semisulcata* Goldf. A. ALTH, p. 242 = *L. decussata* GOLDFUSS.
- non 1850 — *Lima semisulcata* Goldf. R. KNER, p. 26 = *L. decussata* GOLDFUSS.
- non 1844 — *Lima semisulcata* F. M'COY in GRIFFITH (fide SHERBORN).

## Location of type specimen

NILSSON's original specimens are no longer extant (Dr. J. BERGSTRÖM, Lund, pers. comm. 1975). Some other poorly preserved specimens from Skåne are in the Pal. Inst. Lund (from Kjuge) and in the B. M. N. H. (from Barnakålla). In the absence of fossils from the localities indicated by S. NILSSON, it does not seem opportune at present to designate a neotype.

Localities indicated by NILSSON:

Balsberg, Svenstorpsmölla, Köpinge, Ignaberga, Kjugestrand.

## Stratum typicum:

«Mucronata» Chalk, Upper Campanian.

## Original description

«P. testa gibbo-convexa, obovato-oblonga, laeviuscula, medio longitudinaliter sulcata; sulcis 12-16. (Tab. nostra IX. fig. 3.)

Obs. Quoad formam externam proxime accedit Limam gibbosam Sow. min. conch. tab. 152, sed ex quinquaginta fere speciminibus, a nobis examinatis, in nullo Limae, in singulis vero Plagiostomatis cardinem vidimus. — An sit hic Ostracites decussatus Wahlenb. Act. Upsal. VIII. p. 59. tab. 4. f. 7. 8. 9. ?

Descript. Testa multa longior quam lata, & gibbo-convexa; ambitus obovato-oblongus, basin versus aliquantum attenuatus. Rostrum basale valde acutangulum & quasi compressum. In medio dorso longitudinaliter current sulci 12-16, rugosi, vel transversaliter in ziczac striata; de cetero testa sublaevigata, vel striis tantum accretionis notata: auriculae parvae subacutae.

Locus: Ad Balsberg; in petra calcario-arenosa ad Svenstorpsmölla; in lapide arenacea & carbonifero agri Köpingensis; ad Ignaberga &c. haud raro: praeservatim vero vulgaris ad Kjugestrand. Sic in omnibus fere stratis inferioribus occurrit, estque omnium Plagiostomatum maximae apud nos vulgaris species.»

## Description

This description is based on specimens from Spiennes and Cibly, which fit the original description of the species.

## Numbers of specimens studied:

Upper Campanian from Sweden (Kjuge, Barnakålla: Pal. Inst. Lund, B. M. N. H.): ... ..	8
Lower to Middle Maastrichtian:	
from Cibly (K. B. I. N.): ... ..	109
from Spiennes (K. B. I. N.): ... ..	89
Upper Maastrichtian:	
from St. Symphorien (K. B. I. N.): ... ..	30
from Maastricht (K. B. I. N., N. H. M. Maastricht, Mus. Berl.):	7
«Maastrichtian»	
from Wansin, Jandrain, Orp-Le-Grand (K. B. I. N.): ... ..	6
Total ... ..	254

## Diagnosis:

Medium sized *Limatula*-species, with 7 tot 20 rounded ribs (usually 11 to 17, mean about 13).

## General shape:

Orthocline shell with parallel anterior and posterior margins; height a little less than  $1.5 \times$  length; the posterior margin is perpendicular to the dorsal margin; frontal margin asymmetrical. The maximum convexity cannot be located exactly because of the gentle rounding, but is about one third above the ventral margin.

## Auricles and hinge line:

Auricles are small and cannot be delimited from the areas; covered with growth lines but no other ornament. Anterior auricle has a slight byssal sinus. Auricular angles are obtuse, more so on the anterior auricle. Dorsal margin not straight, but forms an obtuse angle; the dorsal auricular margins meet under the umbo.

## Ornament:

The ornament consist of:

- concentric growth lines, which are weak and are best seen on the areas;
- rounded ribs radiate from the umbo to the ventral margin on the median part of the shell (on the areas only growth lines occur); maximum width 1 mm. At the posterior area the first rib is sharply delimited and is as high as the other ribs. Towards the anterior area, the ribs narrow whilst the intercostal intervals become wider.

The distance from the auricular angle to the first rib on the anterior margin is longer than at the posterior side of the shell. The ribs are smooth near the top of the shell; near the ventral margin, they bear tubercles at the points of intersection with the growth lines.

The ribnumber varies:

In Spiennes	: from 11 to 17, mean 13.51, n = 89;
In Cibly	: from 7 to 16, mean 13.05, n = 108;
In St. Symphorien	: from 11 to 15, mean 13.00, n = 30.

## Discussion of synonymy:

— The description of *Ostracites decussatus* WAHLENBERG agrees completely with that of *Limatula semisulcata* (NILSSON, 1827), not with that of *Limatula decussata* (GOLDFUSS, 1836). WAHLENBERG's figures 7 and 8 look more like *L. semisulcata* (NILSSON, 1827); fig. 9 does not resemble a *Limatula* at all, but it could be a somewhat unfortunate reconstruction. WAHLENBERG's name can be considered a *nomen oblitum* and there is no need, according to Article 23b (I. C. Z. N.) to change *L. semisulcata* (NILSSON, 1827) at present.

— GEINITZ gave a poor figure; the specimens figured by him came from the Upper Turonian, and hence the doubt about their specific attribution.

— For an explanation of the « p.p. » for VOGEL, see further under *L. kunradensis*.

— FRITSCH figured the species only once and badly (in 1877). His specimens ranged from Turonian to Santonian, so they are older than the other known *L. semisulcata* (NILSSON). From the Czech strata only steinkern-preservation is known, so no certain identification can be made.

— G. MUELLER described specimens with sixteen to twenty ribs, but did not figure them. They are steinkerns and therefore it is uncertain whether they belong to *L. semisulcata* (NILSSON), *L. kunradensis* n. sp. or *L. decussata* (GOLDFUSS).

— SOWERBY in FITTON gave no clear picture or description of his *L. semisulcata* (NILSSON) from the Gault clay. Already d'ORBIGNY stated that, because of the ribnumber (11 to 16), the spines on the ribs and the age, these specimens belong to a different species, named by him *L. fittoni*.

— The *L. semisulcata* DESHAYES from G. MUELLER and the *L. semisulcata* GOLDFUSS from ALTH and from KNER are completely covered with ribs, so they are closer to *L. decussata* (GOLDFUSS).

#### Differentiation :

Based on specimens from the following museums : Mus. Hist. Nat. Gen., B. M. N. H., Geol. Surv. Ind., M. G. Lausanne.

*Limatula decussata* (GOLDFUSS, 1835) is covered with ribs from the anterior to the posterior margin; furthermore, the ribs are keeled. The shell is wider and shorter. Santonian to Lower Maastrichtian.

*Limatula wintonensis* (WOODS, 1904) has the same ribshape as *L. semisulcata* (NILSSON, 1827), but the average number of ribs seems greater (14 to 16); the shell is smaller and approximatively as high as wide. Campanian.

*Limatula fittoni* (sensu H. WOODS, 1904) has keeled, spined ribs, which are narrower than those of *L. semisulcata* (NILSSON). Cenomanian.

*Limatula subaequilateralis* (d'ORBIGNY, 1847) is higher in relation to the length, and possesses more (16 to 21) keeled ribs. Cenomanian.

*Limatula tombeckiana* (d'ORBIGNY, 1847) is shorter in relation to the length (more or less circular); more ribs (12 to 21). Lower Aptian to Lower Albian.

*Limatula dupiniana* (d'ORBIGNY, 1847) has more and keeled ribs, which lie more asymmetrically. Anterior area is smaller than the posterior (reverse in our species). Hauterivian to Lower Aptian.

*Limatula persimilis* (STOLIZCKA, 1870) is more than twice as large and has more (15 to 20) ribs, which are keeled, as seen on plaster casts of the types sent by the Geol. Surv. of India. Cenomanian.

#### Geographical and stratigraphical distribution :

Specimens from the following localities and strata belong undoubtedly to *L. semisulcata* (NILSSON) (own observations) :

Maastrichtian	Upper	St. Symphorien, Maastricht
	Middle	Ciply, Spiennes, Wansin, Jandrain, Orp-Le-Grand
	Lower	
Campanian	Upper	Kjuge, Barnakålla

The specimens mentioned as *L. semisulcata* (NILSSON) from the Turonian to Santonian from Bohemia, France and Germany cannot be assigned with certainty to this species; they show characteristics which are close to those of *L. fittoni* (d'ORBIGNY). Possibly they belong to an intermediate species.

From the Danish Danian I have seen only one specimen, identified as *L. semisulcata* (NILSSON); it was very small and completely ribbed, so it did not belong to this species.

GLIBERT & VAN DE POEL (1973) mentioned *L. semisulcata* (NILSSON) from the Danian of Ciply. The identification of those specimens is correct; but they are strongly worn and have probably been reworked from the underlying Middle Maastrichtian strata into the Tuffeau de Ciply. Thus, this species occurs with certainty from the Upper Campanian to the Upper Maastrichtian. At Maastricht, the species occurs together with *L. kunradensis*. Since the deposits of Maastricht contain both allochthonous and autochthonous elements, it is not certain that both species lived together there.

#### b. *Limatula kunradensis* n. sp.

(Pl. 1, figs 1 a-d)

- . 1835 — *Lima semisulcata* A. GOLDFUSS, p. 90, pl. 104, fig 3 abc (p.p.).
- ? 1847 — *Lima semisulcata* GOLDFUSS A. d'ORBIGNY, p. 562-563, pl. 424, fig. 59.
- v 1895 — *Lima (Limatula) semisulcata* F. VOGEL, p. 19 (p.p.).
- 1964 — *Lima (Limatula) semisulcata* R. GIERS, p. 233. (NILSS.)

#### Location of type specimen :

Koninklijk Belgisch Instituut voor Natuurwetenschappen, Department of Palaeontology, IST, TCM I 10.137.

#### Locus typicus :

Kunrade, Limburg, The Netherlands.

## Stratum typicum :

Kunrade Chalk, Maastrichtian b-c. (Late Maastrichtian, *B. junior* Zone in the international sense.)

## Derivatio nominis :

From Kunrade, the type locality.

## Description

## Numbers of specimens studied :

## Middle Maastrichtian :

from Spiennes (K. B. I. N.) . . . . . 2

## Upper Maastrichtian :

from Kunrade (K. B. I. N., N. H. M. Maastr., Mus. Berlin) . . . 182

from Maastricht (K. B. I. N., N. H. M. Maastr.) . . . . . 14

from Eben-Emael (K. B. I. N.) . . . . . 1

from Eisden (K. B. I. N.) . . . . . 9

Total . . . . . 208

## Diagnosis :

Medium sized *Limatula*-species, with 8 to 22 keeled ribs (usually with 17 to 22 ribs, mean about 18).

## General shape :

Orthocone shell with parallel anterior and posterior margins; height is  $1.58 \times$  length (mean); posterior margin straight, at a right angle with the dorsal margin; anterior margin slightly notched. Ventral margin rounded. Longest antero-posterior diameter situated at about half the height. Moderately convex; maximum convexity a little below half height. Thin shelled.

## Auricles and hinge-line :

Auricles small : see *L. semisulcata* (NILSSON).

## Ornament :

The ornament consists of :

- a. concentric growth lines, which are not very pronounced and are best seen on the areas;
- b. ribs that radiate from the umbo to the ventral margin; they are at the most 0.25 mm. wide, triangular in cross-section and keeled. The intercostal intervals are wider than the ribs. Some specimens show very slight tubercles at the points of intersection with the growth

lines. Ribs are limited to the median part of the shell, the first rib at the posterior area being sharply delimited; on the anterior area, the ribs decrease gradually. The number of ribs varies from 8 to 22, but only 7 out of 208 specimens have less than 17 ribs. The mean rib number is 18.33.

## Discussion of synonymy :

— GOLDFUSS described a *Lima semisulcata* DESH., with 19 to 20 keeled and sparsely granulated ribs. It has been impossible to trace GOLDFUSS reference to DESHAYES. His description is short and somewhat vague, and his figure shows a specimen with keeled ribs, which are narrower than the intercostal intervals. This agrees better with the new species than with *L. semisulcata* (NILSSON). The specimens from the GOLDFUSS collection still available in the Pal. Inst. of Bonn University are from Aachen and from the localities indicated by GOLDFUSS, not from Sweden. The specimens from the GOLDFUSS collection in Munich are lost. Thus it is at present impossible to ascertain whether GOLDFUSS realised the differences between the Swedish Campanian species and the species from the Maastricht type area. Hence p.p.

— d'ORBIGNY's text is almost a copy of GOLDFUSS. His figure looks more like *L. fittoni* (d'ORBIGNY) or *L. subaequilateralis* and it is not clear where his *L. semisulcata* belongs.

— VOGEL noticed a difference between specimens from Maastricht and Geulhem and specimens from Kunrade in the shape of the auricle : the auricular margin should form a straight line in the Maastricht-Geulhem group and not in the other. I cannot confirm this observation : indeed, this characteristic is quite variable in all the populations. He also mentioned differences in general shape and ribs, which he did not discuss any further. Part of VOGEL's collection is now deposited in the Rijksmuseum voor Geologie en Mineralogie in Leiden (The Netherlands). The specimens from Maastricht are *L. semisulcata* (NILSSON); hence the p.p.

— GIERS described shells with 18 to 20 ribs, stated that they agree with *L. semisulcata* GOLDFUSS, but gave no further information. These specimens came from Sendenhorst, Obere Vorhelmer Schichten, Mukronatenkreide (Upper Campanian).

## Differentiation :

The new species differs from *L. semisulcata* (NILSSON, 1827) in the following characteristics : the H/L ratio is greater; the shell is thinner; while the ribs of *L. semisulcata* (NILSSON) are rounded and wider than the intercostal intervals, those from the new species are keeled and narrower than the intercostal intervals; the mean rib-number is about 18, against 13 for *L. semisulcata* (NILSSON); the statistical analysis shows that this characteristic is sufficient to separate the two species.



*Limatula decussata* (GOLDFUSS, 1835) is covered with ribs from anterior to posterior margin; the shell is wider and shorter.

*Limatula wintonensis* (WOODS, 1904) has a semi-circular shape, rounded ribs and narrow intercostal intervals. The rib-number is 10 to 15.

*Limatula subaequilateralis* (d'ORBIGNY, 1847) differs in H/L ratio (smaller in the new species); the ribs are thinner and the auricles pointed; they are longer in relation to the total shell-length.

*Limatula fittoni* (sensu H. WOODS, 1904) agrees closely with *L. kunradensis* n. sp. in general shape. The H/L ratio is only a little smaller. Differences are: the spines on the ribs (pl. 2, fig. 5 and pl. 1, fig. 4); the ornamented area, which lies more asymmetrically; and the smaller size.

*Limatula tombeckiana* (d'ORBIGNY, 1847) differs from the new species in the lesser H/L ratio; the rounded ribs, which are wider than the intercostal areas; and the smaller number of ribs.

*Limatula dupiniana* (d'ORBIGNY, 1847) differs from the new species in: the smaller size, the excentric ornamented area and the smaller number of ribs.

*Limatula persimilis* (STOLIZCKA, 1870) agrees with *L. kunradensis* n. sp. in ribshape and -number, but is more than twice as large and relatively less convex.

#### Geographical and stratigraphical distribution

Maastrichtian	Upper	Kunrade, Eben-Emael, Maastricht, Eisden, Hemmoor
	Middle	
	Lower	
Campanian		Spiennes (4)
	Upper	
	Middle	
	Lower	
		? Gehrden (1), Sendenhorst (2), Haldem (3)

(1) Oral communication Dr. A. V. DHONDT: specimens from the Museum of Berlin, from these strata and localities, agree completely with *L. kunradensis* n. sp.

(2) From GIERS, 1964.

(3) From GOLDFUSS, 1835.

(4) It is possible that these specimens are also Upper Maastrichtian; they could have come from the Tuffeau de St. Symphorien, which overlies the Craie phosphatée at Spiennes.

#### Palaeoecology

Living *Limatula* is not found in the littoral area; it occurs eurybathally (ARNAUD, P. M.: 1973, CLARKE, A. H.: 1962, JEFFREYS, J. G.: 1868, NORDSIECK, F.: 1969, OKUTARI, T.: 1962). Most species live in temperate and polar seas on the shelf (to about 250 m), but those spe-

cies that have been recorded from tropical seas live in deep to bathyal waters (f.i. *L. subauriculata* (MONTAGU, 1808): NORDSIECK, F.: 1969). *Limatula* seems to be a suspension feeder, living on sandy to muddy bottoms (CLARKE, A. H.: 1962, OKUTARI, T.: 1962).

The Kunrade Chalk and the gritty chalk of Eisden are much finer grained than the phosphatic 'chalks' of Spiennes and Ciply. *Limatula kunradensis* n. sp. thus seems to have occurred in a different habitat than *L. semisulcata* (NILSSON).

The deposits at Maastricht, where the two species occur together, are very shallow and probably near shore deposits; mainly they are 'tuffeau' (calcarenitic facies) as on the Sint Pietersberg or at Neder-Kanne, but gritty chalk at Eben-Emael.

*L. kunradensis* n. sp. probably lived on muddy bottoms, *L. semisulcata* (NILSSON) probably on sandy sediments.

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## APPENDIX A

### List of Museums from which material was borrowed :

- British Museum (Natural History), Palaeontology, Mollusca Section, London;
- Geological Survey of India, Calcutta;
- KBIN, Dept. of Palaeontology, Brussels;
- Musée géologique, Lausanne;
- Muséum d'Histoire naturelle, Geneva;
- Naturhistorisches Museum, Basel;
- Natuurhistorisch Museum, Maastricht;
- Paläontologisches Museum, Humboldt Universität, Berlin;
- Palaeontologiska Institutionen, Lund Universitet, Lund;
- Rijksmuseum van Geologie en Mineralogie, Leiden.

## APPENDIX B

TABLE 1

Number of specimens, minimum, maximum, mean and standard deviation of measurements a to g.

Meas.	n	Min	Max	Mean	Std
<i>Maastricht</i>					
a	23	11.0000	32.0000	16.4782	4.4504
b	7	1.2100	2.0800	1.5634	0.3242
c	7	0.9900	2.0000	1.4271	0.3774
d	14	0.8300	1.9450	1.3874	0.3451
e	14	0.6450	2.4950	1.8346	0.5101
f	11	0.5400	1.4450	1.0018	0.2719
g	10	0.4300	1.7300	0.8344	0.3847
<i>Cipty</i>					
a	108	7.0000	16.0000	13.0463	3.5914
b	64	0.9700	2.3300	1.6305	0.2510
c	64	0.7750	1.9950	1.4412	0.2636
d	92	0.6200	1.9050	1.2666	0.2654
e	85	0.9200	2.6100	1.8575	0.6583
f	92	0.3500	1.3400	1.1034	0.7481
g	67	0.3250	1.0500	0.7559	0.3191
<i>Kunrade</i>					
a	153	8.0000	22.0000	18.3267	1.9796
b	69	0.5900	2.0050	1.2414	0.3517
c	69	0.5550	1.6350	1.1081	0.2907
d	114	0.3850	1.8800	0.9282	0.2558
e	113	0.4200	2.3400	1.4273	0.3906
f	105	0.4100	1.8000	0.8140	0.2663
g	74	0.2400	1.6550	0.5214	0.2206
<i>Saint Symphorien</i>					
a	30	11.0000	15.0000	13.0000	1.0504
b	16	1.1800	1.9950	1.4888	0.4972
c	16	1.0600	1.8100	1.4633	0.2280
d	23	0.9250	1.6500	1.2532	0.1987
e	22	1.0200	2.4600	1.8199	0.3664
f	26	0.6600	1.2650	0.9757	0.1641
g	20	0.4650	0.9250	0.6757	0.2008
<i>Spiennes</i>					
a	89	11.0000	17.0000	13.5115	3.5243
b	76	1.1250	2.2550	1.7320	0.3170
c	76	0.7750	2.2200	1.6022	0.3248
d	87	0.6500	2.4800	1.4113	0.2953
e	86	0.5400	2.8300	2.0245	0.4299
f	87	0.4800	1.7950	1.0904	0.2414
g	76	0.0950	1.7900	0.7886	0.2459

TABLE 2a

Results of F-test and observed differences.

Measurement	Result of F-test : significance level	Differences between :
a	0.001	Kunrade $\neq$ rest, exc. Maastricht
b	0.001	
c	not significant	Kunrade $\neq$ rest
d	not significant	
e	not significant	
f	0.001	Kunrade $\neq$ Spiennes, Cipty
g	0.001	
Ratio		Kunrade $\neq$ rest
1	0.025	Kunrade $\neq$ Spiennes, St. Symph.
2	0.001	
3	0.001	Kunrade $\neq$ Spiennes, St. Symph., Cipty; Spiennes $\neq$ St. Symph.
4	not significant	
5	not significant	
6	0.001	Kunrade $\neq$ rest, exc. Maastricht

TABLE 2b

Mean vectors of the canonical variates.

Can v	Spiennes	Kunrade	St. Symphorien	Cipty
1	7.572	12.850	7.565	7.535
2	5.634	6.196	6.392	6.620

TABLE 2c

Eigenvectors for the canonical transformation.

Measurement	Can. v. 1	Can. v. 2	Can. v. 3
a	0.973	0.230	0.120
b	2.255	-2.099	2.001
c	0.283	5.468	-2.116
d	-4.009	3.024	-3.099
f	-0.617	-1.013	1.871
g	-0.583	-1.200	2.470

EXPLANATION OF PLATE

PLATE I

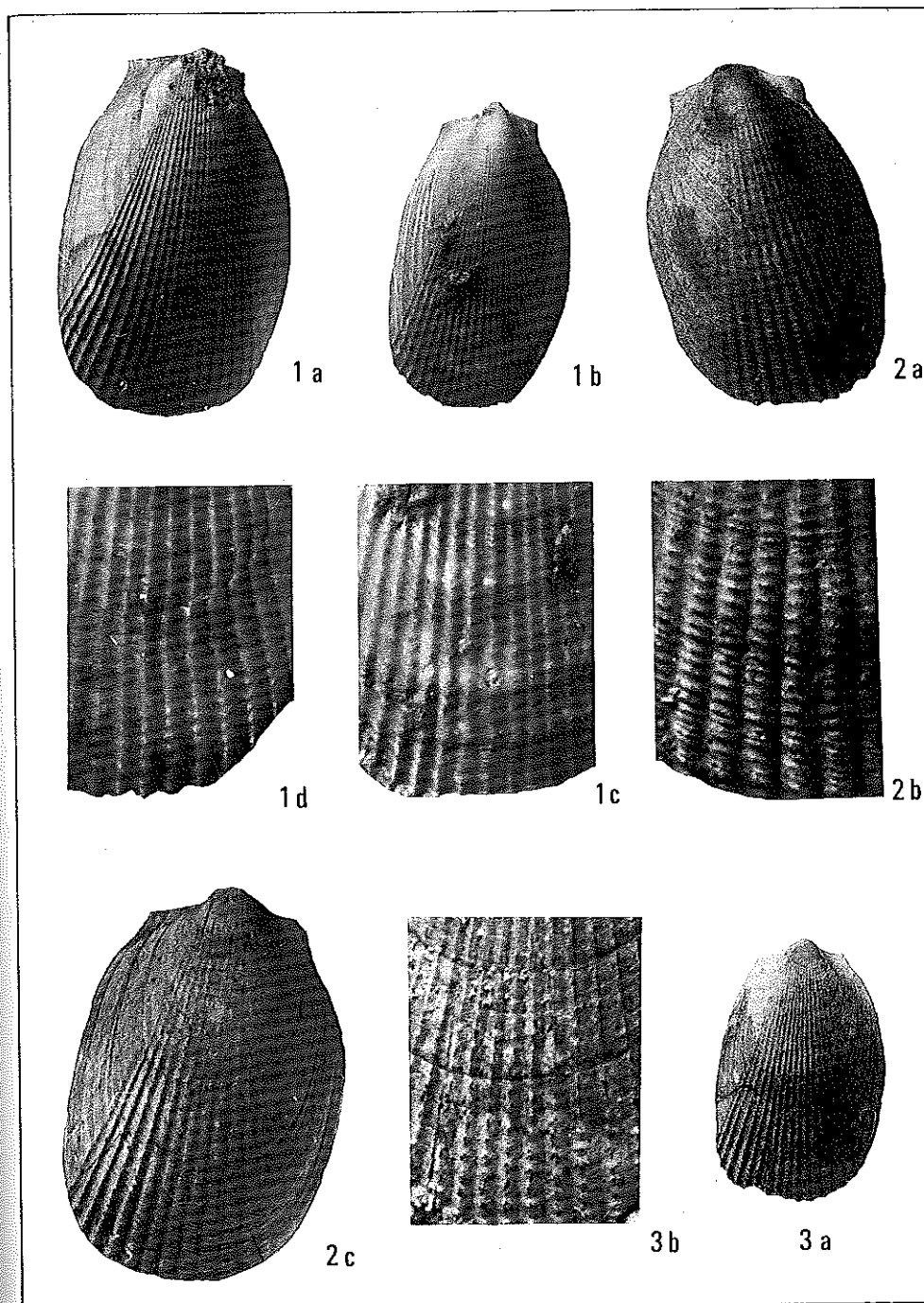
- Fig. 1. — *Limatula kunradensis* n. sp.  
1 a: Loc.: Maastricht, Limburg, the Netherlands, Upper Maastrichtian, KBIN TCM I 9839 (× 2.5);  
1 b: Loc.: Kunrade, Limburg, the Netherlands, Kunrade Chalk, Upper Maastrichtian, KBIN TCM I 10137 (× 2), holotype;  
1 c: same specimen as on 1 b (× 5);  
1 d: Kunrade, Limburg, the Netherlands, Kunrade Chalk, Upper Maastrichtian, KBIN TCM I 10136 (× 5).
- Fig. 2. — *Limatula semisulcata* (NILSSON, 1827)  
2 a: Loc.: Spiennes, Hainaut, Belgium, Craie phosphatée, Middle Maastrichtian, KBIN TCM I 10134 (× 2);  
2 b: same specimen as on 2 a (× 5);  
2 c: Loc.: Ciplly, Hainaut, Belgium, Craie phosphatée, Middle Maastrichtian, KBIN TCM I 9838 (× 2.5).
- Fig. 3. — *Limatula fittoni* (d'ORBIGNY, 1850)  
3 a: Loc.: Haldon, Devon, England, Upper Greensand, Cenomanian, BMNH L 15615 (× 2);  
3 b: same specimen as on 3 a (× 5).

ABBREVIATIONS

Abbreviations and signs used in synonymy lists as in DHONDT, A. V., 1973, (pp. 74-75).

CONTENTS

Abstract .....	1
Résumé .....	1
Introduction .....	2
Systematics and biometry .....	2
— Material and methods .....	4
— Results .....	8
— Description of the species .....	8
a. <i>Limatula semisulcata</i> .....	13
b. <i>Limatula kunradensis</i> n. sp. ....	16
Palaeoecology .....	17
Acknowledgments .....	17
References .....	21
Appendix A: List of Museums .....	22
Appendix B: Statistical data .....	24
Explanation of Plate .....	24
Abbreviations .....	24
Contents .....	24



Robert MARQUET. — *Limatula* species (Limidae, Bivalvia, Mollusca) from the Maastrichtian in Belgium and in the Netherlands