Cainozoic Research, **7**(1-2), pp. 27-67, April 2010

The identity of *Isocrassina*, *Laevastarte* and *Ashtarotha* (Mollusca, Bivalvia, Astartidae) and their representatives from beaches and estuaries in The Netherlands and Pliocene strata in Belgium

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Received 1 March 2009; revised version accepted 13 July 2009

The identity of the subgenera *Isocrassina* Chavan, 1950, *Laevastarte* Hinsch, 1952, and *Ashtarotha* Dall, 1903, of the genus *Astarte* Sowerby, 1816 in the family Astartidae (Mollusca, Bivalvia) is discussed. *Isocrassina* has been widely used for Pliocene species in the North Sea Basin. Here it is demonstrated, that this is based on a redefinition of this subgenus, which excludes its type-species. As the North Sea species differ considerably from the type-species of *Isocrassina* in aspects of ornament and details of the hinge, it is concluded that they should be placed in the genus *Laevastarte*. A slightly modified definition of *Isocrassina* and *Laevastarte* is given and both are raised to genus level. The morphological basis for *Ashtarotha* is quite weak and it is found doubtful if it should be maintained. The species now incorporated in *Laevastarte*, known from the beaches and estuaries in the province of Zeeland (The Netherlands) are described and extensively illustrated. The present study also includes *in situ* specimens from excavations in the Antwerp region (Belgium) as well as from some boreholes in Zeeland. One new species, *Laevastarte ovatacostata* n. sp., and a new forma, *Laevastarte bipartita* (Sowerby, 1826) forma *confusa* are introduced. Neotypes are designated for *Astarte omalii* De la Jonkaire, 1823 and *Astarte basterotii* De la Jonkaire, 1823.

KEYWORDS: Bivalvia, Astartidae, *Astarte*, *Isocrassina*, *Laevastarte*, *Ashtarotha*, Pliocene, Miocene, North Sea Basin, systematics, new taxa, neotype designation

Introduction

During the revision of the Naturalis collection of fossil bivalves from Dutch beaches and estuaries the identification of species of the family Astartidae, traditionally, caused major problems. These difficulties have resulted in a lot of confusion in existing literature, where different views on the taxonomy of the species- and genus group taxa occur. Many, if not all species display a wide variability in shape, ornament and other characteristics, which may be due to their reproduction mode. Research in boreal and arctic environments revealed that *Tridonta elliptica* (Brown, 1827), *T. borealis* Schumacher, 1817, *T. montagui* (Dilwyn, 1817), *Astarte crenata* (Gray, 1824) and *A. sulcata* (da Costa, 1778) produce large eggs with a large amount of yolk (Thorson, 1936, 1946; Ockelmann, 1958). The eggs are laid on the sediment and the larvae have no or just a very short planktonic stage and therefore settle close to their parents. As a result there is only restricted exchange of genetic material between specimens living at some distance from each other. The limited dispersal should increase isolation and may therefore have promoted speciation. It cannot be decided, of course, whether the warm-temperate Pliocene species in the North Sea Basin had a similar way of reproduction, which is less common in warmer environments.

Høpner Petersen (2001) described several new species of Astartidae from the recent Arctic and Baltic fauna. Previously, these species used to be identified as *Tridonta borealis* and *T. elliptica* and most of them have a very restricted geographical distribution. He wrote (p. 12): "I have merely extended the [nomenclatural] concepts and lifted 'forma' and 'varieties' to 'species' level. I accept all names and descriptions as valid for a species, until otherwise proven by comparison with the original material." This research is very valuable because it shows the huge variation within the astartids and the limited distribution of the (recently evolved) species in a recent setting. The authoritative CLEMAM list, however, does not share this point of view and assigns all of these new taxa to *Astarte borealis* and *Astarte incertae sedis* (= a nominal taxon in need of reassessment). Molecular analyses will be necessary to shed light on the status of

these taxa and their relationships.
As a result of the morphological diversity within the species there is no general agreement on the genus group taxonomy of Astartidae. Chavan (1969) subdivided the genus *Astarte* into eight subgenera, but, as will be shown later in this paper, the characteristics of these taxa do not always correspond with the original diagnosis and there are many different opinions on assigning species to the various subgenera.
The aim of the present paper is to give a revision of the species as incorporated in the (sub)genus *Isocrassina* by Janssen & Van der Slik (1974b) and Marquet (2005). The most important mutual characteristic of these species is the conspicuous commarginal ornament of the umbonal region which becomes less clear or totally disappears towards the ventral margin. In connection with these species the taxonomic status of the genera *Isocrassina*, *Laevastarte* and *Ashtarotha* is discussed. The present approach is predominantly of morphological character, in order to first build a taxonomical framework necessary for further biostratigraphical research on this group.

Material and methods

The present study is based on extensive, reworked fossil material from beaches and estuaries in the province of Zeeland (The Netherlands), supplemented by *in situ* collected specimens from excavations in the Antwerp region (Belgium) and some boreholes in Zeeland (The Netherlands). Additionally, fossil and Recent specimens from Italy, the Mediterranean and the eastern United States were studied.
The most important features to distinguish the species are details of the umbonal ornamentation (strength, ratio between ribs and interspaces, curvature of the ribs) and the degree of inward turning of the umbones. Besides these, various other features are helpful in identifying the species. Concerning shell shape the length/height ratio (L/H ratio) of juvenile shells of 5 mm high is given, as well as the outline of juvenile shells of 10 mm high. In the absence of juvenile specimens their shape was reconstructed from adult specimens by following the commarginal ornament at 5 and 10 mm from the umbo, respectively. The width of the commarginal ribs is measured at their basis. The width of interspaces is measured between the basis of adjacent ribs. As the transition of ribs to interspaces often is gradual these ratios are by approximation. Illustrations of the umbonal regions of the various species are all at the same magnification, enabling easy comparison of ornamentations (Figures 48-49).

The following abbreviations are used:

CLEMAM	Checklist on European Marine Molluscs: http://www.somali.asso.fr/clemam/index.clemam.html
IRSNB	Institut royal des Sciences naturelles de Belgique, Brussels (Belgium).
MNHN	Muséum national d'Histoire naturelle, Paris (France).
NITG/RGD	Nederlands Instituut voor Toegepaste Geowetenschappen TNO (formerly Rijks Geologische Dienst, The Netherlands); collections now housed in NCB Naturalis, Leiden (The Netherlands).
NITG/Vreede	Collection M.E. Vreede, formerly in the Nederlands Instituut voor Toegepaste Geowetenschappen TNO (formerly Rijks Geologische Dienst, The Netherlands), now housed in NCB Naturalis, Leiden (The Netherlands).
RGM	NCB Naturalis (Collections Department, Cainozoic Mollusca), Leiden (The Netherlands), formerly Rijksmuseum van Geologie en Mineralogie.
RMNH	NCB Naturalis (Collections Department, Recent Mollusca), Leiden (The Netherlands), formerly Rijksmuseum van Natuurlijke Historie.

L	Length of the shell.
H	Height of the shell.
Hh	Height of the hinge.
S	Semidiameter of a single valve (convexity).

Explanation of some frequently used descriptive terms:

bipartite	Shell containing two more or less sharply delimited adult parts with differently developed ornament or growth directions.
commarginal	Parallel with the outer margin of the shell, replacing the more frequently seen, but actually incorrect term "concentric" for growth lines or ribs.
commissure	The plane where the two valves of the shell meet.
prosogyrate	Umbones bending to the anterior (front) side of the shell.
turned inwards	Umbones turned towards the commissure.
1/1	Indication of a paired specimen.
/2	Valves are indicated as half a specimen.

Figure 1. *Isocrassina castanea* (Say, 1822). Hudson Bay (Canada); recent. RMNH.MOL.113685, ex coll. Verreaux. Scale bar = 1 cm.

Figure 2. *Laevastarte henckeliusiana* (Nyst, 1836). Kleine Spouwen, Berg, Keistraat (province of Limburg, Belgium); Oligocene, Rupelian, Berg Sands, horizon with *Astarte trigonella* . RGM 577 701, leg. M. van den Bosch & A.W. Janssen. Scale bar = 1 cm.

Figures 3, 4. *Ashtarotha undulata* (Say, 1824). Eastern USA; Miocene (only information on label: "Mioceen, Maryland Geol. Surv. p. 354"). RGM 577 700. Scale bar = 1 cm.

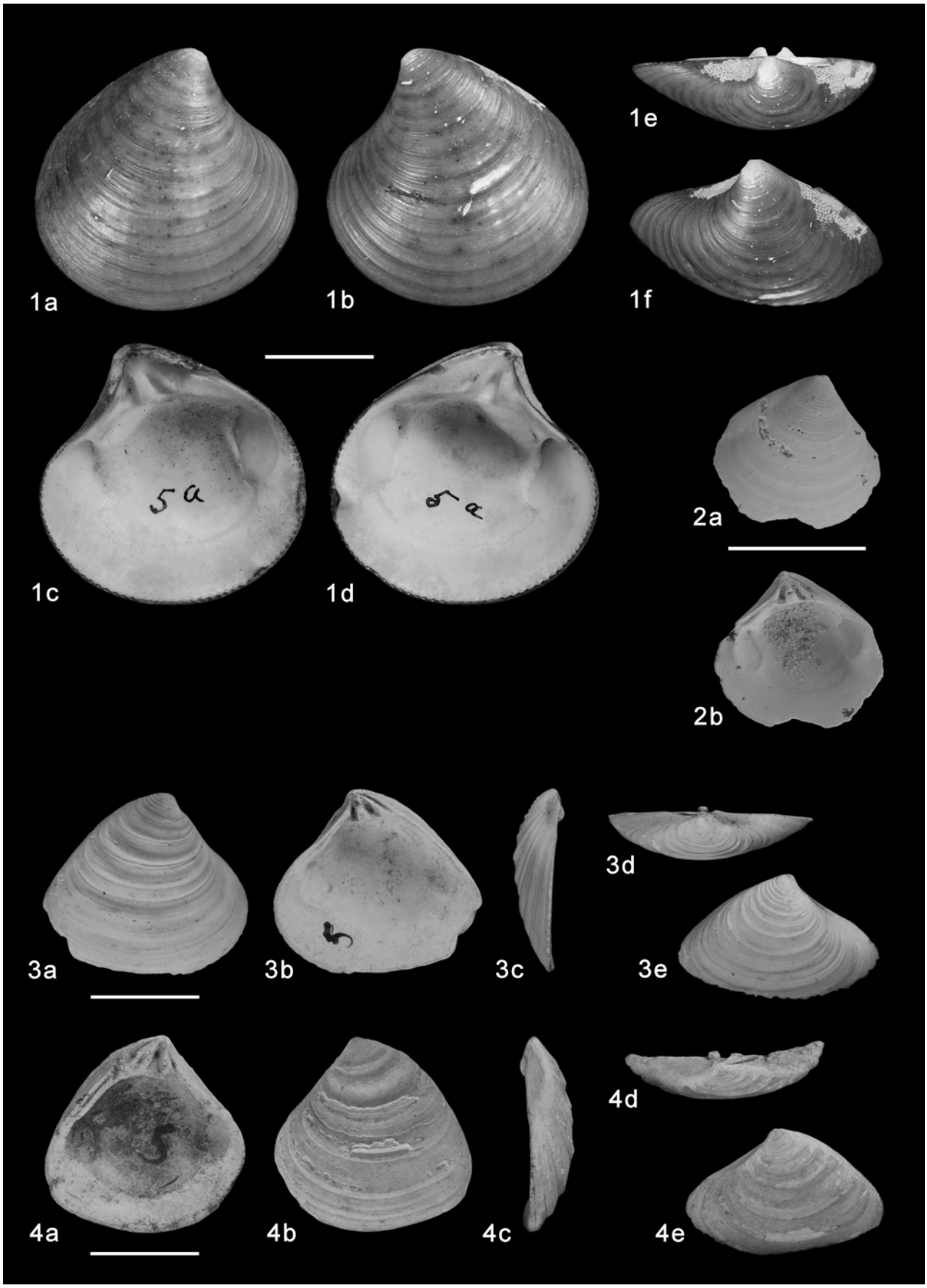


Figure 1-4.

The genus group taxa *Isocrassina, Laevastarte* and *Ashtarotha*

In respect to the taxa dealt with in this paper many earlier authors did not recognize subgenera within the genus *Astarte* Sowerby 1816 while others used the name *Isocrassina* Chavan, 1950, interpreted as subgenus or genus. The subgenus name *Laevastarte* Hinsch, 1952, is less widely used, and the same is true for *Ashtarotha* Dall, 1903.

Isocrassina Chavan, 1950

Isocrassina was introduced as a subgenus of *Astarte* by Chavan (1950). Although the volume of the journal in which this taxon was introduced is that for 1949, it actually was published as late as June 1950, thus the latter date is the correct one. As the note on the publication date is on one of the last pages of the volume, it is comprehensible that Glibert & Van de Poel (1970) overlooked this and mentioned 1949. Also, they missed the just published volume of the milestone work Treatise on Invertebrate Paleontology (Chavan, 1969) in which the correct year 1950 is used.

Chavan (1950, p. 509, translated) wrote: "I introduce the group: subgenus *Isocrassina*, type *Astarte castanea* Say nov. subg. of *Astarte*, comprising those species which are constantly distinguished by a trigonal, slightly inaequilateral form, an ornament of weak and broadly rounded ribs and a very deep lunule, the margin of which coincides with A_{II}." (A_{II} = the anterior lateral tooth in the left valve). Apart from the type species *Astarte castanea* (Say, 1822), which is a recent species of eastern North America, Chavan included *A. arata* Conrad, 1840, as a precursor from the Miocene of the same area, *A. fusca* (Poli, 1791), a Recent species from the Mediterranean, and *A. omalii* De la Jonkaire, 1823, from the Pliocene of Belgium, in his subgenus *Isocrassina*.

Recent specimens of the type species *Astarte castanea* were available for comparison (Figure 1). This species is known under the vernacular name of 'Smooth Astarte' and indeed its smooth surface is striking. Prominent ornament is lacking, the only features being broad, barely elevated commarginal waves covered with weak irregular commarginal lines. Also on the beaks real ribs are completely absent. The shape of the shell is high-trigonal, with the beaks just in front of the midline, and a very gradually curved ventral margin. The lunule is moderately deep and in the left valve its margin coincides with the anterior lateral tooth. The latter characteristic is difficult to observe, even in perfectly preserved Recent specimens, because the tooth is very weak. All of these observations agree with Chavan's original definition of *Isocrassina*. A further, striking feature, however, not mentioned by Chavan, is the completely filled up cavity underneath the hinge plate at the anterior side. This filling is extended on the inner shell wall, almost reaching the anterior muscle scar (Figure 1).

Unfortunately no material of *Astarte arata* was available for study. Gardner (1943, p. 55) wrote: "Shell heavy, relatively inflated, high, rounded, trigonal. […] Lunule smooth, deeply sunken, elongate-cordate. […] Surface sculptured with irregular, concentric undulations – strongest and most regular near the umbones, evanescent ventrally, particularly on the posterior half of the shell. Fine, irregular, discontinuous, concentric striations developed in the adults – most conspicuous near the basal and posterior margins." Shell form and lunule correspond well with the definition of *Isocrassina* as well as with the observations on *Astarte castanea*. The ornament, however, is clearly different, with well developed and regular ribs on the umbones, compared to the smooth umbones in *Astarte castanea*.

The other two species included in *Isocrassina* by Chavan differ even more. *Astarte fusca* and *A. omalii* not only have a prominent ornament of commarginal ribs in the umbonal region, but also they have a much lower, less trigonal shape with the umbo further in front of the midline.

The definition of *Isocrassina* clearly is insufficient to include all four species. Almost 20 years later Chavan was the author of the section on Crassatellacea in the Treatise on Invertebrate Paleontology, giving (Chavan, 1969, p. 562) a redefinition of *Isocrassina*: "*A. (Isocrassina*) Chavan, 1950 [3] [**A. castanea* Say, 1830 (=**Venus castanea* Say, 1822); OD]. Subtrigonal-rounded, almost equilateral, thick; strong close-set umbonal ribs passing to low, rounded, spaced concentric undulations. Large shallow lunule. Hinge thick, with high cardinals and short laterals. […] [= *Laevastarte* Hinsch, 1952 (type, *Tellina fusca* Poli, 1791; OD).]". In this subsequent definition 'trigonal' is replaced by 'subtrigonal-rounded', the 'very deep lunule' by a 'large shallow' one and nothing is said about the anterior lateral tooth of the left valve coinciding with the margin of the lunule. The most striking difference, however, concerns the ornament. No longer 'weak and broad rounded ribs' but 'strong close-set umbonal ribs passing to low, rounded, spaced concentric undulations'. Obviously, Chavan extended his original diagnosis of *Isocrassina* to also fit the other species initially included, *viz. Astarte fusca* and *Astarte omalii* fit perfectly in this definition. However, the type species of *Isocrassina*, *Astarte castanea*, has no umbonal ribs whatsoever, which makes this subsequent diagnosis inappropriate.

Figure 5. *Laevastarte fusca fusca* (Poli, 1791). Spalato and Naples, Mediterranean Sea (Italy); recent. RMNH.MOL.113682, ex coll. F. Cantraine. Scale bar = 1 cm.

Figure 6. *Laevastarte fusca incrassata* (Brocchi, 1814). Castell' Arquato, Piacenzia, Emilia-Romagna, Italy; Pliocene, Piacenzian. RGM 577 699, ex RGM 27 025. Scale bar = 1 cm.

Figure 7. *Laevastarte fusca incrassata* (Brocchi, 1814). San Nicomede (Parma, Emilia-Romagna, Italy), streambed Torrente Stirone, about 8.20-8.60 m. below base of sandstone level; Pliocene, Piacenzian, grey sandy clay. RGM 577 703, leg. A.W. Janssen. Scale bar = 1 cm.

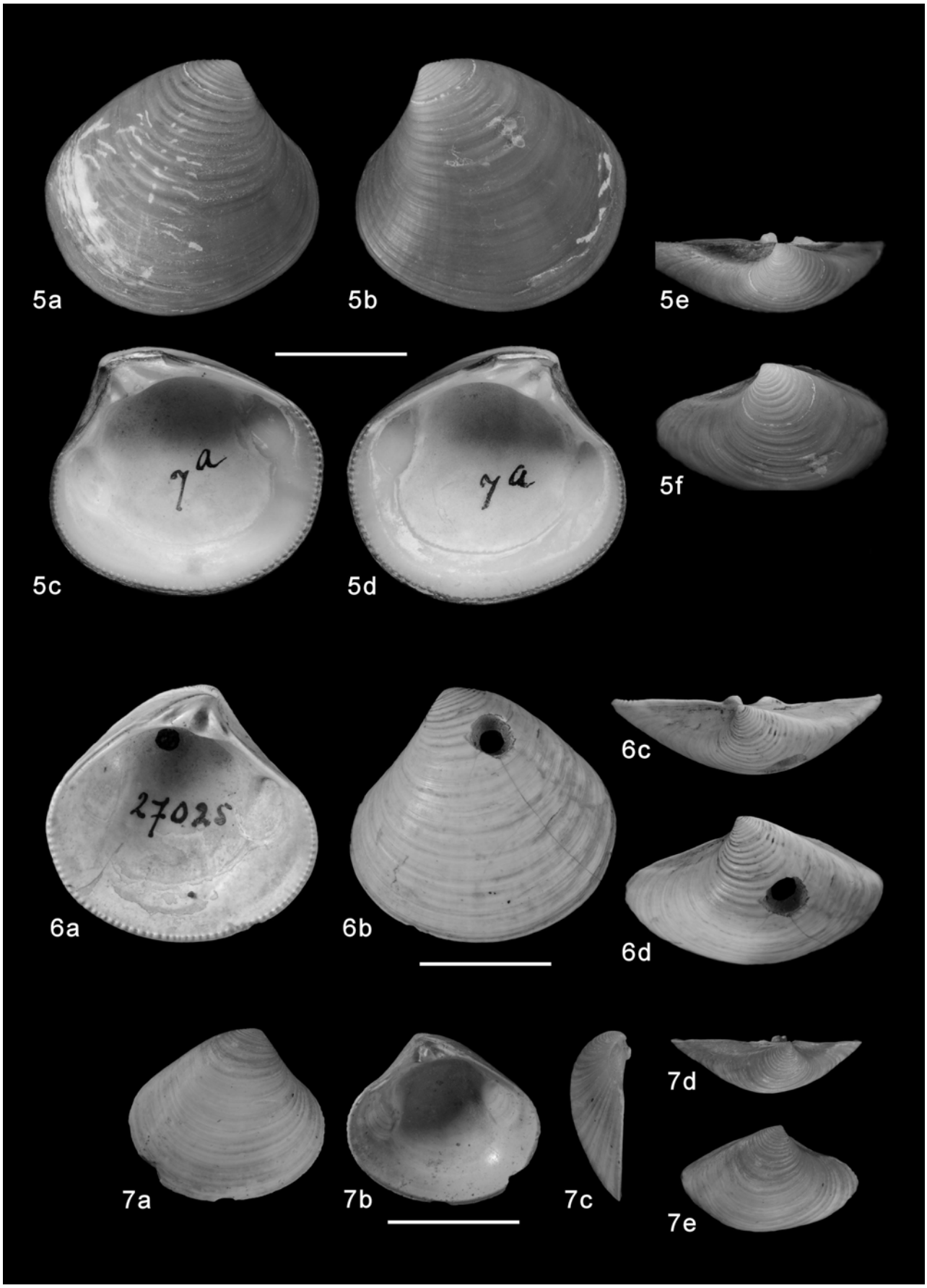


Figure 5-7.

Before Chavan (1950) introduced the subgenus *Isocrassina* all species covered in the present paper used to be included in *Astarte s.str*. In spite of the nature of Chavan's paper, which is basically non-taxonomic, the name *Isocrassina* was noticed and already used not long after its first publication by Glibert (1957). Others, like Spaink (1968) and Janssen & Van der Slik (1974a, b) followed. Spaink (1972) returned to *Astarte* without subgenera, mentioning *Isocrassina* only as a synonym. Perhaps this was in connection with Glibert & Van de Poel (1970) who extensively discussed why they did not use *Isocrassina* any longer. Recently, Marquet (2005) increased *Isocrassina* to genus level. In the CLEMAM list, on the other hand, all recent European species with commarginal ornament (including *Astarte fusca*) are listed in the genus *Astarte*, without application of subgenera.

Laevastarte Hinsch, 1952

Two years after the first publication of *Isocrassina* another subgenus of *Astarte* was introduced, *viz*. *Laevastarte* Hinsch (1952), with *Astarte fusca* (Poli, 1791) as the type-species. The original diagnosis is (p. 155, translated): "An *Astarte* with regular curvature of the exterior. The relatively fine, concentric ribs are restricted to the area near the umbones, the rest of the exterior is smooth. A keel is lacking. Next to the type-species I place into it the following species: *Astarte (Laevastarte) basterotii* Jonkaire and *Astarte (Laevastarte) henckelusiana* [sic] Nyst (Oligocene)". This diagnosis is followed by an extended description (p. 155, translated): "The umbo, which is situated a little in front of the midline, is not flattened. Outline and curvature are rather evenly rounded. The lunule is not very deeply impressed. The distance between the ribs is on the top about 0.1 mm and increases to about 0.5 mm. Broad ridges never develop. The ribs weaken rather early, the major part of the outside is smooth, except for growth lines."
Comparison with recent specimens of *Astarte fusca* from the Mediterranean (Figure 5) reveals that they fit this definition and description excellently, except for the commarginal ribs. In the recent form these are coarser and not restricted to the umbonal area as stated in the definition, but extending as far as 15 mm from the umbo of 20 mm high adult specimens. In the Pliocene *Astarte fusca incrassata* (Brocchi, 1814) (Figures 6-7) the commarginal ribs disappear much earlier. Hinsch (1952) illustrated a fossil identified as *Astarte (Laevastarte) fusca* originating from the Gram-Stufe (Late Miocene) of Germany and judging from its illustration Glibert & Van de Poel (1970) supposed that it probably represents *Astarte fusca incrassata*.
Unfortunately, all paleontological collections of the Geologisches Landesamt Hamburg have been destroyed (pers. comm. K. Bandel), including the specimen illustrated by Hinsch, so this cannot be checked anymore. As Hinsch designated *Astarte fusca* [s.l.] as type-species, indicating that it occurs from Late-Oligocene to Recent, it is best to restrict it to *Astarte fusca s.str., viz*. the Recent form, to avoid further confusion about its identity.
Extensive material of *Astarte basteroti* de la Jonkaire, 1823, was studied for this paper (see specification below). This species corresponds very well to the *Laevastarte* subgenus definition of Hinsch (1952). Also of *Astarte henckeliusiana* Nyst, 1836, material was available (Kleine Spouwen, Belgium; Oligocene, Rupelian, Berg Sands, horizon with *Astarte trigonella*) (Figure 2). It has a low trigonal shell with a moderately prosogyr and hardly inwards turned umbo just in front of the midline. The shell is flat with a weakly angular transition (but no keel) to the posterior area. The very fine but distinct commarginal ornament, with interspaces half as wide as the ribs, increases very slowly in strength and disappears at a distance of 5 mm from the umbo. The remaining part of the shell is smooth except for growth lines. The discriminating characteristics of *Laevastarte* correspond with these observations.
The name *Laevastarte* has barely been used afterwards and Chavan (1969) included it in the synonymy of *Isocrassina*. Glibert & Van de Poel (1970) rejected *Laevastarte* as a subgenus of *Astarte*, like they also did with *Isocrassina*.

Ashtarotha Dall, 1903

A third subgenus is of interest in connection with the species dealt with in this paper. The taxon *Ashtarotha* was described by Dall (1903a, p. 936) as follows: "Section *Ashtarotha* Dall, 1903. Umbones concentrically sculptured and conspicuously flattened; disk smoother outside of the flattened area; otherwise like *Astarte*. Type, *Astarte undulata* Say, Miocene. *A. bipartita* Sowerby, 1829, appears to belong here." A few months later (Dall, 1903b, p. 1487) the description was repeated in almost the same words.
One sample of the type-species *Astarte undulata* Say, 1824, was available in the Naturalis collections (without location, only information on label: "Mioceen, Maryland Geol. Surv. p. 354"). The good to poorly preserved specimens display a large variation, especially so in the flattening of the umbonal region and the strength of the ornament. The sample might represent more than a single species. Specimens with a flattened umbo (Figures 3-4) have these characteristics: high to elongated trigonal, hardly convex shell with wedge-shaped posterior end. The flattened umbo is situated just in front of the midline; it is prosogyrate and not or hardly turned inwards. The shell margins in the umbonal region are sharp, best seen from the inside. Fine commarginal ornament is present on the umbo; the riblets are about twice as wide as their interspaces. Ribs are also present beyond the flattened umbonal area. They are widening and flattening towards the ventral margin, becoming wavy and irregular, with interspaces wider than the ribs. There is no posterior area and as a result the ornamentation follows a regular oval line. The ventral margin is not crenulated in the examined specimens.
Dall (1903a) suggested that *Astarte bipartita* Sowerby,

1829 might also be incorporated in *Ashtarotha*. The discriminating characteristics of the subgenus can indeed all be applied to this species. Furthermore, the sharp shell margins in the umbonal region which are so characteristic for *A. bipartita* (Figures 21a, 22b) are also present in the type-species of *Ashtarotha*.
Hinsch (1952) is one of the very few authors who applied *Ashtarotha* to North Sea Basin species, following Dall (1903a) in considering *A. bipartita* as belonging to *Ashtarotha*. In his description of the genus Hinsch wrote (1952, p. 157, translated): "A large-sized *Astarte* with coarse, concentric ribs near the umbo. Often the umbonal area is strikingly flattened and the ribs change into very wide thickenings that may cover the entire outside. In more tumid forms the ribs disappear early and the lunule is deeply impressed. The maximum distance between the ribs is at least 1 mm and may reach 5 mm. […] Between *Astarte (Ashtarotha) omalii* and *Astarte (Ashtarotha) bipartita* there are various transitional forms, to which also *Astarte (Ashtarotha) mutabilis* Wood belongs. This induced me to also include *Astarte (Ashtarotha) omalii* without flattened umbo in *Ashtarotha* and to expand the diagnosis accordingly.". It is clear that Hinsch's approach of the genus differed from the original diagnosis by Dall, by focusing on the coarse ribs as the main feature and by this also including species that lack the flattened umbonal area, the most important characteristic of *Ashtarotha* as described by Dall.

Discussion

As demonstrated above the original definition of *Isocrassina* Chavan, 1950 does not fit the European species often assigned to it. The revised diagnosis of *Isocrassina*, as given by Chavan (1969), however, includes characteristics not acknowledged by its type species. Probably the application of *Isocrassina* in the literature on the European fossil astartids is mainly based on the 1969 description. Here the name *Isocrassina* is restricted to species demonstrating the characteristics of its type species, *Astarte castanea*, notably the complete absence of well-developed umbonal ribs which clearly distinguishes it from species with commarginal ribs. The filling of the cavity beneath the anterior part of the hinge plate and the extension of it on the inside of the shell are also very characteristic for the type-species. Without the possibility of consulting other species with a smooth exterior it is not clear if this filling is characteristic for all of these species or just for *A. castanea*. Completely smooth species are not known from the Pliocene and Miocene of the North Sea Basin, which implies that *Isocrassina* is not present in that region.
The main characteristic distinguishing *Ashtarotha* from other subgenera of *Astarte* is the flattened umbo. However, specimens of *Astarte bipartita* show that there is a huge variability in the umbonal convexity, ranging from flat to quite convex. This characteristic does not seem to be very stable, not even in the type-species *Astarte undulata*, as is clear from illustrated specimens of various subspecies in Gardner (1943). The expanded diagnosis of the genus given by Hinsch (1952) focuses on the coarse ornament as the main characteristic, with the flattened umbo as an often (but not always) occurring feature. In his view the strength of the ornament differentiates *Ashtarotha* and *Laevastarte*. The problem with this view is, however, that an objective distinction between coarse and fine sculpture is hard to give and also some species do not fit in this scheme. Hinsch applied distances between the ribs, but based on this for instance the species *A. fusca* and *A. ovatacostata* spec. nov. can be assigned to *Ashtarotha* as well as *Laevastarte*, depending on the specimen at hand. Distinguishing (sub-) genera using the strength of the ornament therefore is not a solid basis. Considering the observed variability and unstable features application of the name *Astharotha* is here rejected.
From the North Sea Basin and beyond many species (often assigned to *Isocrassina*) are known which are characterised by close-set commarginal ribs in the umbonal region which become less conspicuous or disappear altogether towards the ventral margin. This is a very characteristic feature and an obvious reason to assign those species to a separate genus group. As discussed above *Isocrassina* and *Ashtarotha* are rejected as genus for these species and instead of that all species are placed in the genus *Laevastarte*.

Redefinition of *Isocrassina* and *Laevastarte*

The diagnosis of *Isocrassina* as given by Chavan (1950) is adapted in agreement with its type species: trigonal and slightly inaequilateral shell with a deep lunule. Prominent ornamentation is absent and only broad, barely elevated commarginal waves, covered with weak irregular commarginal lines are present. As a result the outer surface of the shell is nearly smooth. The absence of prominent ornamentation is a major morphological feature, clearly indicating this taxon as an independent genus. Type-species is *Isocrassina castanea* (Say, 1822) (Recent, eastern North America).
The diagnosis of *Laevastarte* as given by Hinsch (1952) is adapted according to its type species and the originally included species: trigonal to rectangular shell, slightly to strongly inaequilateral, with fine to coarse commarginal ornament, well-developed and regular at the umbones, initially gradually increasing in strength and more strongly so towards the ventral margin. At some distance from the umbones the ribs start to fade, in most species disappearing altogether and in a few species becoming less conspicuous and more irregular. Type-species is *Laevastarte fusca* (Poli, 1791) s.l. (Recent, Mediterranean).

***Laevastarte* species from the North Sea Basin**

Family Astartidae d'Orbigny, 1814
Genus *Laevastarte* Hinsch, 1952

***Laevastarte omalii omalii* (De la Jonkaire, 1823)**
Figures 8-9, 48

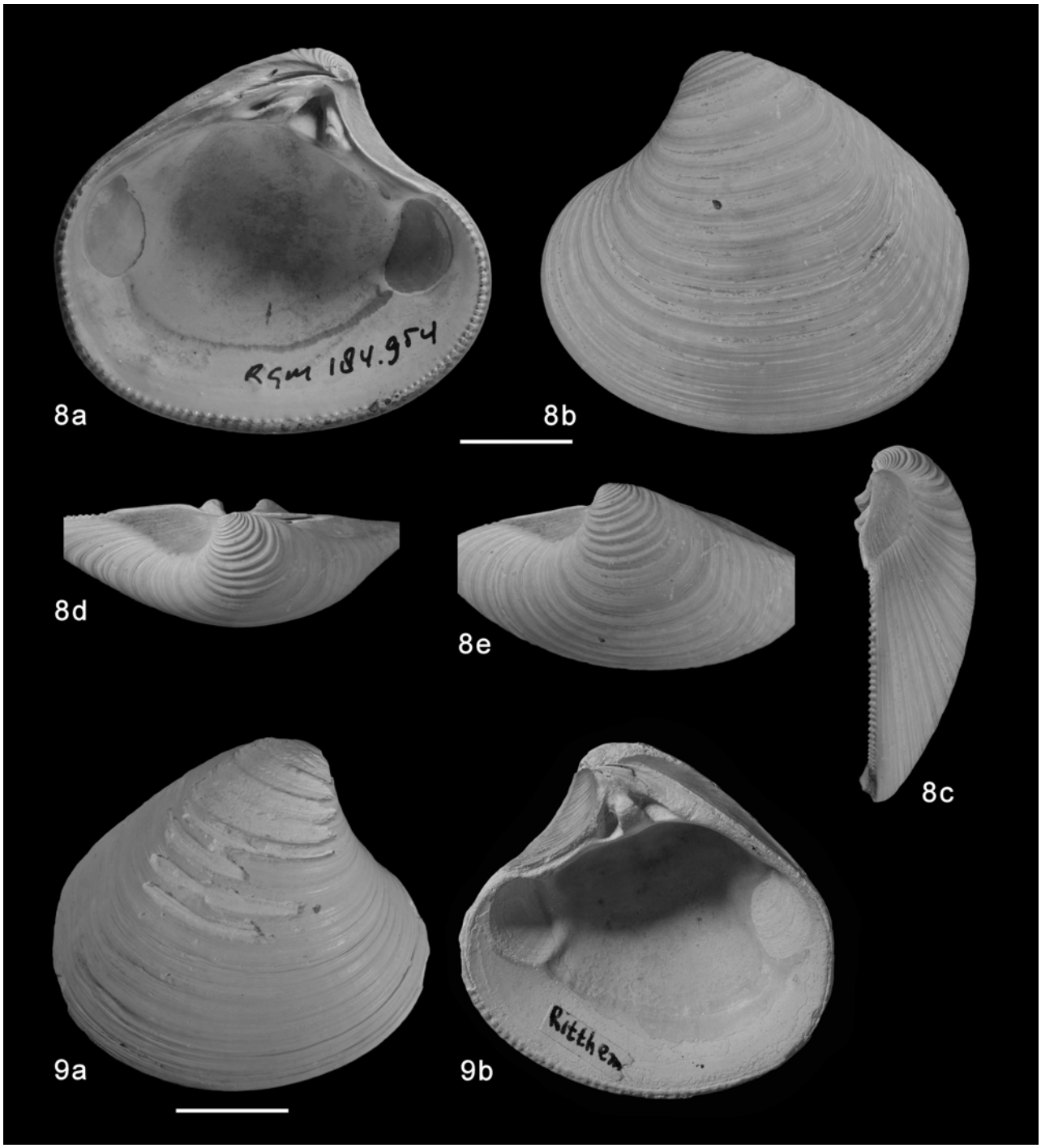


Figure 8. *Laevastarte omalii omalii* (De la Jonkaire, 1823). Neotype of *Astarte omalii* De la Jonkaire, 1823. Antwerpen (Ekeren) (province of Antwerpen, Belgium), construction pit for connection of 5th dock with Amerikadock (quay nr. 319); Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, Upper shell bed. RGM 184 954. Scale bar = 1 cm.

Figure 9. *Laevastarte omalii omalii* (De la Jonkaire, 1823). Ritthem (province of Zeeland, the Netherlands), beach near Fort Rammekens, washed ashore. (RGM 485 247, ex coll. F.J. Janssen). Scale bar = 1 cm.

*1823 *Astarte Omalii* De la Jonkaire, p. 129, pl. 6, fig. 1a-c.
1853 *Astarte Omalii*, Delajonkaire – Wood, p. 180 (*non* pl. 17, fig. 1a-e; non pl.17, fig. 1f?).
1878 *Astarte Omaliusi*, Laj. – Nyst, pl. 21, fig. 4a-c (*non* fig. 4d?).
1881 *Astarte Omaliusi*, Lajonk. – Nyst, p. 193.
1957 *Astarte (Isocrassina) omalii* Jonkaire, 1823 – Glibert, p. 2. (*non* pl. 2, fig. 2a, b, d).
1974b *Astarte (Isocrassina) omalii omalii* De la Jonkaire, 1823 – Janssen & Van der Slik, p. 52, pl. 36, fig. 92a-c.
2005 *Isocrassina omalii* (de la Jonkaire, 1823) – Marquet, p. 30, pl. 15, fig. 2.

Material examined – **Antwerp** (province of Antwerp, Belgium), construction pit for 4th dock (quay nr. 271), Pliocene, Zanclean, Kattendijk Formation, Kattendijk

Sand Member: 1/1 (RGM 184 960), many valves (RGM 577663); **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, upper shell bed: 1/2 (RGM 184 952), 1/2 left valve (RGM 184 954, designated neotype, see below), 1/2 (RGM 184 955), many valves (RGM 577 662), 14/2 (RGM 577 664); **Antwerp** (province of Antwerp, Belgium), construction pit for tunnel below B1-B2 canal dock, 21.00-21.80 m below surface, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 3/2 (RGM 577 658, ex coll. D. van der Mark); **Antwerp (Oorderen)** (province of Antwerp, Belgium), Pont du port pétrolier, F15/5, 9.60-9.75 m below surface, Pliocene, Zanclean, Kattendijk Formation, "Sables à Isocardia cor": 1/1 (IRSNB IST 4813).
Province of Zeeland, The Netherlands: **Borssele, De Kaloot**, washed ashore: 2/2 (RGM 485 248, ex coll. L. van der Slik), 1/2 (RGM 577 661, ex coll. P. Kaas & A.N.Ch. ten Broek); **Domburg-Westkapelle**, washed ashore: 3/2 (RGM 485 250, ex coll. D. van der Mark), 1/2 (RGM 485 256), 1/2 (RGM 485 257, ex coll. A.W. Lacourt), 1/2 (RGM 485 271, ex coll. M.I. Gerhardt), 18/2 (RGM 485 276, ex coll. M.I. Gerhardt), 2/2 (RGM 485 279, ex coll. J. Janse), 1/2 (RGM 485 280, ex coll. M. van den Bosch), 1/2 (RGM 485 284, ex coll. Filiaal), 1/2 (RGM 485 288, ex coll. Filiaal), 28/2 (RGM 577 655, ex coll. J. de Visser); **North Sea, Sluisse Hompels**, "black level", dredged: 2/2 (RGM 485 262); **Ritthem, beach near Fort Rammekens**, washed ashore: 1/2 (RGM 485 247, ex coll. F.J. Janssen); **Terneuzen**, construction pit new sea sluice, shellbed on bottom of pit, 20-24 m below suface, Holocene basal crag with reworked Pliocene shells: 1/2 (RGM 113 072), 2/2 (RGM 113 576), 1/2 (RGM 485 232), 2/2 (RGM 485 243); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 75 148), 1/2 (RGM 77 441), 1/2 (RGM 82 600), 3/2 (RGM 97 790), 3/2 (RGM 114 827), 2/2 (RGM 126 982), 1/2 (RGM 184 936, ex coll. F.J. Janssen), 1/2 (RGM 485 249), 4/2 (RGM 485 251, ex coll. L. van der Slik), 1/2 juv. (RGM 485 252, ex coll. F.J. Janssen), 1/2 (RGM 485 253, ex coll. G.J. van der Velde), 1/2 (RGM 485 254, ex coll. D. van der Mark), 1/2 (RGM 485 259, ex coll. P. Kaas & A.N.Ch. ten Broek), 10/2 (RGM 485 260, ex coll. Filiaal), 1/2 (RGM 485 261), 1/2 (RGM 485 264, ex coll. D. van der Mark), 5/2 (RGM 485 266, ex coll. D. van der Mark), 1/2 juv. (RGM 485 267), 1/2 (RGM 485 268, ex coll. L. van der Slik), 1/2 (RGM 485 270, ex coll. L. van der Slik), 1/2 juv. (RGM 485 272, ex coll. L. van der Slik), 6/2 (RGM 485 273), many valves (RGM 485 274, ex coll. NITG/Vreede), many valves (RGM 485 275, ex coll. Filiaal), 9/2 (RGM 485 277, ex coll. NITG/Vreede), 10/2 (RGM 485 278), 1/2 (RGM 485 281, ex coll. L. van der Slik), 2/2 (RGM 485 282, ex coll. P. Kaas & A.N.Ch. ten Broek), 12/2 (RGM 485 285, ex coll. Filiaal), 3/2 (RGM 485 286, ex coll. D. van der Mark), 4/2 (RGM 485 287, ex coll. Filiaal), 2/2 (RGM 485 346, ex coll. NITG/Vreede), 1/2 (RGM 485 348, ex coll. Filiaal), 1/2 (RGM 485 349, ex coll. Filiaal), 1/2 (RGM 577 656, ex coll. D. van der Mark), 3/2 (RGM 577 657, ex coll. NITG/Vreede), 1/2 (RGM 577 659), 3/2 (RGM 577 660, ex coll. L. van der Slik); **Westerschelde, near Nieuwesluis,** dredged: 4/2 (RGM 113 574), 1/2 (RGM 113 912).

Dimensions – Up to about 38 mm long and 34 mm high.

Description – Large species with considerable variation in convexity and outline. Usually broad-oval but sometimes high-trigonal and then about as long as high. Juvenile shells of 5 mm high are just a bit longer than high. Shells up to about 10 mm high have a more or less rectangular outline, caused by a prominent bend in the ribs.
The prominent umbo is lying well in front of the midline. It is slightly pointed, strongly prosogyrate and clearly turned inwards: seen from the inside a considerable part of the outer umbonal surface is visible.
The lunule is very deep and wide, slightly heart-shaped, about 3 times longer than wide, with its greatest width close to the umbo. The escutcheon is clearly delimited, 6-8 times longer than wide and 1½-2 times longer than the lunule.
The ornament on the first 1½-2 mm of the umbo consists of commarginal ribs which rapidly evolve from fine to rather coarse. The interspaces are as wide as or slightly narrower than the ribs. In this initial stage the ribs follow a regular oval shape because the transition to the posterior area is not or hardly marked. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases very rapidly. The interspaces become 1-1½ times as wide as the ribs themselves. Here the transition to the posterior area is marked by a slightly angular bend of the ribs. The ribs are fading slowly between 10-15 mm from the umbo. On the posterior area this already occurs at 6 mm from the umbo. The remainder of the shell is nearly smooth, often just covered by hardly elevated commarginal undulations superimposed by weak irregular commarginal lines. Many specimens additionally display some irregular ribs on this part of the shell.
In the left valve near the lunule the margin of the shell follows a more or less straight line along the anterior cardinal tooth. Only near the top end of the tooth the shell margin bends over it, covering just a small part of the tooth. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
The margin of the shell bordering the lunule is a wide ridge which widens slightly to its base on the inner shell wall. The imaginary line, drawn along the shell margin bordering the lunule near the cardinal tooth, crosses the anterior muscle scar mostly at considerable distance behind the middle of the scar but sometimes near the middle. The ventral margin of adult specimens is usually crenulated. Many specimens from the Dutch beaches and tidal channels have a corroded surface.

Discussion – This species can be recognized by the large, convex shell with prominent, strongly prosogyrate and clearly inwards turned umbo, a deep and wide lunule and strong ribs with wide interspaces. In *Laevastarte omalii scaldensis* the shell margin covers a large part of

the anterior cardinal tooth in the left valve. The margin along the lunule is very narrow and has narrow base. Usually, shells of *L. omalii scaldensis* are a bit more elongated and more inflated and ribs are developed up to the ventral margin of the shell, although becoming irregular.
In the material from the Dutch beaches and estuaries specimens of *L. omalii omalii* that have their exterior covered with ribs up to the ventral margin are quite common. Despite their ornament, which is comparable with that of *L. omalii scaldensis* (only a bit weaker) they are considered to belong to *L. omalii omalii* by the presence of a wide ridge along the lunule, a non-covered cardinal tooth and the same general outline.
Laevastarte basteroti is distinguished from *L. omalii omalii* by a combination of several characteristics. The ribs on the umbo are about as strong or a little weaker, but their interspaces are much narrower than the ribs and the width of ribs and interspaces increases much more gradually (Figure 48). The lunule of *L. basteroti* is less deep and wide, and the imaginary line, drawn along the shell margin bordering the lunule near the cardinal tooth, crosses the anterior muscle scar mostly at considerable distance in front of the middle of the scar but sometimes near the middle.
Glibert (1957) discussed *Astarte (Isocrassina) omalii*, but examination of his illustrated specimens showed that only one of them actually belongs to *Laevastarte omalii omalii* (fig. 2c, IRSNB IST 4813). The other three specimens belong to other species: *L. bipartita* (fig. 2a, 2d) and an unidentifiable species (fig. 2b). The illustrated specimens of Wood (1853) belong to *L. bipartita* and its varieties.
Lauriat-Rage (1982) mentioned *Astarte (Astarte) omalii omalii* from the Redonian of the localities Gourbesville and Le Bosq d'Aubigny (Pliocene and Early Pleistocene, Western France). According to this author the French specimens have a non-inwards turned umbo, which is also clearly visible on the illustrations (Lauriat-Rage, 1982: pl. 2, fig. 5; pl. 3, figs 1-6; pl. 4, figs 1-8). The shells are wedge-formed and in many specimens the ornament is visible all the way down to the ventral margin. These characteristics are quite different from *L. omalii omalii* of the North Sea Basin. The French specimens obviously belong to another species.

Neotype designation – No syntypes of *Astarte omalii* de la Jonkaire, 1823 could be traced in the collections of the museums in Brussels (IRSNB) and Paris (MNHN) (pers. comm. R. Marquet and D. Merle, respectively). Because of the existing confusion it is considered necessary to designate a neotype. I herewith designate a left valve, with registration number RGM 184 954 as neotype of *Astarte omalii* de la Jonkaire, 1823 (Figure 8).

Neotype locality – Antwerp (Ekeren) (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, upper shell bed. This closely resembles the locality "Anvers; partie inférieure du calcaire grossier" mentioned by de la Jonkaire (cited incorrectly by Marquet (2005) as "partie supérieure"). Usually, the "Calcaire grossier" is used for a part of the Lutetian (Eocene of the Paris Basin) but de la Jonkaire most likely used it for the lower part of the Pliocene near Antwerp *viz.* the Kattendijk Formation.

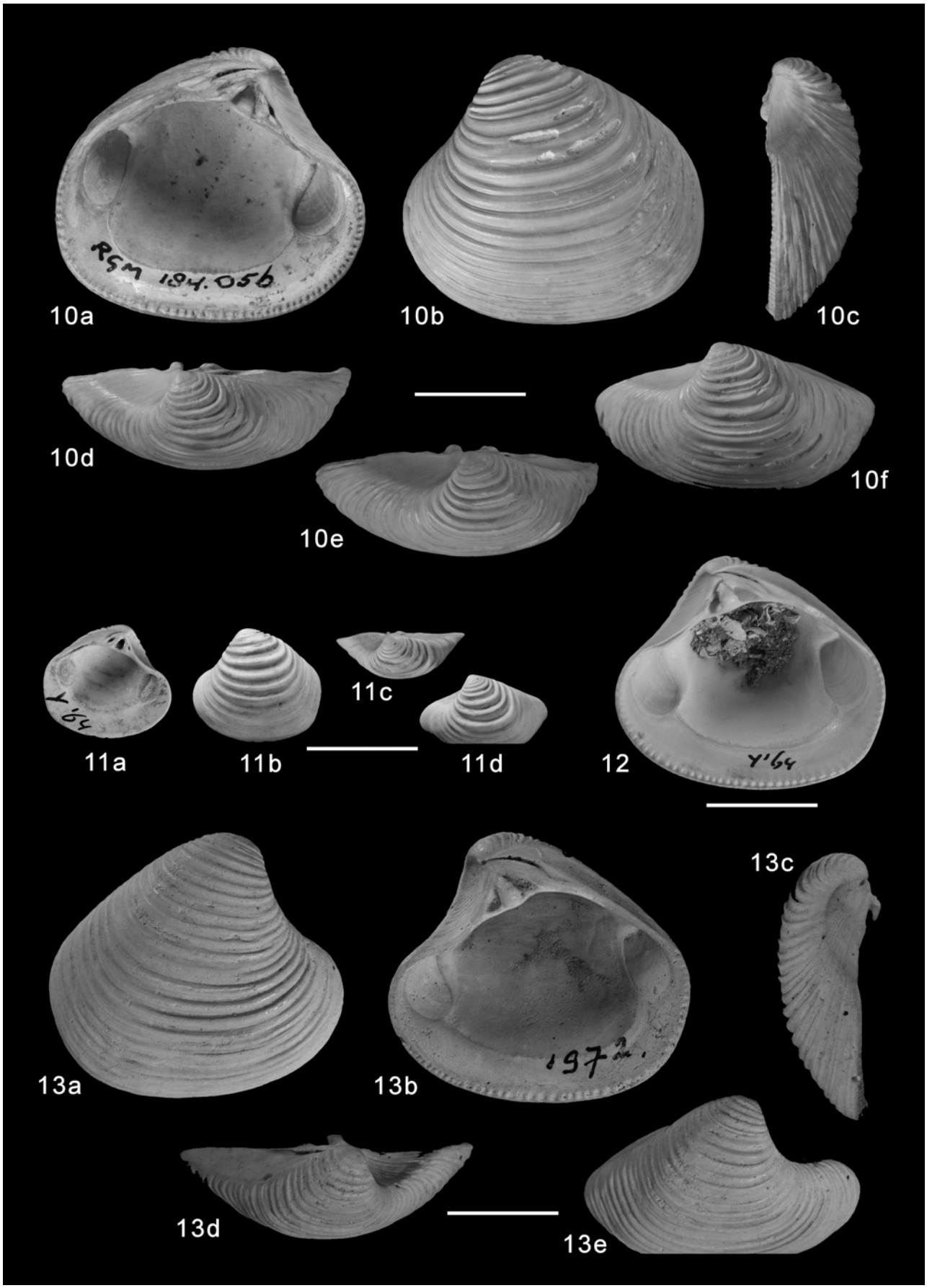
Occurrence – *Laevastarte omalii omalii* is endemic in the North Sea Basin. Its stratigraphic distribution within the North Sea Basin is best known from the large excavations near Antwerp, where it occurs *in situ* in the Kattendijk Sand Member (Pliocene, Zanclean, Kattendijk Formation) and the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation). Reworked specimens are known from the basal crag of the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation) in the same area and (as reworked specimens) from the Holocene basal crag in the construction pit of the sluice at Terneuzen. It is also recorded *in situ* from the Coralline Crag Formation of East Anglia. Reworked specimens are found at many localities around the Westerschelde estuary, as specified above. The largest numbers have been sucker-dredged from the tidal channel near Ellewoutsdijk.

***Laevastarte omalii scaldensis* (Janssen & Van der Slik, 1974)**
Figures 10-13, 48

*1974a *Astarte (Isocrassina) omalii scaldensis* Janssen & Van der Slik, p. 7, pl. 3, figs 1-2.
1974b *Astarte (Isocrassina) omalii scaldensis* Janssen & Van der Slik, 1974 – Janssen & Van der Slik, p. 53, pl. 37, fig. 93.

Material examined – Province of Zeeland, The Netherlands: **Borssele, De Kaloot**, washed ashore: 1/2 (RGM 485 293, ex coll. M.I. Gerhardt); **Domburg-Westkapelle**, washed ashore: 2/2 (RGM 485 294, ex coll. M.I. Gerhardt), 1/2 (RGM 485 298, ex coll. M.J. de Graag), 1/2 (RGM 485 310, ex coll. D. van der Mark); **Ritthem, beach near Fort Rammekens**, washed ashore: 1/2 juv. (RGM 485 296, ex coll NITG/Vreede); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 184 055 holotype, ex coll. F.J. Janssen), ½ (RGM 184 056 paratype, ex coll. F.J. Janssen), 17/2 (RGM 184 060 paratype, ex coll. F.J. Janssen), 1/2 (RGM 184 061 paratype, ex coll. M. van den Bosch), 1/2

Figure 10. *Laevastarte omalii scaldensis* (Janssen & Van der Slik, 1974). Paratype. Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 184 056, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figures 11, 12. *Laevastarte omalii scaldensis* (Janssen & Van der Slik, 1974). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 485 311, ex coll. D. van der Mark. Scale bar = 1 cm.
Figure 13. *Laevastarte omalii scaldensis* (Janssen & Van der Slik, 1974). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 485 309, ex coll. A.S. Timmermans. Scale bar = 1 cm.


RSM 194.056
10a
10b
10c
10d
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10f
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13a
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13d
13e

Figure 10-13.

(RGM 485 220), many valves (RGM 485 289, ex coll. NITG/Vreede), many valves (RGM 485 290), 7/2 (RGM 485 291, ex coll. L. van der Slik), 3/2 (RGM 485 292, ex coll. L. van der Slik), 12/2 (RGM 485 295, ex coll. Filiaal), 10/2 (RGM 485 297), 7/2 (RGM 485 299, ex coll. Filiaal), 1/2 (RGM 485 300, ex coll. G.J. van der Velde), 1/2 juv. (RGM 485 301, ex coll. P. Kaas & A.N.Ch. ten Broek), 1/2 juv. (RGM 485 302, ex coll. D. van der Mark), 4/2 (RGM 485 303, ex coll. NITG/Vreede), 1/2 (RGM 485 304, ex coll. L. van der Slik), 3/2 (RGM 485 305, ex coll. A.W. Lacourt), 3/2 (RGM 485 306), 3/2 (RGM 485 307, ex coll. Filiaal), 3/2 juv. (RGM 485 308, ex coll. F.J. Janssen), 1/2 (RGM 485 309, ex coll. A.S. Timmermans), 1/2 & 1/2 juv. (RGM 485 311, ex coll. D. van der Mark), 1/2 (RGM 485 312, ex coll. D. van der Mark), many valves (RGM 485 313, ex coll. Filiaal), 1/2 (RGM 485 347, ex coll. G.J. van der Velde), 4/2 juv. (RGM 577 674, ex coll. D. van der Mark); **Westerschelde, near Nieuwesluis**, dredged: 1/2 (RGM 485 227).

Dimensions – Up to 30 mm long and 27 mm high.

Description – Medium-sized, convex shell with a widely oval outline. Most juvenile shells of 5 mm high are up to 1½ times longer than high but some specimens are only slightly longer than high. Shells up to a height of *c*. 10 mm have a more or less rectangular outline, caused by a prominent curve in the ribs. The ventral margin is sometimes partly straight.
The umbo is prominent and situated well in front of the midline. It is slightly pointed, strongly prosogyrate and clearly turned inwards. Seen from the inside a considerable part of the outer umbonal surface is visible.
The lunule is very deep and wide, slightly heart-shaped, about 3 times longer than wide, with its greatest width close to the umbo. The escutcheon is clearly delimited, 7-10 times longer than wide and 1½-2 times longer than the lunule.
The initial 1½-2 mm of the umbo are covered with commarginal ribs which rapidly develop from fine to rather coarse. The interspaces are as wide as or somewhat narrower than the ribs themselves. In this initial stage the ribs follow a regular oval shape because the transition to the posterior area is not or hardly marked. Between 2 and up to 10 mm from the umbo the width of ribs and interspaces increases very rapidly. The interspaces become 1-1½ times as wide as the ribs. Here, the transition to the posterior area is marked by a slightly angular bend of the ribs. The width of many ribs decreases on the posterior area but they remain visible.
In adult specimens ribs are present up to the ventral margin of the shell, but their width, height and relative position change to more and more irregular. The ribs are fading on the posterior area but usually are remaining faintly visible.
In the left valve near the lunule the margin of the shell follows a straight line over the anterior cardinal tooth, covering a large part of it. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
The margin of the shell bordering the lunule is a narrow ridge with a hardly or not widened base. The ventral margin of adult specimens usually is crenulated. Specimens from the Dutch beaches and tidal channels usually have a distinct light brown colour and a glossy, hardly corroded surface.

Discussion – Typically, *Laevastarte omalii omalii* is a bit less elongated and less inflated than *L. omalii scaldensis*. In the reworked Dutch material specimens of that subspecies are more corroded, and lack the glossy surface of many specimens of *L. omalii scaldensis*. The shell margin bordering the lunule in *L. omalii omalii* is not very narrow and it has a broad base. Furthermore, the nominal species has less well-developed commarginal ribs on the ventral part of the shell, which often is nearly smooth. Its shell margin in the left valve runs along the anterior cardinal tooth, covering only a small part of it. For differences with other species see *L. omalii omalii*.
Some reworked Dutch specimens of *L. omalii* cannot with certainty be assigned to one of the subspecies. They contain ornament present up to the ventral margin (although often less clear than in *L. omalii scaldensis*) but lack a narrow ridge-like margin along the lunule. These usually are poorly preserved specimens, but as far as preservation allows it can be seen that other characteristics also show considerable variation.

Occurrence – *Laevastarte omalii scaldensis* is a North Sea Basin endemic, hitherto exclusively known from reworked specimens. At first sight the *in situ* collected specimen illustrated by Glibert (1957, pl. 2, fig. 2c) shows resemblance with the present subspecies. However, examination of the actual specimen made clear that it belongs to *L. omalii omalii*. Reworked specimens are found at many localities around the Westerschelde estuary, as specified above. The largest numbers have been sucker-dredged from the tidal channel near Ellewoutsdijk.

***Laevastarte basteroti* (De la Jonkaire, 1823)**
Figures 14-15, 48

*1823	*Astarte Basterotii*	De la Jonkaire, p. 129, pl. 6, fig. 3a-c.
1853	*Astarte Basterotii*,	Lajonkaire – Wood, p. 177, pl. 17, fig. 2a-b (*non* fig 2c-d?)
1878	*Astarte Basteroti*,	Laj. – Nyst, pl. 21, fig. 3a-c, f (*non* fig 3d-e?).
1881	*Astarte Basteroti*,	Lajonk. – Nyst, p. 194.
1957	*Astarte (Isocrassina) basteroti*	Jonkaire, 1823 – Glibert, p. 4.
1974b	*Astarte (Isocrassina) fusca basteroti*	De la Jonkaire, 1823 – Janssen & Van der Slik, p. 54, pl. 38, fig. 96.
2005	*Isocrassina basteroti*	(de la Jonkaire, 1823) – Marquet, p. 29, pl. 14, fig. 2.

Material examined – **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Plio-

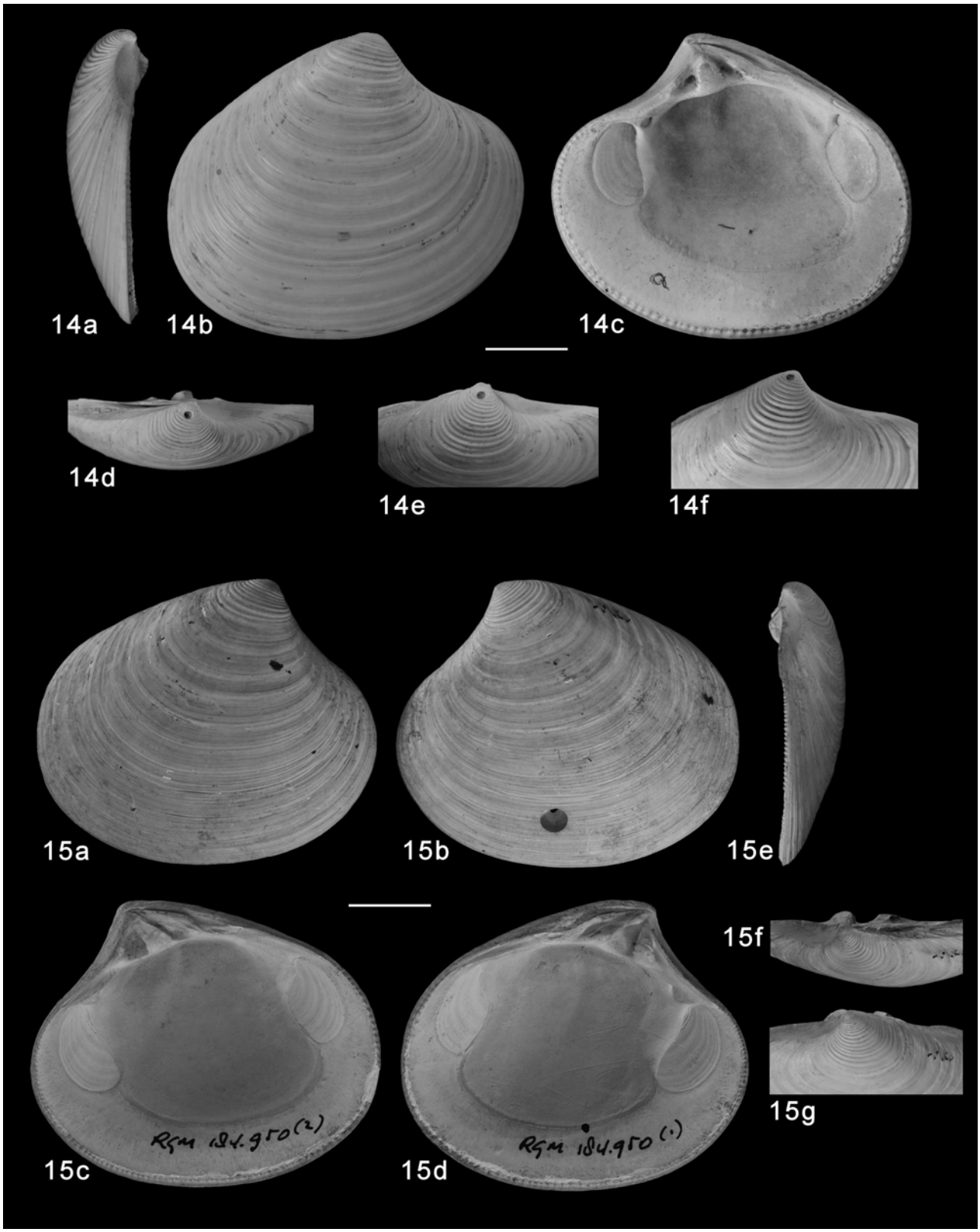

Figure 14. *Laevastarte basteroti* (De la Jonkaire, 1823). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 551, ex coll. L. van der Slik. Scale bar = 1 cm.

Figure 15. *Laevastarte basteroti* (De la Jonkaire, 1823). Neotype of *Astarte basterotii* De la Jonkaire, 1823. Antwerpen (Ekeren) (province of Antwerpen, Belgium), construction pit for connection of 5th dock with Amerikadock (quay nr. 319); Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, Upper shell bed. RGM 184 950. Scale bar = 1 cm.

cene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, upper shell bed: 1/1 (RGM 184 950, designated neotype, see below), 1/1 & 5/2 (RGM 577 550); **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Piacenzian, Lillo Formation, Oorderen Sand Member: 9/2 (RGM 577 696); **Lillo** (province of Antwerp, Belgium), tunnel underneath docks, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 12/2 (RGM 114 677).

Province of Zeeland, The Netherlands: **St. Jansteen**, borehole N, layer 7, 7.80-8.60 m below surface: 4/2 def. & 3 fragments (RGM 577 549, ex coll. NITG/RGD); **Borssele, De Kaloot**, washed ashore: 8/2 & 12/2 juv. (RGM 485 269, ex coll. M.I. Gerhardt), 3/2 juv. (RGM 485 333, ex coll. F.J. Janssen), 3/2 (RGM 577 666, ex coll. P. Kaas & A.N.Ch. ten Broek), 1/2 (RGM 577 667), 2/2 (RGM 577 679, ex coll. M.I. Gerhardt), 24/2 juv. (RGM 577 680, ex coll. Filiaal); **Cadzand**, washed ashore: 2/2 (RGM 114 829, ex coll. C.J. Verhey); **Domburg-Westkapelle**, washed ashore: 1/2 def. (RGM 485 258, ex coll. Filiaal), 1/2 (RGM 485 315, ex coll. D. van der Mark), 3/2 def. (RGM 485 318, ex coll. Filiaal), 3/2 (RGM 485 319, ex coll. J. Janse), 2/2 & 4/2 juv. (RGM 485 329, ex coll. D. van der Mark), 1/2 (RGM 485 337, ex coll. M. Jonkergouw-Nieuwenhuis), 1/2 juv. (RGM 485 338, ex coll. D. van der Mark), 7/2 juv. (RGM 485 339, ex coll. Filiaal), many valves (RGM 577 546, ex coll. J. de Visser), 4/2 (RGM 577 665, ex coll. Filiaal), 1/2 (RGM 577 678, ex coll. A.W. Lacourt), 1/2 (RGM 577 682, ex coll. M.I. Gerhardt), 14/2 (RGM 577 685, ex coll. M.I. Gerhardt), 3/2 juv. (RGM 577 688, ex coll. Filiaal), 11/2 (RGM 577 689, ex coll. L. van der Slik), 1/2 juv. (RGM 577 690), 1/2 (RGM 577 691), 2/2 (RGM 577 692, ex coll. Filiaal); **North Sea, Sluisse Hompels**, dredged: 2/2 (RGM 577 670); **Ritthem, beach near Fort Rammekens**, washed ashore: 1/2 juv. (RGM 485 316, ex coll. NITG/Vreede), 2/2 & 16/2 juv. (RGM 485 330, ex coll. NITG/Vreede), 1/2 juv. (RGM 485 341, ex coll. Filiaal), 9/2 juv. (RGM 577 676, ex coll. Filiaal); **Terneuzen**, construction pit new sea sluice, shellbed on bottom of pit, 20-24 below surface, Holocene basal crag with reworked Pliocene shells: 2/2 (RGM 113 073), 1/2 (RGM 113 075), 7/2 (RGM 113 575), 6/2 (RGM 113 578); **Westerschelde, intertidal shoal in front of Braakman**, washed ashore: 1/2 (RGM 577 681, ex coll. Filiaal); **Westerschelde, near Ellewoutsdij**k, sucker-dredged: 2/2 (RGM 75 146), 3/2 (RGM 82 601), 5/2 (RGM 97 791), 1/2 juv. (RGM 114 826), 1/2 (RGM 114 828), 4/2 (RGM 125 991), 1/1 (RGM 485 255, ex coll. F.J. Janssen), 1/2 (RGM 485 263, ex coll. Instituut v. Mijnbouwkunde T.H. Delft), 1/2 (RGM 485 314, ex coll. L. van der Slik), 2/2 juv. (RGM 485 317, ex coll. D. van der Mark), 12/2 (RGM 485 320, ex coll. F.J. Janssen), 1/2 juv. (RGM 485 321, ex coll. L. van der Slik), 1/2 (RGM 485 322), 4/2 juv. (RGM 485 323), 3/2 & 6/2 juv. (RGM 485 325, ex coll. M. van den Bosch), 1/2 (RGM 485 326, ex coll. F.J. Janssen), 2/2 (RGM 485 327, ex coll. L. van der Slik), 2/2 (RGM 485 328, ex coll. L. Van der Slik), 4/2 (RGM 485 331, ex coll. G.J. van der Velde), 1/2 juv. (RGM 485 332, ex coll. L. van der Slik), 3/2 & 5/2 juv. (RGM 485 334, ex coll. L. van der Slik), 2/2 (RGM 485 335), 1/2 juv. (RGM 485 336, ex coll. L. van der Slik), 2/2 (RGM 485 340, ex coll. G.J. van der Velde), 2/2 (RGM 485 342, ex coll. Filiaal), 1/2 (RGM 485 352, ex coll. F.J. Janssen), 4/2 (RGM 577 545, ex coll. F.J. Janssen), many valves (RGM 577 547, ex coll. NITG/Vreede), 1/2 (RGM 577 551, ex coll. L. van der Slik), 3/2 juv. (RGM 577 552, ex coll. NITG/Vreede), 1/2 juv. (RGM 577 553, ex coll. L. van der Slik), 1/2 (RGM 577 668, ex coll. L. van der Slik), 1/2 (RGM 577 669, ex coll. Filiaal), 1/2 (RGM 577 671), 8/2 (RGM 577 672, ex coll. P. Kaas & A.N.Ch. ten Broek), 2/2 (RGM 577 673, ex coll. L. van der Slik), 9/2 (RGM 577 677, ex coll. P. Kaas & A.N.Ch. ten Broek), 5/2 (RGM 577 683, ex coll. D. van der Mark), 4/2 (RGM 577 684, ex coll. Instituut v. Mijnbouwkunde T.H. Delft), 1/2 (RGM 577 686, ex coll. D. van der Mark), 3/2 (RGM 577 687, ex coll. D. van der Mark); **Westerschelde, near Nieuwesluis,** dredged: 1/2 (RGM 112 891).

Dimensions – Up to about 46 mm long and 38 mm high.

Description – Large shell, widely oval in shape with a considerable variation in convexity. Juvenile shells of 5 mm high are slightly longer than high. Shells up to about 10 mm high have an oval-rectangular outline.

The umbo is situated well in front of the midline. It is slightly pointed, strongly prosogyrate and clearly turned inwards. Seen from the inside, a considerable part of the outer umbonal surface is visible, the part behind the umbo being much larger than that in front of it.

The lunule is quite shallow, elongated to wide lancet-shaped, 4-5 times longer than wide, reaching its greatest width about halfway its length. The lunule is wider and deeper in convex forms of this species. The escutcheon is clearly delimited. It is 8-10 times longer than wide and 1½-2 times longer than the lunule.

The initial 2 mm of the umbo is covered with fine commarginal ribs with much narrower interspaces. In this stage the ribs follow a regular oval shape because the transition to the posterior area is not or hardly marked. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases gradually. The interspaces become about as wide as the ribs. The transition to the posterior area is often but not always marked by a weak bend of the ribs. At 8-10 mm from the umbo the ribs on the middle part of the shell gradually start to fade. The ribs on the posterior area are fading at the same moment or a bit earlier. In adult specimens the youngest part of the shell is only covered with faint growth lines.

Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, at a right angle with the commissure.

Seen from within, looking at the shell in a right angle, the anterior shell outline between the umbo and the transition to the ventral margin is markedly concave. The maximum distance between this margin and an imaginary straight line from umbo to transition point is equal to or larger than the maximum depth of the lunule. The imaginary line, drawn along the shell margin bordering

the lunule near the cardinal tooth, crosses the anterior muscle scar mostly at considerable distance before the middle of the scar but sometimes near the middle.

Discussion – This species is recognized by its large, quite flat shell, the strongly prosogyrate and clearly inwards turned umbo, the quite shallow and elongated lunule and moderately strong commarginal ribs in the umbonal region, with interspaces which initially are much narrower than the ribs. *Laevastarte omalii* s.l. has a wider and generally deeper lunule. The ornamentation on the umbo is coarser with relative wider interspaces and its strength increases much more rapidly (Figure 48). Juvenile shells have a less oval, more rectangular outline. In *L. omalii* s.l. the imaginary line, drawn along the shell margin bordering the lunule near the cardinal tooth, crosses the anterior muscle scar mostly at considerable distance behind the middle of the scar and not in front of it. *Laevastarte ovatacostata* differs in having a generally less convex shell with a less inwards turned umbo. The commarginal ribs follow a regular oval shape and do not bend at the transition to the posterior area (Figure 48).

Neotype designation – Syntypes of *Astarte basterotii* de la Jonkaire, 1823, could not be traced in IRSNB or MNHN (pers. comm. R. Marquet and D. Merle, respectively). The species is very well illustrated by de la Jonkaire (1823), showing without doubt a species that has been identified and figured as such by many subsequent authors. Nevertheless, it has also frequently been confused and/or synonymised with other taxa. Furthermore, as it hitherto has never been separated from the here introduced *Laevastarte ovatacostata*, it is desirable to designate a neotype. I herewith designate the paired specimen RGM 184 950 as neotype of *Astarte basterotii* de la Jonkaire, 1823 (Figure 15).

Neotype locality – Antwerp (Ekeren) (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, upper shell bed. This closely resembles the locality mentioned by de la Jonkaire ("Anvers; partie inférieure du calcaire grossier"; see note on neotype locality of *Astarte omalii*).

Occurrence – Gladenkov *et al*. (1980) report this species from the Pliocene strata of Tjörnes (northern Iceland) but their illustrated specimens have a less elongated, more triangular form and possess pronounced ribs on the ventral part of the shell. They clearly belong to a different species, which implies that *Laevastarte basteroti* is only occurring in the North Sea Basin. The stratigraphic provenance is best known from the large excavations near Antwerp where it has been found *in situ*. It is rare in the Kattendijk Sand Member (Pliocene, Zanclean, Kattendijk Formation), common in the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation) and very common in the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation) (Marquet, 2005). *In situ* it is also recorded from the Coralline and Red Crag Formations of Great Britain. Reworked specimens are found at many localities around the Westerschelde estuary, as specified above. The largest numbers have been sucker-dredged from the tidal channel near Ellewoutsdijk.

***Laevastarte ovatacostata* n. sp.**
Figures 16-20, 48

(?)1853 *Astarte Basterotii*, Lajonkaire – Wood, pl. 17, fig. 2c-d.
(?)1878 *Astarte Basteroti*, Laj. – Nyst, pl. 21, fig. 3d-e.

Holotype – Adult left valve, RGM 577 504, leg. A.W. Janssen (Figure 16).

Type locality – **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member.

Derivatio nominis – From Latin: *ovatus* (adj.) – egg-shaped, oval, and *costa* (n) – rib; *costata* – ribbed. Named after the oval shape of the commarginal ribs on the juvenile shell.

Paratypes – From the type locality: 1 right valve (RGM 577 505); **Antwerp** (province of Antwerp, Belgium), construction pit for 4th dock (quay nr. 271), Pliocene, Piacenzian, Lillo Formation, Oorderen Sand Member: 2 left valves (RGM 577 697, ex coll. M. van den Bosch); **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Piacenzian, Lillo Formation, Oorderen Sand Member: 3 left & 3 right valves (RGM 577 695); **Doel** (province of Oost-Vlaanderen, Belgium), Deurgankdok construction works, outcrop in northern wall, section I (51°17'802" N, 4°15'708" E), Pliocene, Zanclean, Lillo formation, Luchtbal Sand Member, ca. 4.2 m above base of outcrop: 1 right valve (RGM 577 508, leg. F.P. Wesselingh); **Lillo** (province of Antwerp, Belgium), tunnel underneath docks, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 1 left valve (RGM 577 503, ex coll. D. van der Mark, 1965), 1 left & 2 right valves (IRSNB IST 7252, 7253 and 7254 respectively, ex RGM 114 677, leg. G. Kortenbout van der Sluijs, 1966).
Province of Zeeland, The Netherlands: **St. Jansteen**, borehole N, layer 7, 7.80-8.60 m below surface: 1 left valve (RGM 577 501, ex coll. NITG/RGD), 3 left & 1 right valves (RGM 577 502, ex coll. NITG/RGD); **Terneuzen**, construction pit new sea sluice, shell bed on bottom of pit, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 1 right valve (RGM 113 911, leg. G. Kortenbout van der Sluijs); **Vlissingen**, exact locality unknown: 1 left & 1 right valve (RGM 577 507, ex coll. NITG/RGD); **Westerschelde, near Ellewoutsdijk,** sucker-dredged: 5 left & 1 right valves (RGM 577 506, leg. M. van den Bosch), 7 left & 2 right valves (RGM 577 509, ex coll. F.J. Janssen), 1 left & 1 right valve (RGM 577 510, ex coll. L. van der Slik), 1

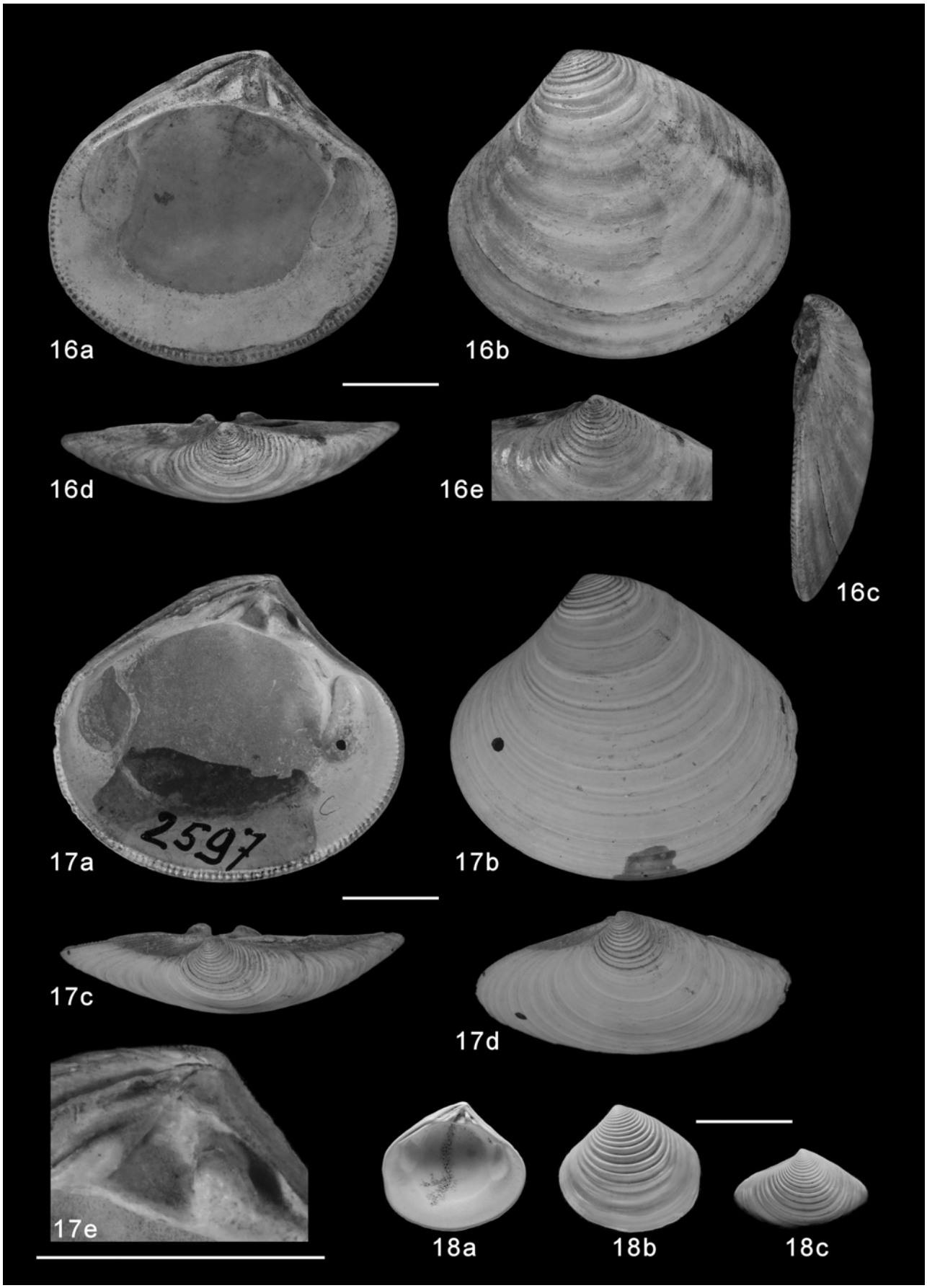

Figure 16-18.

right valve (RGM 577 554, ex coll. G. van der Velde), 1 right valve (RGM 577 555, ex coll. G. van der Velde), 1 left valve (RGM 577 556, ex coll. G. van der Velde; **Westerschelde**, suppleted sand in Sloe harbour area: 1 right valve (RGM 485 352, ex coll. F.J. Janssen).

Other material – Province of Zeeland, The Netherlands: **Borsele, De Kaloot**, washed ashore: 1 right valve (RGM 577 511, ex coll. J. Janse, 1933), 7 left & 6 right valves (RGM 577 639, ex coll. Filiaal), 1 left & 5 right valves (RGM 577 650, ex coll. M.I. Gerhardt); **Cadzand**, washed ashore: 1 left valve (RGM 108 541, ex coll. Bootsgezel), 1 left valve (RGM 485 240, leg. C.J. Verhey, 1966); **Domburg-Westkapelle**, washed ashore: 7 left & 3 right valves (RGM 577 518, ex coll. D. van der Mark, 1963-1964), 1 left valve (RGM 577 519, leg. A. Bloklander, P. Creuzberg & H. Odé, 1939, ex coll. Filiaal), 6 left valves (RGM 577 520, ex coll. M. Jonkergouw-Nieuwenhuis, 1969), 39 left & 36 right valves, many of them juvenile (RGM 577 557, ex coll. J. de Visser), 1 right valve (RGM 577 628, ex coll. P. Kaas & A.N.Ch. ten Broek), 1 left valve (RGM 577 632, ex coll. M.I. Gerhardt), 2 left & 1 right valve (RGM 577 635, ex coll. L. van der Slik), 5 left & 8 right valves (RGM 577 636, ex coll. Filiaal), 1 right valve (RGM 577 640, ex coll. A.W. Lacourt), 1 left valve fragment (RGM 577 641, leg. W.C. van Heurn), 4 left valves & 2 right valves frag. (RGM 577 642, ex coll. Filiaal), 18 left & 13 right valves, many of them juvenile (RGM 577 645, ex coll. M.I. Gerhardt), 1 left valve (RGM 577 646, leg. B. Hubert), 2 right valves, juv. (RGM 577 647, ex coll. L. van der Slik), 2 right valves, juv. (RGM 577 648, leg. W.C. van Heurn), 1 left valve, juv. (RGM 577 649, ex coll. Filiaal); **North Sea, Sluisse Hompels**, "black level", dredged: 3 left & 4 right valves (RGM 577 638, leg. A.C. Rijken); **Ritthem**, washed ashore: 1 right valve (RGM 577 521, ex coll. F.J. Janssen), 6 left & 1 right valves (RGM 577 522, ex coll. NITG/Vreede nr. 1958, 1962 & 3255), 2 left valves, juv. (RGM 577 559, ex coll. NITG/Vreede), 2 left & 3 right valves, juv. (RGM 577 630, ex coll. Filiaal); **Terneuzen**, construction pit new sea sluice, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 2 left valves (RGM 485 233, leg. G. Kortenbout van der Sluijs); **Walcheren**, washed ashore: 1 left & 1 right valve (RGM 577 644, leg. W.C. van Heurn); **Westerschelde, near Nieuwesluis**, dredged: 1 right valve (RGM 577 512, leg. J.P. Jacobs); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1 right valve (RGM 485 230, leg. G. Kortenbout van der Sluijs), 2 left valves (RGM 485 244, leg. M. Freudenthal), 5 left & 4 right valves (RGM 577 513, ex coll. NITG/Vreede nr. 2443), 1 left & 1 right valve (RGM 577 514, leg. J.A.W. Lucas et al., ex coll. Filiaal), 1 right valve (RGM 577 515, leg Th. Schmierer), 1 left & 2 right valves (RGM 577 516, ex coll. L. van der Slik), 1 right valve (RGM 577 517, ex coll. P. Kaas & A.N.Ch. ten Broek nr. 3470, leg. 1950-1951), 14 left & 13 right valves (RGM 577 558, ex coll. NITG/Vreede), 1 right valve (RGM 577 560, ex coll. L. van der Slik), 1 left & 1 right valve (RGM 577 561, ex coll. NITG/Vreede), 2 left & 1 right valve (RGM 577 625, ex coll. P. Kaas & A.N.Ch. ten Broek), 4 left & 3 right valves (RGM 577 626, ex coll. P. Kaas & A.N.Ch. ten Broek), 1 left & 1 right valve (RGM 577 627, ex coll. D. van der Mark), 1 left & 1 right valve (RGM 577 629, ex coll. A.S. Timmermans), 2 left valves (RGM 577 631, ex coll. L. van der Slik), 2 left valves (RGM 577 633, leg. P. Buurman), 1 left & 3 right valves (RGM 577 634, ex coll. D. van der Mark), 1 right valve (RGM 577 637, leg. A.P. Audretsch), 2 left valves (RGM 577 675, leg. A.P. Audretsch); **Westerschelde**, suppleted sand in Sloe harbour area: 1 right valve (RGM 577 643, ex coll. D. van der Mark).

Dimensions – RGM 577 504 (holotype, left valve): L 34.5 mm, H 31 mm, S 7.5 mm; RGM 577 503 (paratype, left valve): L 35 mm, H 33 mm, S 8 mm; RGM 577 507 (paratype, left valve): L 41.5 mm, H 36.5 mm, S 9 mm; RGM 577 505 (paratype, right valve): L 28 mm, H 25 mm, S 6.5 mm; RGM 485 352 (paratype, right valve): L 32 mm, H 26.5 mm, S 6 mm.

Diagnosis – Large, rather flat, sub-circular shell; umbo somewhat prosogyrate and only slightly turned inwards; umbonal part of exterior with regular commarginal ornament of oval ribs and initially much narrower interspaces; sculpture increasing gradually in strength and interspaces at last becoming as wide as the ribs.

Description – Large shell, sub-circular, slightly trigonal in shape. The shells are rather flat although more tumid specimens occur. Juvenile shells of 5 mm high are longer than high. Shells up to about 10 mm high have a regular oval outline. Adult shells are also oval but their posterior margin tends to be straight instead of regularly curved.
The umbo of adult specimens is situated well in front of the midline; in juvenile shells it has a nearly central position. It is slightly pointed, somewhat prosogyrate and slightly turned inwards. Seen from the inside only a very small part of the outer umbonal surface is visible, divided in two nearly equal parts behind and in front of the umbo (see Figure 17e).

Figure 16. *Laevastarte ovatacostata* n. sp. Holotype. Antwerpen (Ekeren) (province of Antwerpen, Belgium), construction pit for connection of 5th dock with Amerikadock (quay nr. 319), Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member. RGM 577 504, leg. A.W. Janssen. Scale bar = 1 cm.

Figure 17. *Laevastarte ovatacostata* n. sp. Paratype. St. Jansteen (province of Zeeland, the Netherlands), borehole N, layer 7, 7.80-8.60 mbs. RGM 577 501, ex coll. NITG/RGD. Scale bar = 1 cm.

Figure 18. *Laevastarte ovatacostata* n. sp. Paratype. Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 556, ex coll. G. van der Velde. Scale bar = 1 cm.

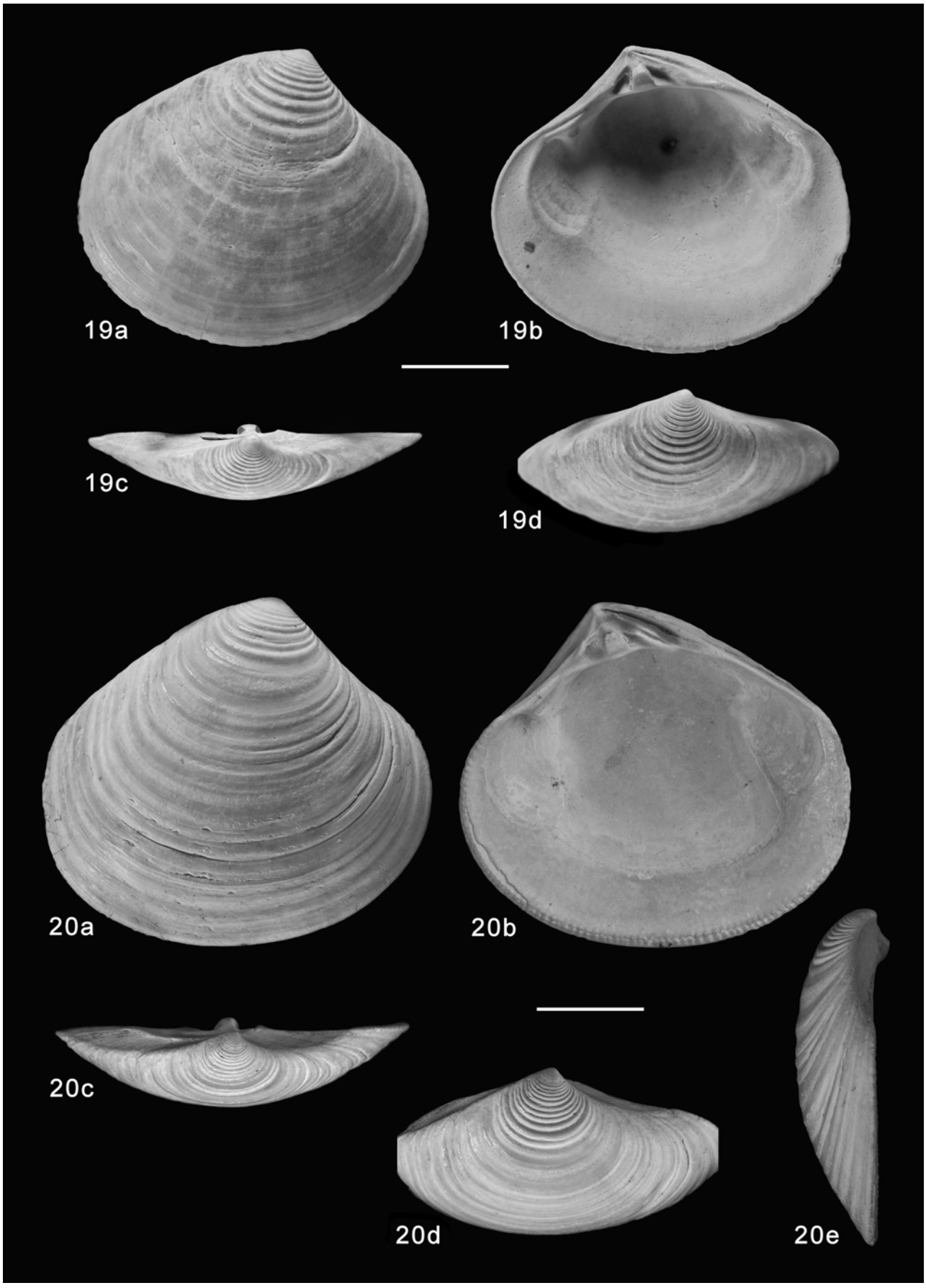

Figure 19-20.

The lunule is shallow, elongated to wide lancet-shaped, 5-6 times longer than wide. Its greatest width is reached about halfway its length. The escutcheon is clearly delimited. It is 7-8 times longer than wide and 1½-2 times longer than the lunule.
The first 2 mm of the umbo are covered with fine commarginal riblets separated by much narrower interspaces. In this initial stage the ribs follow a regular oval line. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases gradually. The interspaces become as wide as the ribs. At 8-10 mm from the umbo the ribs on the middle part of the shell suddenly start to fade. The ribs on the posterior area are fading at the same moment or somewhat earlier. Except for the last few, all ribs are almost equally strong over their entire length. In many specimens the posterior margin straightens at the same moment the ribs disappear (at about 10 mm from the umbo) and the transition to the ventral margin becomes angular. Up to this point the commarginal ribs are oval and strikingly equable. However, some specimens show a very weak, angular bend of the ribs which hardly disturbs their oval form. This may occur as early as 4mm from the umbo. In adult specimens the youngest part of the shell is only covered with faint growth lines.
In the left valve an indistinct anterior lateral tooth coincides with the margin of the lunule and there are two posterior lateral teeth, of which PII coincides with the shell margin. There are two cardinal teeth in the left valve, both about equally strong but their relative strength varies from specimen to specimen. The right valve contains two anterior laterals of which AI coincides with the margin of the lunule, and one posterial lateral tooth coinciding with the shell margin. This valve also has two cardinal teeth, the anterior one (3a) weak and lying close to the anterior edge near the lunule. The centrally placed cardinal 3b is high-trigonal and much stronger than the anterior cardinal. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
The margin of the shell bordering the lunule is a blunt edge which widens considerably to its base. Especially in the right valve this edge is very conspicuous with a strongly developed lateral tooth situated on it. Seen from within, looking at the shell in a right angle, the anterior shell outline between the umbo and the transition to the ventral margin is only slightly concave and often nearly straight. The maximum distance between this margin and an imaginative line from umbo to transition point is half of or less than the maximum depth of the lunule. Adult specimens normally have fine crenulations on the inside of the ventral margin; this feature can already be observed at specimens of 18 mm length.

Discussion – Laevastarte ovatacostata can be recognized by the sub-circular shell with regular oval ribs (not curved at the transition to the posterior area) and the just slightly inwards turned umbo. Its strongest resemblance is with *Laevastarte basteroti* which generally is more convex and always has a more strongly prosogyrate and more inwards turned umbo. In *L. basteroti* the visible part of the outside behind the umbo (seen from within) is much larger than that in front of the umbo (Figures. 14c & 15c). Its commarginal ornament is not regularly oval but normally displays a bend at the transition to the posterior area (Figure 48). Flat specimens of *Laevastarte bipartita* (forma *confusa*, see below) are distinguished by several characters. Their ornamentation is coarser and more angular (Figures 48 & 49). The umbo is not turned inwards at all or hardly so (Figure 29f), and in the juvenile stage it is located well in front of the midline. The shell margins near the umbo are sharp. *Laevastarte ariejansseni* initially has a quite similar ornament as *L. ovatacostata* but it is finer, it hardly increases in strength and the posterior part of many ribs is more weakly developed than the rest of the same rib (Figure 48). Besides this the shell is far more tumid and the hinge-area is relatively larger. It is assumed that the specimens illustrated by Wood (1853, pl. 17, fig. 2c-d) and Nyst (1878, pl. 21, fig. 3d-e) concern the present species, based on the slighty prosogyrate umbo, the shallow lunule and the overall outline.

Occurrence – Laevastarte ovatacostata is probably endemic to the North Sea Basin. *In situ* it occurs in the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation) and the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation), exposed in the large excavations in the harbour area of Antwerp. It is also present in the nearby borehole St. Jansteen (probably Pliocene). Reworked specimens are found at many localities around the Westerschelde estuary, as specified above. Large numbers have been sucker-dredged from the tidal channel near Ellewoutsdijk and the species is also common on the beach southwest of Domburg.

***Laevastarte bipartita* (Sowerby, 1826)**
Figures 21-22, 49

*1826	*Astarte bipartita*	Sowerby, p. 38, pl. 521, fig. 3.
1853	*Astarte Omalii*,	Delajonkaire – Wood, p. 180, pl. 17, fig. 1a-b.
1853	*Astarte Omalii*,	Delajonkaire var. *undulata* – Wood, pl. 17, fig. 1c (*non* Say 1824).
1853	*Astarte Omalii*,	Delajonkaire var. *bipartita* – Wood, p. 180, pl. 17, fig. 1d.
1853	*Astarte Omalii*,	Delajonkaire var. *acuminata* – Wood, pl. 17, fig. 1e.
1957	*Astarte (Isocrassina) omalii*	Jonkaire, 1823 – Glibert, p. 2, pl. 2, fig. 2a, d.

Figure 19. *Laevastarte ovatacostata* n. sp. Paratype. Westerschelde (province of Zeeland, the Netherlands), suppleted sand in Sloe harbour area. RGM 485 352, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figure 20. *Laevastarte ovatacostata* n. sp. Paratype. Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 555, ex coll. G. van der Velde. Scale bar = 1 cm.

1972 *Astarte omalii latecostata* nom. nov. – Spaink, p. 25, fig. 1.
1972 *Astarte omalii bipartita* Sowerby – Spaink, fig. 3.
1974b *Astarte (Isocrassina) omalii omalii* De la Jonkaire, 1823, forma *bipartita* Sowerby, 1826 – Janssen & Van der Slik, p. 53, pl. 36, fig. 92f-g.
1974b *Astarte (Isocrassina) omalii omalii* De la Jonkaire, 1823, forma *latecostata* Spaink, 1972 – Janssen & Van der Slik, p. 53, pl. 36, fig. 92h-k.
2005 *Isocrassina bipartita* (J. Sowerby, 1826) – Marquet, p. 31, pl. 16, fig. 1-2.

Remarks – There is some confusion concerning the authorship of this species. Janssen & Van der Slik (1974b) only mention "Sowerby" whereas Marquet (2005) gives "J. Sowerby" as the author. However, according to Cleevely (1974) the authorship has to be attributed to James de Carle Sowerby and not to his father James Sowerby. The latter died in 1822 and has written none of the descriptions published in volume 66 (November 1822) or later of the *Mineral Conchology*.

Material examined of the nominal form – **Antwerp** (province of Antwerp, Belgium), construction pit for tunnel below B1-B2 canal dock, 21.00-21.80 m below surface, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 1/2 (RGM 184 957, ex coll. D. van der Mark).
Province of Zeeland, The Netherlands: **Borssele, De Kaloot,** washed ashore: 1/2 (RGM 577 564, ex coll. J. Janse), 1/2 (RGM 577 568, ex coll. L. van der Slik); **Domburg-Westkapelle**, washed ashore: 11/2 (RGM 577 593, ex coll. J. de Visser); **Terneuzen**, construction pit new sea sluice, shellbed on bottom of pit, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 1/2 (RGM 485 242); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 485 222), 1/2 (RGM 577 563, ex coll. A.W. Lacourt), 6/2 (RGM 577 565, ex coll. Filiaal), 1/2 (RGM 577 566, ex coll. Filiaal), 3/2 (RGM 577 567, ex coll. G.J. van der Velde), 3/2 (RGM 577 569, ex coll. D. van der Mark), 2/2 (RGM 577 570, ex coll. L. van der Slik), 4/2 (RGM 577 571, ex coll. L. van der Slik), 4/2 (RGM 577 572, ex coll. F.J. Janssen), 4/2 (RGM 577 573, ex coll. NITG/Vreede), 1/2 (RGM 577 574, ex coll. D. van der Mark), 1/2 (RGM 577 575, ex coll. M.J. de Graag).

Dimensions – Up to 27 mm long and 26 mm high.

Description – The outer surface of the very convex and thick-walled, trigonal shell is nearly flat up to about 10 mm from the umbo. Further below the shell is distinctly convex, giving it a conspicuous bipartite form. Juvenile shells of 5 mm high are much longer than high. Shells up to about 10 mm high have an oval to oval-rectangular outline. Adult shells are as high as long.
The umbo is situated well in front of the midline. It is pointed, strongly prosogyrate and protruding but not or only very slightly turned inwards. This latter feature is clearly visible from the inside, from where the outer surface of the umbo is almost never visible. This results in sharp shell margins in the umbonal region, best seen from the inside. In this position shells show a nearly straight dorsal margin which after a distinct bend changes into the posterior margin. The position of this bend corresponds with the location of the bipartite transition on the outside of the shell, giving the shell a very typical, humpbacked appearance.
The lunule is deep, widely lancet-shaped, 3 times longer than wide and with its greatest width situated in the half nearest to the umbo. The escutcheon is clearly delimited, about 7 times longer than wide and 1½ times longer than the lunule.
The first 2 mm of the umbo are covered with coarse, rounded commarginal ribs. Initially, the interspaces are much narrower than the ribs themselves, but they increase rapidly in width, at a distance of 2 mm from the top becoming already as wide as the ribs. In this initial stage the ribs follow a regular long-drawn oval line because the transition to the posterior area is not or hardly marked. The ventral section of the ribs tends to be somewhat straight. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases very rapidly. The interspaces become 1½ times as wide as the ribs. The ribs follow a partly straight, long-drawn oval line, the transition to the posterior area is marked by a slightly angular curve. The ribs are fading in a highly variable way. Sometimes they disappear very suddenly at 10-15 mm from the umbo, leaving a nearly smooth surface on the younger part of the shell. In other specimens the ribs are fading more gradually, often remaining visible as irregular ridges and waves down to the ventral margin. On the posterior area the ribs are fading at the same moment or a bit earlier as on the middle part of the shell. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
Seen from within, looking at the shell in a right angle the anterior shell outline between the umbo and the transition to the ventral margin is always distinctly curved.

Discussion – This species and its three forms (see below) may easily be distinguished from other *Laevastarte* species, the most important characteristic being the very coarse and (except in *L. bipartita* f. *confusa*) rapidly increasing commarginal ornamentation in the umbonal region (Figure 49). Besides this the elongate shape of juvenile shells, the umbo which is not turned inwards (or hardly so) and the often sharp-edged margins near the umbo are important features. Most authors after Sowerby (1826) have interpreted this taxon as a subspecies or forma of *L. omalii*. Based mainly on stratigraphic data Marquet (2005) considered *L. bipartita* an independent species. The morphological differences here described strongly support his view.

Figure 21. *Laevastarte bipartita* (Sowerby, 1826). Borssele (province of Zeeland, the Netherlands), De Kaloot, washed ashore. RGM 577 564, ex coll. J. Janse. Scale bar = 1 cm.
Figure 22. *Laevastarte bipartita* (Sowerby, 1826). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 566, ex coll. Filiaal. Scale bar = 1 cm.

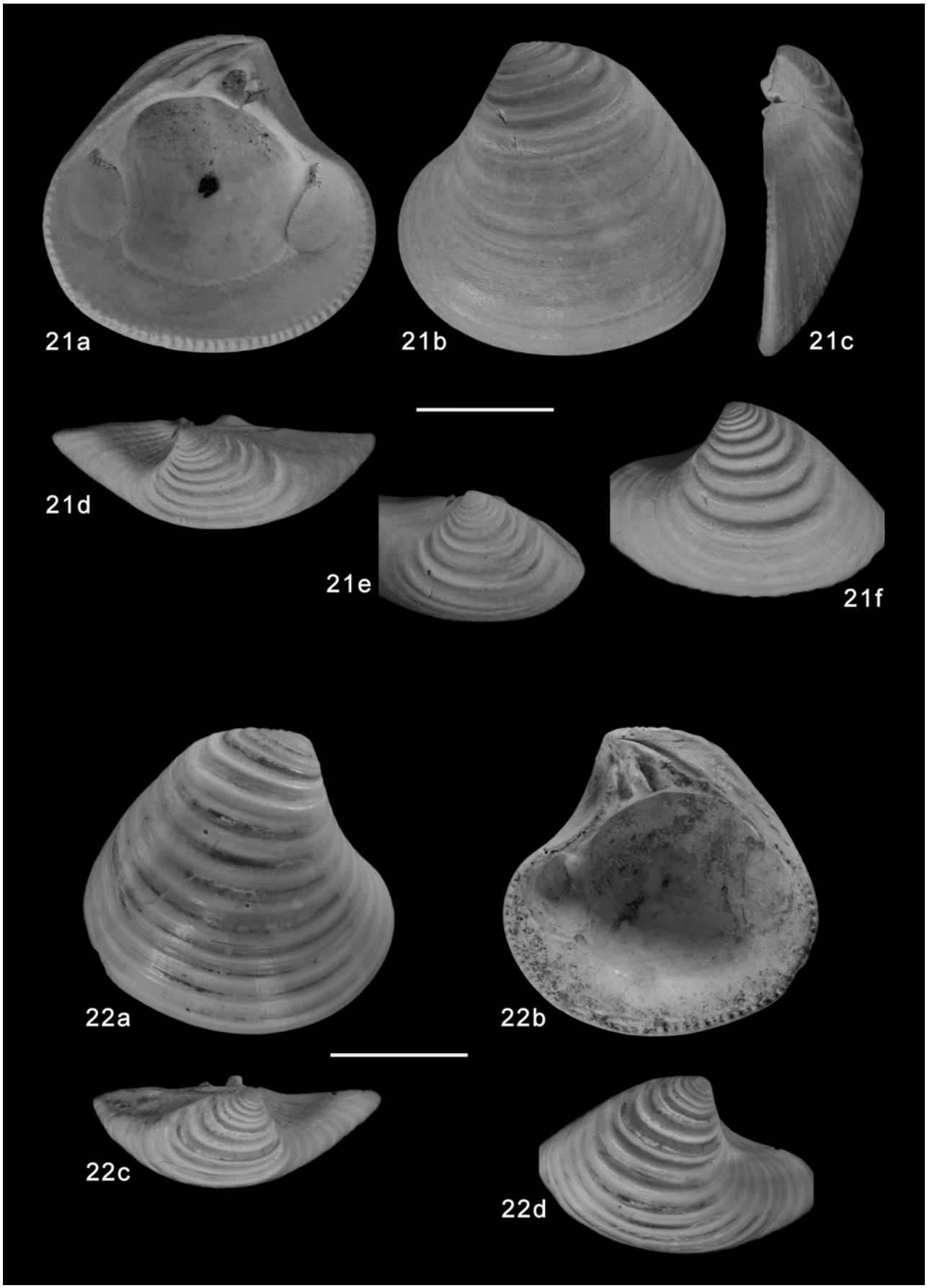

Figure 21-22.

Bipartite specimens (*L. bipartita* s.s.) can be recognized immediately. At first glance *L. mutabilis mutabilis* and *L. mutabilis altenai* look very similar but those species have a rectangular instead of a triangular shape and a more anteriorly situated umbo, which furthermore is stronger turned inwards in *L. mutabilis mutabilis*. Another distinguishing characteristic is the much wider area behind the nymph in both *L. mutabilis mutabilis* and *L. mutabilis altenai*.
Laevastarte bipartita is an extremely variable species. A few forms can be distinguished in the material, some of which were previously interpreted as variations or subspecies of *L. omalii*. As these forms are connected through intermediates with the typical form as described above, as well as with each other, all of them are here considered formae. Although not having a formal taxonomic status the various extreme forms are described and discussed below. This includes a hitherto non-recognized form, just to demonstrate the variability of *L. bipartita*. More research is needed to reveal the relationship and the stratigraphic and geographic range of the various forms of this species.

Occurrence – Marquet (2005) suggests that a specimen from le Bosq d'Aubigny (Normany, France) figured by Lauriat-Rage (1982, pl.4, fig. 8) could belong to this species. Although there is some resemblance, its ribs remain relatively weak, even at 15 mm from the umbo. This distinguishes this specimen from *Laevastarte bipartita* of the North Sea Basin. *Laevastarte bipartita* and its formae are probably endemic in the North Sea Basin. Its stratigraphic distribution is best known from the Antwerp area where it has been found *in situ* in the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation). Reworked specimens are known from the basal crag of the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation) of the same area (Marquet, 2005). *In situ* occurrences are also known from the Coralline Crag Formation in Great Britain (Wood, 1853). Reworked specimens are found at many localities around the Westerschelde estuary, as specified above. The largest numbers have been sucker-dredged from the tidal channel near Ellewoutsdijk.

Laevastarte bipartita forma ***latecostata*** **(Spaink, 1972)**
Figures 23-24, 49

Material examined – Province of Zeeland, The Netherlands. **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 184 938, ex coll. F.J. Janssen), 1/2 (RGM 577 594, ex coll. L. van der Slik), 1/2 (RGM 577 596, ex coll. M.J. de Graag).

Dimensions – RGM 184 938 (left valve): L 21 mm, H 20 mm, S 6 mm; RGM 577 594 (right valve): L 21 mm, H 17.5 mm, S 4 mm.

Discussion – The quite thin-walled, elongated shell tends to stay almost flat during growth, although bipartite shells do occur. Juvenile shells of 5 mm high are much longer than high and this ratio stays the same in adult specimens. Shells up to about 10 mm high have an oval to oval-rectangular outline. The umbo is lying slightly to clearly in front of the midline. It is pointed, somewhat protruding and moderately to strongly prosogyrate, and only slightly turned inwards. The shell margins in the umbonal region are not very sharp as in *Laevastarte bipartita* s.s. and a "humpback" is lacking, also in bipartite shells. The ornament initially is the same as in *L. bipartita* s.s. but it rapidly evolves into very strong, wave-like ribs which remain present all the way to the ventral margin. These elements are nearly straight in their central part, which is also reflected by the straight ventral margin. The interspaces become 1½-2 times as wide as the ribs. As a result of the thin shell traces of the ribs are visible on the inner surface. Seen from within, looking at the shell in a right angle the anterior shell outline between the umbo and the transition to the ventral margin is nearly straight or just slightly concave. Typical specimens of this form are very rare. The initially very similar ornamentation, the hardly inwards turned umbo and the occasional occurrence of bipartite shells link this form to *L. bipartita* s.s.

Laevastarte bipartita forma ***acuminata*** **(Wood, 1853)**
Figures 25-26, 49

Material examined – **Sudbourne** (Suffolk, Great Britain), Coralline Crag: 1/1 (IRSNB IST 4811); **Antwerp** (province of Antwerp, Belgium), "Bassin Van de Ver", Pliocene, Zanclean, Lillo formation, Luchtbal Sand Member, horizon with Pecten gerardi: 1/1 (IRSNB IST 4814).
Province of Zeeland, The Netherlands: **Borssele, De Kaloot,** washed ashore: 3/2 (RGM 485 350, ex coll. M.I. Gerhardt); **Domburg-Westkapelle**, washed ashore: (RGM 577 585, ex coll. J. de Visser); **Ritthem, beach near Fort Rammekens,** washed ashore: 1/2 juv. (RGM 577 587, ex coll. F.J. Janssen), 8/2 (RGM 577 589, ex coll. NITG/Vreede); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 577 577, ex coll. L. van der Slik), 3/2 (RGM 577 582, ex coll. L. Van der Slik), 2/2 (RGM 577 583, ex coll. M. van den Bosch), 2/2 juv. (RGM 577 586, ex coll. NITG/Vreede), 2/2 (RGM 577 588), 1/2 (RGM 577 590, ex coll. F.J. Janssen), 3/2 (RGM 577 591, ex coll. D. van der Mark), 1/2 (RGM 577 592, ex coll. NITG/Vreede); **Westerschelde, near Nieuwesluis**, dredged: 1/2 (RGM 113 577).

Dimensions – Up to 35 mm long and 34 mm high.

Discussion – The shells of this form are flat and solid, and adult specimens are almost as high as long, displaying a typical high trigonal outline. The umbo is situated slightly in front of the midline or almost in the middle. It is moderately to strongly prosogyrate and protruding, but not or very slightly turned inwards. The shell margins in the umbonal region are quite sharp and a "humpback" is lacking.

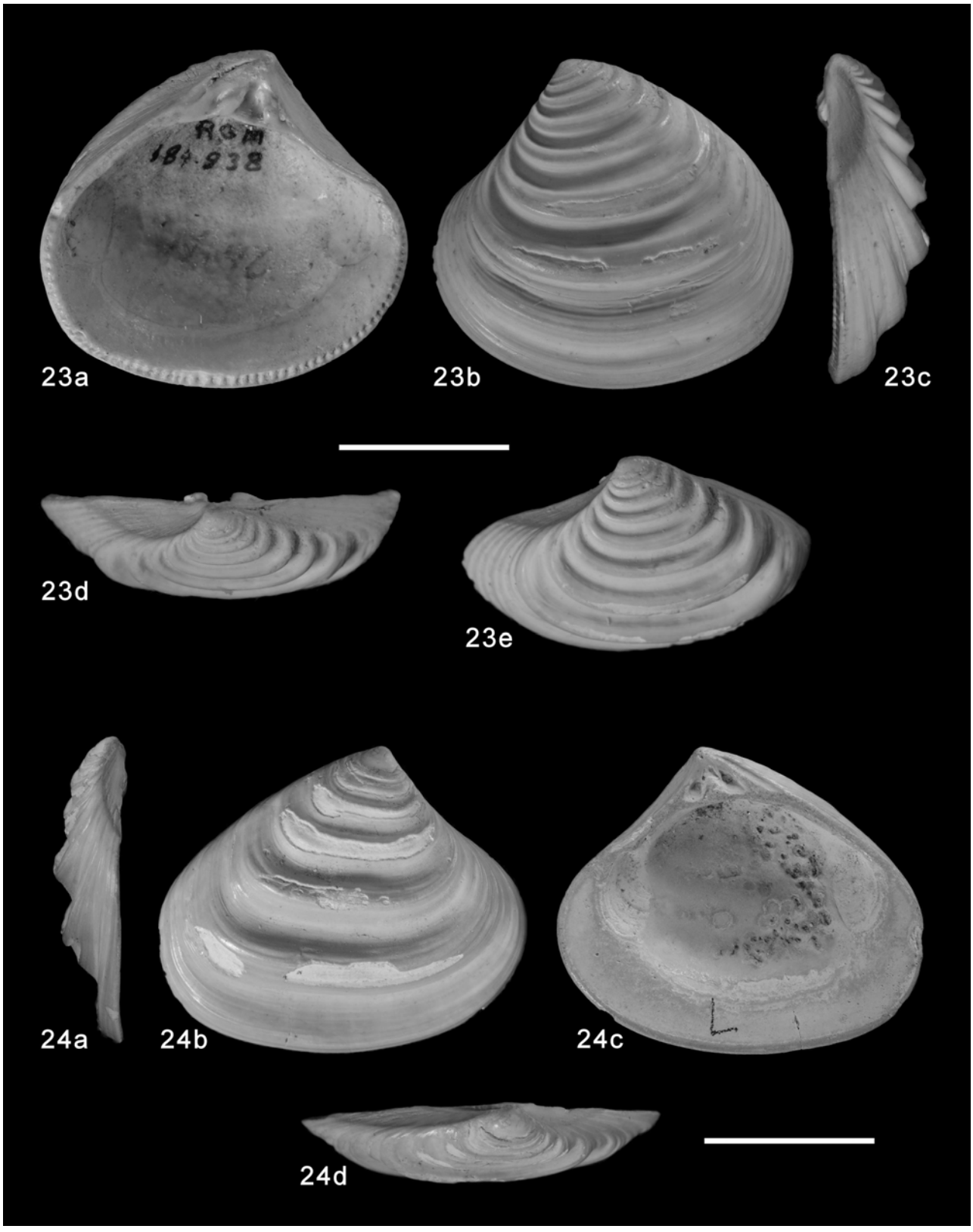

Figure 23. *Laevastarte bipartita forma latecostata* (Spaink, 1972). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 184 938, ex coll. F.J. Janssen. Scale bar = 1 cm.

Figure 24. *Laevastarte bipartita forma latecostata* (Spaink, 1972). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 594, ex coll. L. van der Slik. Scale bar = 1 cm.

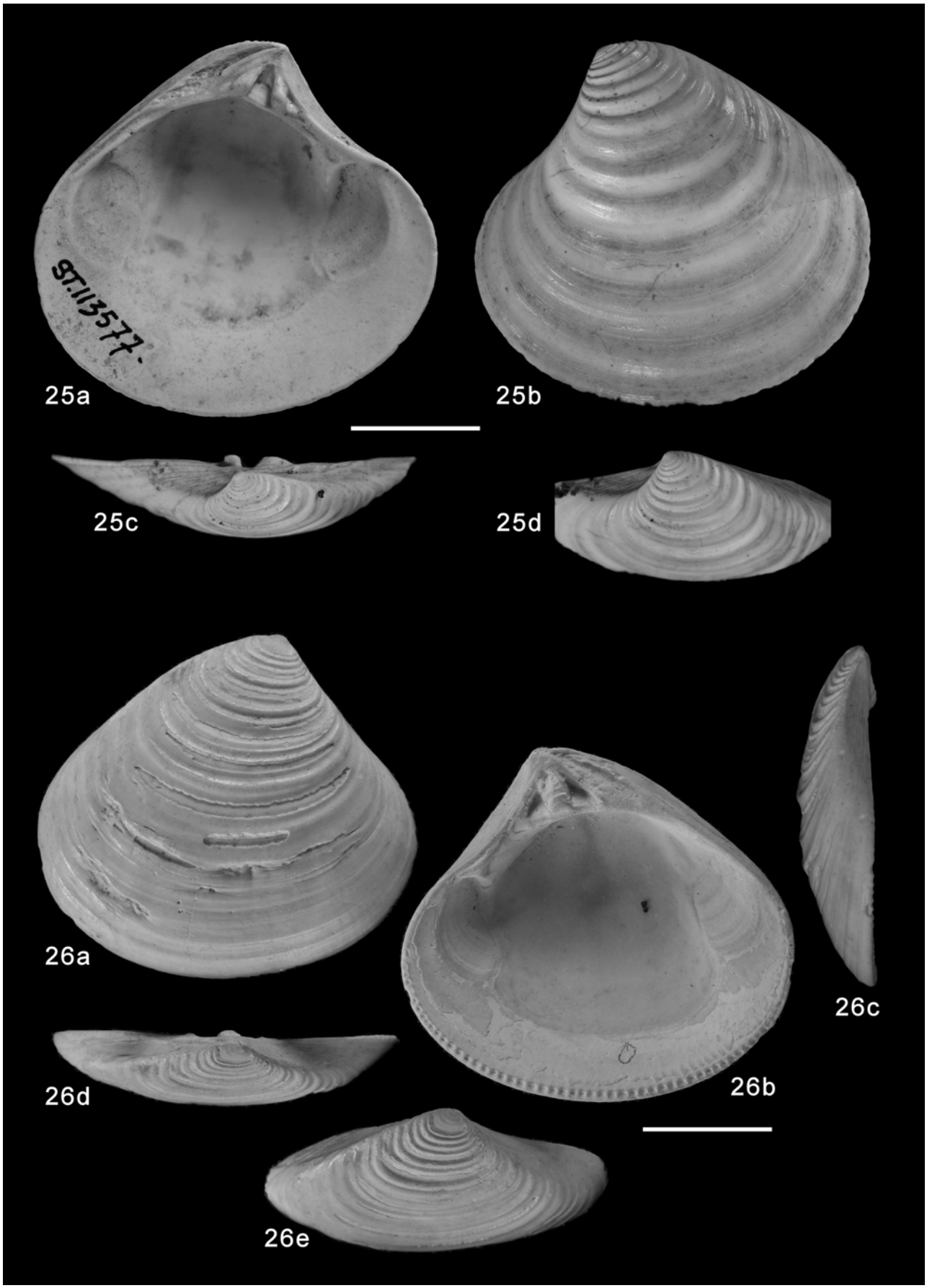

Figure 25-26.

The shell shows a gradual rise between the umbo and the point of maximum semidiameter and from there towards the ventral margin an even more gradual slope. The umbonal angle, measured on the outside and only the juvenile part taken in account, is 105-110°. The lunule is shallow, lancet-shaped, 4-5 times longer than wide, its greatest width situated in the middle or a bit closer to the umbo. The escutcheon is clearly delimited, 7-10 times longer than wide and 1½-2 times longer than the lunule.
The ornamentation is very similar to that of *Laevastarte bipartita* s.s., although its strength is often a bit less. Initially, the ventral section of the ribs is nearly straight but in many specimens the ribs soon follow a more curved line. The ribs rapidly increase in strength and may continue down to the ventral margin, becoming less elevated. Seen from within, looking at the shell in a right angle the anterior shell outline between the umbo and the transition to the ventral margin is nearly straight to moderately concave. Forma *acuminata* is linked to *L. bipartita* s.s. by its (at least initially) very similar ribs and the sharp-edged, hardly or not inwards turned umbo.
Marquet (2005. pl. 16, fig. 2) recorded forma *latecostata* from the Luchtbal Sand Member and the basal crag of the Oorderen Sand Member of the Belgian Pliocene. His illustrations, however, clearly represent forma *acuminata*. According to him, *L. bipartita* s.s. and forma *acuminata* (not forma *latecostata*) co-occur in these deposits and transitional forms do occur. Examination of the actual specimens illustrated by Glibert (1957, pl. 2, fig. 2a & 2d) as *Astarte (Isocrassina) omalii* (= *Laevastarte omalii* s.l.) showed that these also belong to the present species (forma *acuminata*).

Laevastarte bipartita forma ***confusa*** **new form**
Figures 27-29, 49

Derivatio nominis – From Latin: *confúsio* (n) – confusion, *confusus* (adj.) – confused. After the confusion encountered by the mixture of features of the shell, showing resemblance with both *L. bipartita* forma *acuminata* and *L. ovatacostata* n. sp.

Material examined – Province of Zeeland, The Netherlands: **Borssele, De Kaloot**, washed ashore: 1 left valve (RGM 485 351, ex coll. M.I. Gerhardt), 1 left valve (RGM 577 603, ex coll. F.J. Janssen), 8 left & 4 right valves (RGM 577 609, ex coll. M.I. Gerhardt); **Domburg-Westkapelle**, washed ashore: 3 left & 5 right valves (RGM 577 608, ex coll. J. de Visser); **Ritthem, beach near Fort Rammekens**, washed ashore: 1 left & 1 right valve (RGM 577 602, ex coll. NITG/Vreede), 2 left & 3 right valves (RGM 577 607, ex coll. F.J. Janssen); **Terneuzen**, construction pit new sea sluice, shell-bed on bottom of pit, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 2 right valves (RGM 485 229, leg. G. Kortenbout van der Sluijs, 1964), 1 left valve (RGM 485 234, leg. G. Kortenbout van der Sluijs, 1964); **Vlissingen**, "no borehole " on label: 1 right valve (RGM 577 584, ex coll. NITG/RGD), 1 left & 1 right valve (RGM 577 606, ex coll. NITG/RGD); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 2 left valves (RGM 77 438, leg. A.P. Audretsch), 1 left & 1 right valve (RGM 126 984, leg. G.J. van der Slikke), 1 left valve (RGM 485 246, leg. M. Freudenthal), 1 left valve (RGM 577 576, ex coll. L. van der Slik), 1 left & 1 right valve (RGM 577 597, ex coll. F.J. Janssen), 1 left & 1 right valve, juv. (RGM 577 599, ex coll. M. van den Bosch), 1 left valve (RGM 577 600, ex coll. F.J. Janssen), 1 left valve (RGM 577 601, leg. H. Apon), 6 left & 2 right valves (RGM 577 604, ex coll. NITG/Vreede), 3 left & 1 right valve (RGM 577 605, ex coll. F.J. Janssen); **Westerschelde**, suppleted sand in Sloe harbour area: 1 left valve (RGM 577 525, ex coll. F.J. Janssen), 1 left & 1 right valve (RGM 577 598, ex coll. D. van der Mark).

Dimensions – RGM 485 351 (left valve): L 39 mm, H 35 mm, S 8 mm; RGM 577 584 (right valve): L 36.5 mm, H 31 mm, S 7.5 mm; RGM 577 597 (left valve): L 31 mm, H 29 mm, S 7 mm.

Discussion – A typical specimen of this form is shown in Figure 27. This form has a quite large, convex and elongated-oval shell. The umbo of adult shells is situated slightly to distinctly in front of the midline whereas in juvenile shells it is always situated distinctly in front of it. The umbo is pointed, moderately protruding, moderately prosogyrate and hardly or not turned inwards (Figure 29f). The shell margins in the umbonal region are sharp, and a weak "humpback" is developed. The shell shows a steep rise from the umbo to the point of maximum semidiameter and from there a gentle slope towards the ventral margin. The umbonal angle, measured on the outside and only the juvenile part taken in account, is 115-120°. Initially the ornament closely resembles that of *Laevastarte bipartita* s.s., only being a bit weaker. The very well preserved specimen illustrated in Figure 29 demonstrates very fine riblets on the first millimetre, quickly increasing in strength in the next millimetres. Up to 2 mm from the top the central part of the ribs may be quite straight. Further from the umbo they follow a more gradually curved line. The width of ribs and interspaces increases gradually, the interspaces becoming about 1-1½ times as wide as the ribs. The ornament fades at 8-15 mm from the umbo and the remainder of the shell is nearly smooth.
This hitherto unrecognized form can be linked with *Laevastarte bipartita* forma *acuminata* and *L. bipartita* s.s. by intermediate specimens. However, typical specimens of forma *confusa* differ considerably from the other forms of *L. bipartita*.

Figure 25. *Laevastarte bipartita* forma *acuminata* (Wood, 1853). Westerschelde (province of Zeeland, the Netherlands), near Nieuwesluis, dredged. RGM 133 577. Scale bar = 1 cm.

Figure 26. *Laevastarte bipartita* forma *acuminata* (Wood, 1853), Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 577, ex coll. L. van der Slik. Scale bar = 1 cm.

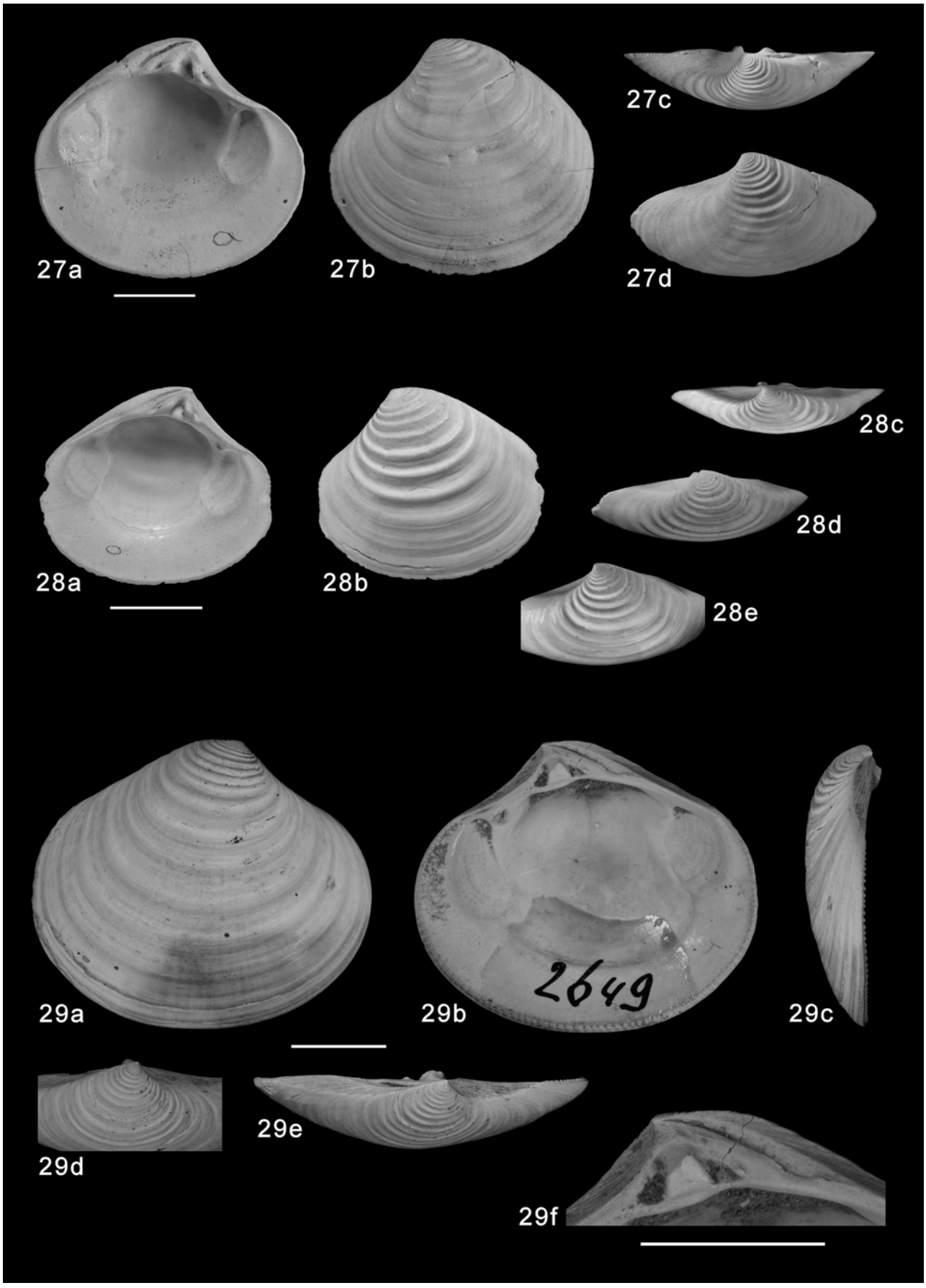

Figure 27-29.

In forma *acuminata* the maximum semidiameter is positioned about halfway between umbo and ventral margin, in forma *confusa* this point is situated much closer to the umbo, due to the steep rise of the shell wall immediately below the umbo. The umbonal angle (measured on the outside) of forma *acuminata* is smaller. The ornament is quite similar in the first 2 mm, but increasing much more rapidly in strength beyond that point in *L. bipartita* s.s, as well as in formae *acuminata* and *latecostata*.
Laevastarte bipartita forma *confusa* may be confused with *L. ovatacostata*. Specimens of the latter differ by their finer and more oval-shaped commarginal ribs. Their umbo is more turned inwards and in juvenile shells it is situated far more centrally. The shell margins near the umbo are not sharp.

Occurrence – Reworked specimens are known from various localities in the province of Zeeland, The Netherlands, as specified above.

***Laevastarte ariejansseni* (Marquet, 2005)**
Figures 30-35, 48

1974a *Astarte (Isocrassina) fusca* (Poli, 1791) subsp. A – Janssen & Van der Slik, p. 6, pl. 3, fig. 3.
1974b *Astarte (Isocrassina) fusca* (Poli, 1791) subsp. n. – Janssen & Van der Slik, p. 54, pl. 35, fig. 94 & pl. 37, fig. 95.
1974b *Astarte (Isocrassina) fusca incrassata* (Brocchi, 1814) – Janssen & Van der Slik, p. 54, pl. 35, fig. 94.
*2005 *Isocrassina fusca ariejansseni* Marquet, p. 32, pl. 17, fig. 1.

Material examined – **Antwerp (Ekeren)** (province of Antwerp, Belgium), construction pit for connection between 5th dock and Amerikadock at quay nr. 319, Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, upper shell bed: 1/2 (RGM 184 057), 1/2 (RGM 184 953), 2/1 & 9/2 (RGM 577 622), many valves (RGM 577 623); **Antwerp** (province of Antwerp, Belgium), construction pit for tunnel below B1-B2 canal dock, 21.00-21.80 m below surface, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 1/2 (RGM 577 544, ex coll. D. van der Mark); **Doel** (province of Oost-Vlaanderen, Belgium), Deurgankdok construction pit, outcrop in northern wall, section I (51°17'802" N, 4°15'708" E), c. 4.2 m above base of outcrop, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 4/2 & 1 fragment (RGM 577 527); **Doel** (province of Oost-Vlaanderen, Belgium), Deurgankdok construction pit, Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member: 1/1 (IRSNB IST 6695); **Doel** (province of Oost-Vlaanderen, Belgium), Deurgankdok construction pit, Pliocene, Zanclean, Lillo Formation, Luchtbal Sand Member: 1/2 (IRSNB IST 6698, holotype), 1/2 (IRSNB IST 6697, paratype), 1/2 (IRSNB IST 6696, paratype).
Province of Zeeland, The Netherlands. **Borssele, De Kaloot,** washed ashore: 1/2 (RGM 57 7651, ex coll. M.I. Gerhardt); **Cadzand**, washed ashore: 1/2 (RGM 485 239, ex coll. C.J. Verhey); **Domburg-Westkapelle**, washed ashore: 1/2 (RGM 577 653, ex coll. L. van der Slik); **Terneuzen**, construction pit new sea sluice, shell-bed on bottom of pit, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 2/2 (RGM 485 228), 2/2 (RGM 485 235), 1/2 (RGM 485 237); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 184 939, ex coll. F.J. Janssen), 1/2 (RGM 184 940, ex coll. F.J. Janssen), 1/2 (RGM 485 231), 1/2 (RGM 485 245), 1/2 (RGM 577 524, ex coll. NITG/Vreede), 14/2 (RGM 577 526, ex coll. Filiaal), 6/2 (RGM 577 528, ex coll. NITG/Vreede), 1/2 (RGM 577 529, ex coll. D. van der Mark), 7/2 (RGM 577 530), 6/2 (RGM 577 531, ex coll. F.J. Janssen), 1/2 (RGM 577 532, ex coll. F.J. Janssen), 1/2 (RGM 577 533, ex coll. F.J. Janssen), 2/2 (RGM 577 534, ex coll. L. van der Slik), 1/2 (RGM 577 535, ex coll. A.S. Timmermans), 1/2 (RGM 577 536), 1/2 (RGM 577 542, ex coll. Filiaal), 6/2 (RGM 577 543, ex coll. L. van der Slik), 3/2 (RGM 577 537, ex coll. G.J. van der Velde), 2/2 (RGM 577 538, ex coll. L. van der Slik), 6/2 (RGM 577 539, ex coll. L. van der Slik), 1/2 (RGM 577 540, ex coll. Filiaal), 1/2 (RGM 577 541, ex coll. Filiaal), 4/2 (RGM 577 624, ex coll. Filiaal), 2/2 (RGM 577 652, ex coll. D. van der Mark), 8/2 (RGM 577 654, ex coll. P. Kaas & A.N.Ch. ten Broek), 2/2 (RGM 577 715, ex coll. F.J. Janssen).

Figure 27. *Laevastarte bipartita* forma *confusa* new form. Westerschelde (province of Zeeland, the Netherlands), suppleted sand in Sloe harbour area. RGM 577 525, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figure 28. *Laevastarte bipartita* forma *confusa* new form. Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 576, ex coll. L. van der Slik. Scale bar = 1 cm.
Figure 29. *Laevastarte bipartita* forma *confusa* new form. Vlissingen (province of Zeeland, the Netherlands), "no borehole". RGM 577 584, ex coll. NITG/RGD. Scale bar = 1 cm.
Figure 30. *Laevastarte ariejansseni* (Marquet, 2005). Antwerpen (Ekeren) (province of Antwerpen, Belgium), construction pit for connection of 5th dock with Amerikadock (quay nr. 319); Pliocene, Zanclean, Kattendijk Formation, Kattendijk Sand Member, Upper shell bed. RGM 184 057. Scale bar = 1 cm.
Figure 31, 32. *Laevastarte ariejansseni* (Marquet, 2005). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 534, ex coll. L. van der Slik. Scale bar = 1 cm.
Figure 33. *Laevastarte ariejansseni* (Marquet, 2005). Cadzand (province of Zeeland, the Netherlands), washed ashore. RGM 485 239, ex coll. C.J. Verhey. Scale bar = 1 cm.
Figure 34. *Laevastarte ariejansseni* (Marquet, 2005). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 532, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figure 35. *Laevastarte ariejansseni* (Marquet, 2005). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 533, ex coll. F.J. Janssen. Scale bar = 1 cm.

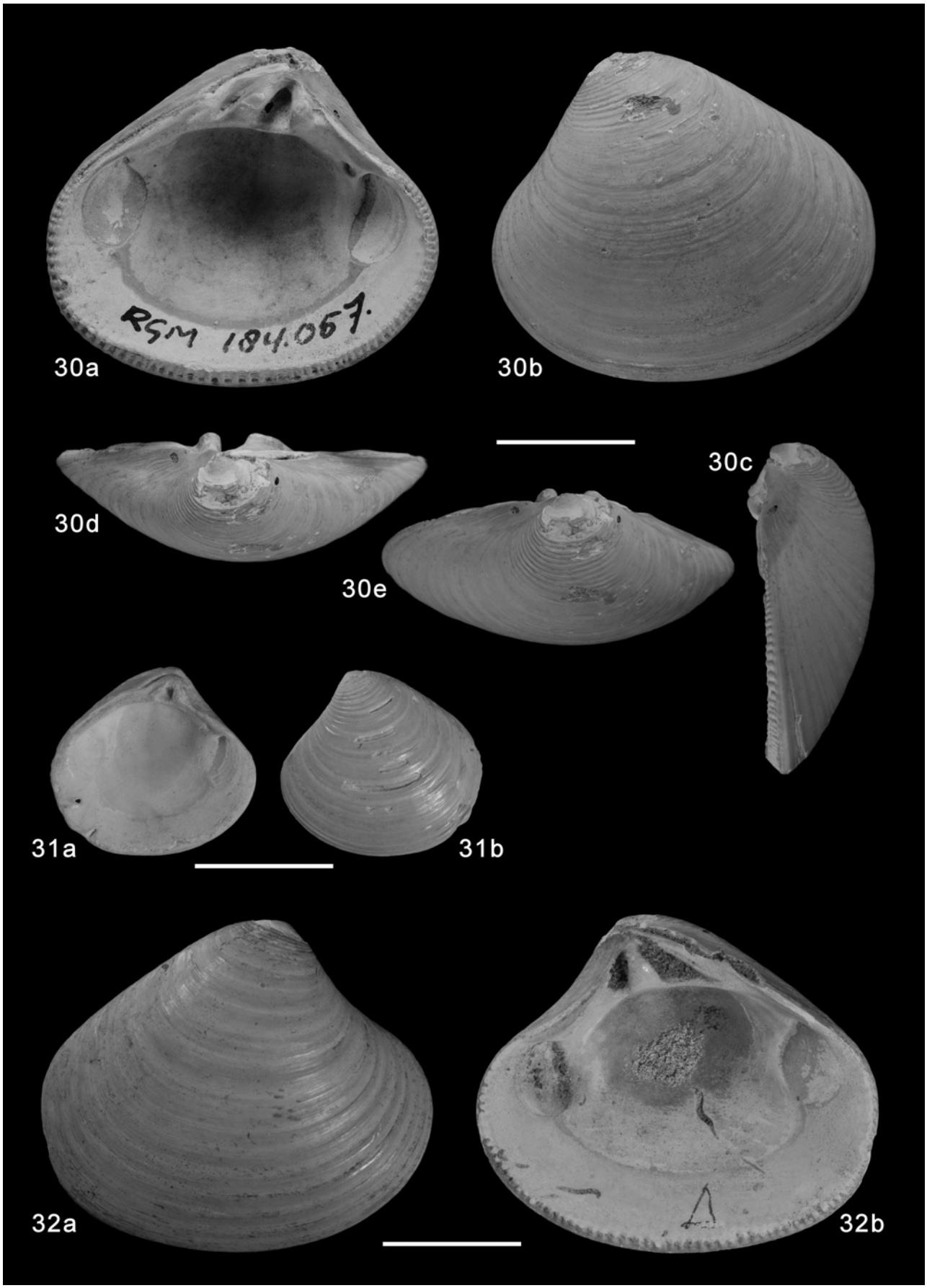

Figure 30-32.

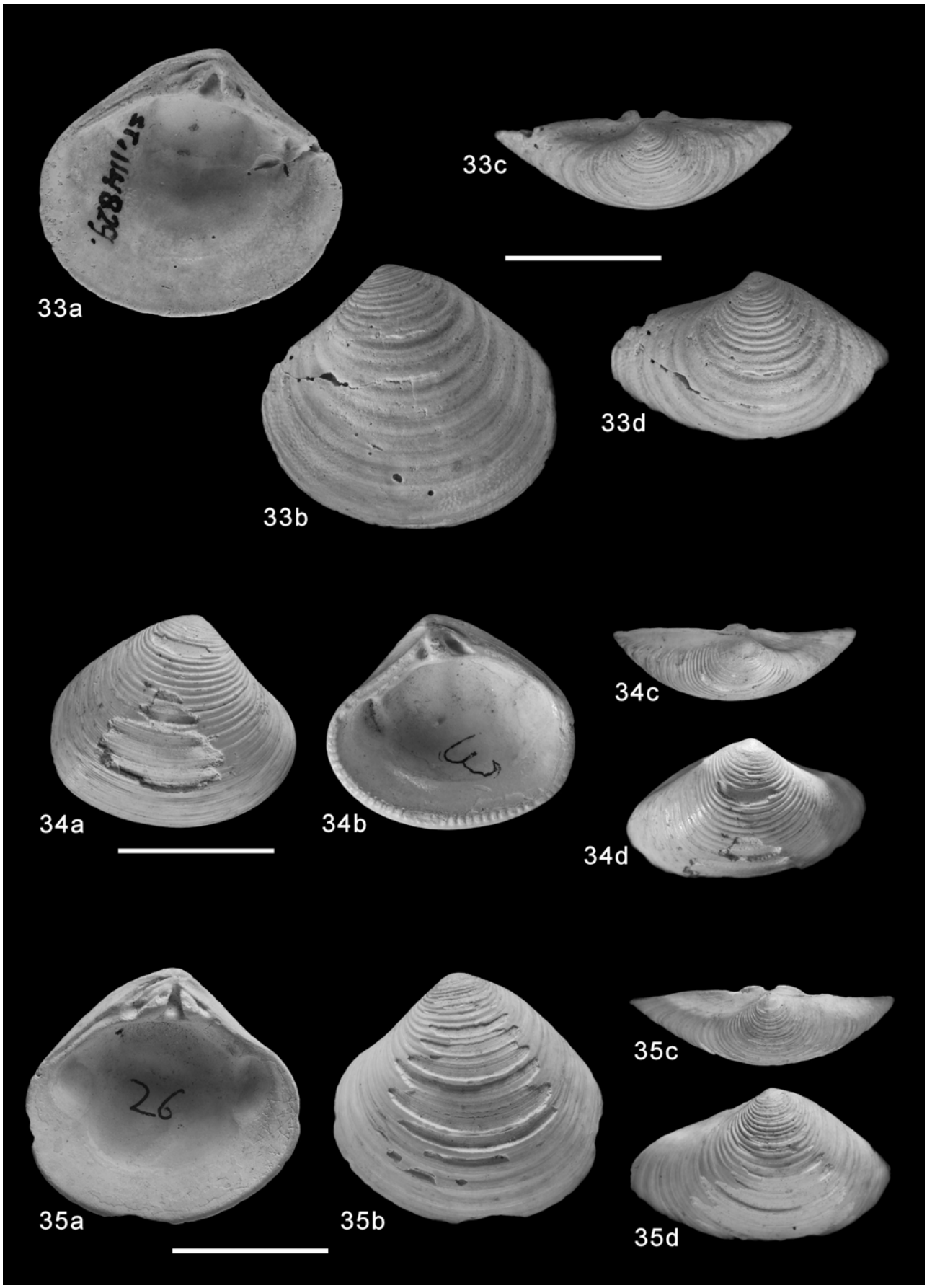

Figure 33-35.

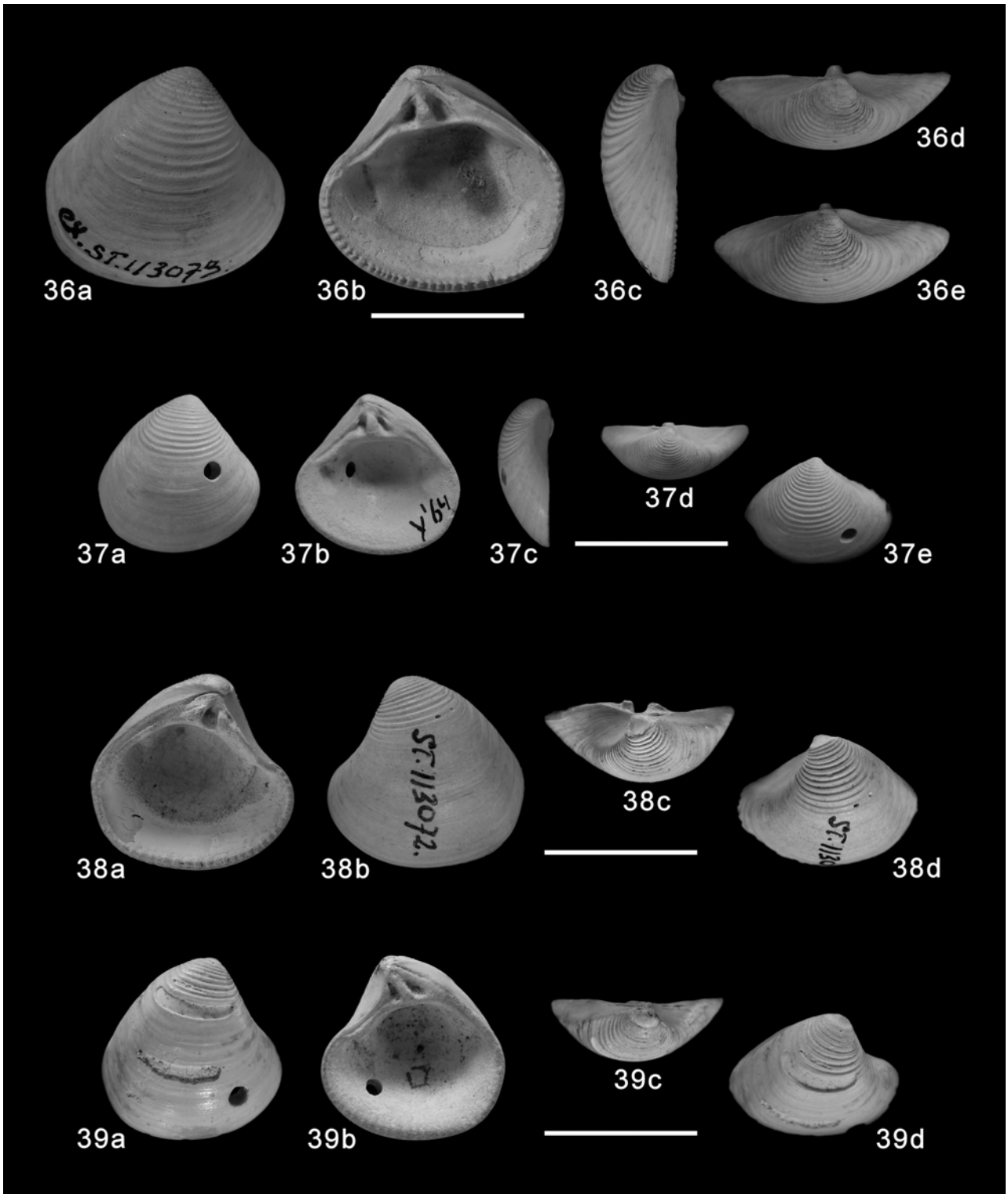

Figure 36. *Laevastarte* cf. *peelensis* (Spaink, 1968). Terneuzen (province of Zeeland, the Netherlands), construction pit new sea sluice, shellbed on bottom of pit, 20-24 mbs; Holocene basal crag with reworked Pliocene shells. RGM 485 225. Scale bar = 1 cm.

Figure 37. *Laevastarte* cf. *peelensis* (Spaink, 1968). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 613, ex coll. D. van der Mark. Scale bar = 1 cm.

Figure 38. *Laevastarte* cf. *peelensis* (Spaink, 1968). Terneuzen (province of Zeeland, the Netherlands), construction pit new sea sluice, shellbed on bottom of pit, 20-24 mbs; Holocene basal crag with reworked Pliocene shells. RGM 485 238. Scale bar = 1 cm.

Figure 39. *Laevastarte* cf. *peelensis* (Spaink, 1968). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 611, ex coll. L. van der Slik. Scale bar = 1 cm.

Dimensions – Up to 27 mm long and 23 mm high.

Description – Medium-sized species, oblique trigonal-oval in shape with a quite solid, convex to moderately flattened shell. Juvenile shells of 5 mm high are slightly longer than high. Shells up to *c.* 10 mm high have an oval outline, becoming more obliquely trigonal-oval in larger specimens. The posterior part of the adult shell is truncated and slightly produced with rounded edges.
The umbo is bluntly pointed, moderately prosogyrate and moderately turned inwards. It is positioned well in front of the midline.
The lunule is rather deep, widely lancet-shaped, 3 times longer than wide in convex shells and quite shallow, elongately lancet-shaped, 4 times longer than wide in less convex specimens. Its greatest width is situated in its middle. The escutcheon is 6-7 times longer than wide and about 1½ times as long as the lunule. Although not very sharply delimited it is clearly separated from the rest of the shell.
The first 2 mm of the umbo are covered with very fine, steep-sided commarginal riblets with interspaces that are as wide slightly narrower. In this initial stage the ribs follow a regular circular or oval line. There is no marked transition to the posterior area. Between 2 and up to 8 mm from the umbo the width of ribs and interspaces usually increases very slowly. In some specimens the strength of the ribs increases faster. The interspaces stay as wide as or somewhat narrower than the ribs. In this part of the shell there also is no transition indicated to the posterior area. The shape of the ribs changes from oval-shaped to more rounded. At 8 mm from the umbo the ribs on the middle part of the shell suddenly disappear. On the posterior part there is no sudden disappearance of the ornament but it fades gradually, a process starting already closer to the top. As a result of this a large number of ribs is weaker on the posterior part than on the middle and anterior parts of the shell. In adult specimens the youngest part of the shell is smooth, only covered with faint growth lines.
In the left valve the margin of the shell near the lunule follows a more or less straight line along the anterior cardinal tooth. Only near the top end of the tooth the shell margin bends over it, covering just a small part of it. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
The margin of the shell along the lunule is a blunt edge which widens considerably to its base. Especially in the right valve this edge is very conspicuous with a strongly developed lateral tooth placed on it. Seen from within, looking at the shell in a right angle, the antero-dorsal margin between the umbo and the transition to the ventral margin is only slightly concave. The maximum distance between the antero-dorsal margin and an imaginative line from umbo to transition point is about ⅓ to ¼ of the maximum depth of the lunule. There is only a shallow cavity underneath the hinge plate. The greatest semi-diameter of the shell is situated in or behind the midline and clearly behind the umbo. Seen from within, the umbonal angle between the antero-dorsal margin and the margin directly behind the umbo is about 115°. The crenulation of the ventral margin can already be developed in specimens with a length of 12 mm.

Discussion – This species can be recognized by its generally convex shell, the slightly produced posterior side, the bluntly rounded umbo, the blunt, wide-based margin along the lunule and the very fine, regular, rounded to oval commarginal ribs that disappear suddenly, many of them fading on the posterior part of the shell. *Laevastarte omalii omalii*, *L. omalii scaldensis* and *L. basteroti* are also convex but their ornament is (much) coarser, the ribs are bent at the transition to the posterior area (Figure 48), the umbo is more pointed and the cavity underneath the hinge plate is much deeper. *Laevastarte ovatacostata* usually has a markedly less convex shell with a more pointed umbo and a narrower hinge. Its ribs start very fine as well, but increase in width more rapidly and the strength of the ribs stays rather equal over their full length. *Laevastarte* cf. *peelensis* can have a strong resemblance but it may be distinguished by its thicker shell that is as long as high, larger hinge and more prosogyrate umbo with a smaller umbonal angle. The lunule is wider and has its greatest width close to the umbo and the ornament is similar but increases more quickly.
Janssen & Van der Slik (1974a & b) and Marquet (2005) considered *L. ariejansseni* a subspecies of *L. fusca* (Poli, 1791). However, both taxa are very different, see Figure 5 for a Recent specimen of *L. fusca*. It has a more pointed and more prosogyrate umbo, the sculpture on the umbo is following a nearly circular shape instead of an oval one and the large cardinal tooth in the right valve is clearly bifid, a character not seen in *L. ariejansseni*. Therefore, the present species cannot belong to the *fusca*-group and is considered as a separate species.
From Dutch beaches and estuaries small specimens with a crenulated ventral margin are known. As this crenulation is often supposed to be an adult feature. Janssen & Van der Slik (1974b) regarded these specimens as belonging to a small species: *L. fusca incrassata* (Brocchi, 1814). Dall (1903a) wrote that crenulation is not only developed in fully adult specimens but also during growth interruptions. Furthermore, such small specimens can be linked with adult specimens of *L. ariejansseni* by transitional stages. These specimens are also clearly different from *L. fusca incrassata* of the Italian Pliocene (Figures 6-7), not only by the characters mentioned above for *L. fusca* s.s., but also by the shell margin along the lunule. In *L. fusca incrassata* it is shaped as a narrow ridge with a slightly widening base and not a quite blunt, wide-based ridge as in *L. ariejansseni*.

Occurrence – *Laevastarte ariejansseni* is endemic in the North Sea Basin. In excavations near Antwerp it occurs in the Kattendijk Sand Member (Pliocene, Zanclean, Kattendijk Formation) and the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation). Reworked specimens haven been found in the basal crag of the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation) and at many places in the province of Zeeland. It also

occurs in the Late Miocene of Belgium and the Coralline Crag Formation of Great Britain (Marquet, 2005).

***Laevastarte* cf. *peelensis* (Spaink, 1968)**
Figures 36-39, 48

*1968 *Astarte (Isocrassina) omalii peelensis* Spaink, p. 8-9, pl.1, figs 1 & 5.
1974b *Astarte (Isocrassina) omalii peelensis* Spaink, 1968 – Janssen & van der Slik, p. 51, pl. 35, fig. 91a-c (non 91d-e = *L. omalii omalii*).

Material examined – **Baarlo** (Province of Limburg, The Netherlands), diepboring 9, 100-160 m below surface, Middle Miocene: 1/2 holotype (RGM 577 694, ex coll. NITG/RGD) and 52/2 paratypes (RGM 577 579, RGM 577 580 & RGM 577 581, ex coll. NITG/RGD); **Belfeld** (Province of Limburg, The Netherlands), Station, Flachbohrung 20, 27.20-31.50 m below surface, Late Miocene: 10/2 paratypes (RGM 577 612, ex coll. NITG/RGD).
Province of Zeeland, The Netherlands: **Terneuzen**, construction pit new sea sluice, shell bed on bottom of pit, 20-24 m below surface, Holocene basal crag with reworked Pliocene shells: 1/2 (RGM 485 225), 1/2 (RGM 485 238), 2/2 (RGM 485 241), 1/2 (RGM 577 617); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 184 935, ex coll. F.J. Janssen), 1/2 (RGM 485 226), 25/2 (RGM 577 523, ex coll. Filiaal), 1/2 (RGM 577 611, ex coll. L. van der Slik), 1/2 (RGM 577 613, ex coll. D. van der Mark), 1/2 (RGM 577 614, ex coll. D. Van der Mark), 11/2 (RGM 577 615, ex coll. F.J. Janssen), 9/2 (RGM 577 616, ex coll. F.J. Janssen), 1/2 (RGM 577 618, ex coll. M.J. de Graag), 1/2 (RGM 577 619, ex coll. NITG/Vreede), 5/2 (RGM 577 620, ex coll. L. van der Slik), 3/2 (RGM 577 621, ex coll. Filiaal).

Dimensions – 17 mm long and 16 mm high, sometimes a slightly larger.

Description – Small-sized shell, trigonal in form with a very solid, thick-walled, convex shell. Juvenile shells of 5 mm high are slightly longer than high with a nearly equilateral oval outline. Larger shells are becoming more and more oblique and trigonal. The posterior side of the shell is weakly truncated.
The umbo is bluntly pointed, moderately prosogyrate and moderately turned inwards. It is situated slightly to distinctly in front of the midline.
The lunule is shallow and widely lancet-shaped, 3½-4 times longer than wide. Its greatest width is reached close to the umbo. The anterior edge of the shell along the lunule is nearly straight. The escutcheon is 6-7 times longer than wide and about 1½ times as long as the lunule. Only the anterior part of the escutcheon is sharply delimited but the posterior part is still clearly separated from the rest of the shell.
The first 2 mm from the umbo display very fine, steep-sided commarginal ribs with interspaces that are narrower or nearly as wide as the ribs. In this initial stage the ribs follow a regular oval shape. There is no marked transition to the posterior area. Between 2 and up to 8 mm from the umbo the width of ribs and interspaces increases slowly. The interspaces stay narrower or nearly as wide as the ribs. In this part of the shell usually there also is no obvious transition to the posterior area but in some specimens the ribs show a weak bend at this point. At 6-7 mm from the umbo the ribs on the middle part of the shell are fading or they disappear quite suddenly. On the posterior part this starts earlier. In adult specimens the youngest part of the shell is nearly smooth, only covered by faint, irregular commarginal lines.
The hinge is very strong and heavy, its height (Hh) is about 1/4 of the total height (H), with a H/Hh-ratio between 3.5 and 4.3. Well-preserved specimens possess coarse grooves on the sides of the cardinal teeth, perpendicular to the commissure.
The margin of the shell along the lunule is a blunt edge which widens considerably to its base. Especially in the right valve this edge is very conspicuous with a strongly developed lateral tooth placed on it. Seen from within, looking at the shell in a right angle, the antero-dorsal margin between the umbo and the transition to the ventral margin is straight or very slightly concave. The same is true for the margin along the lunule, which shows a short curve close to the umbo after which it continues in a straight line towards the aforementioned transition point. The margin along the escutcheon, on the contrary, is distinctly curved outward. Also seen from within, the umbonal angle between the antero-dorsal margin and the margin directly behind the umbo is *c.* 105°. Well-preserved specimens with a length of 12 mm or more have a crenulated ventral margin, strongly varying in strength, sometimes even in one and the same specimen. The majority of specimens from Zeeland suffers from corrosion of the outer surface, especially so on the umbonal part.

Discussion – This species displays a considerable variability in many aspects of the shell. The majority of specimens from beaches and estuaries of south-western Netherlands differ from the most abundant form as known from the type-area in the south-east of The Netherlands.

Figure 40. *Laevastarte peelensis* (Spaink, 1968). Holotype. Baarlo (province of Limburg, the Netherlands), diepboring 9, 100-160 mbs; Middle Miocene. RGM 577 694, ex coll. NITG/RGD. Scale bar = 1 cm.
Figure 41. *Laevastarte peelensis* (Spaink, 1968). Paratype. Baarlo (province of Limburg, the Netherlands), diepboring 9, 100-160 mbs; Middle Miocene. RGM 577 581, ex coll. NITG/RGD. Scale bar = 1 cm.
Figure 42. *Laevastarte peelensis* (Spaink, 1968). Paratype. Baarlo (province of Limburg, the Netherlands), diepboring 9, 100-160 mbs; Middle Miocene. RGM 577 580, ex coll. NITG/RGD. Scale bar = 1 cm.

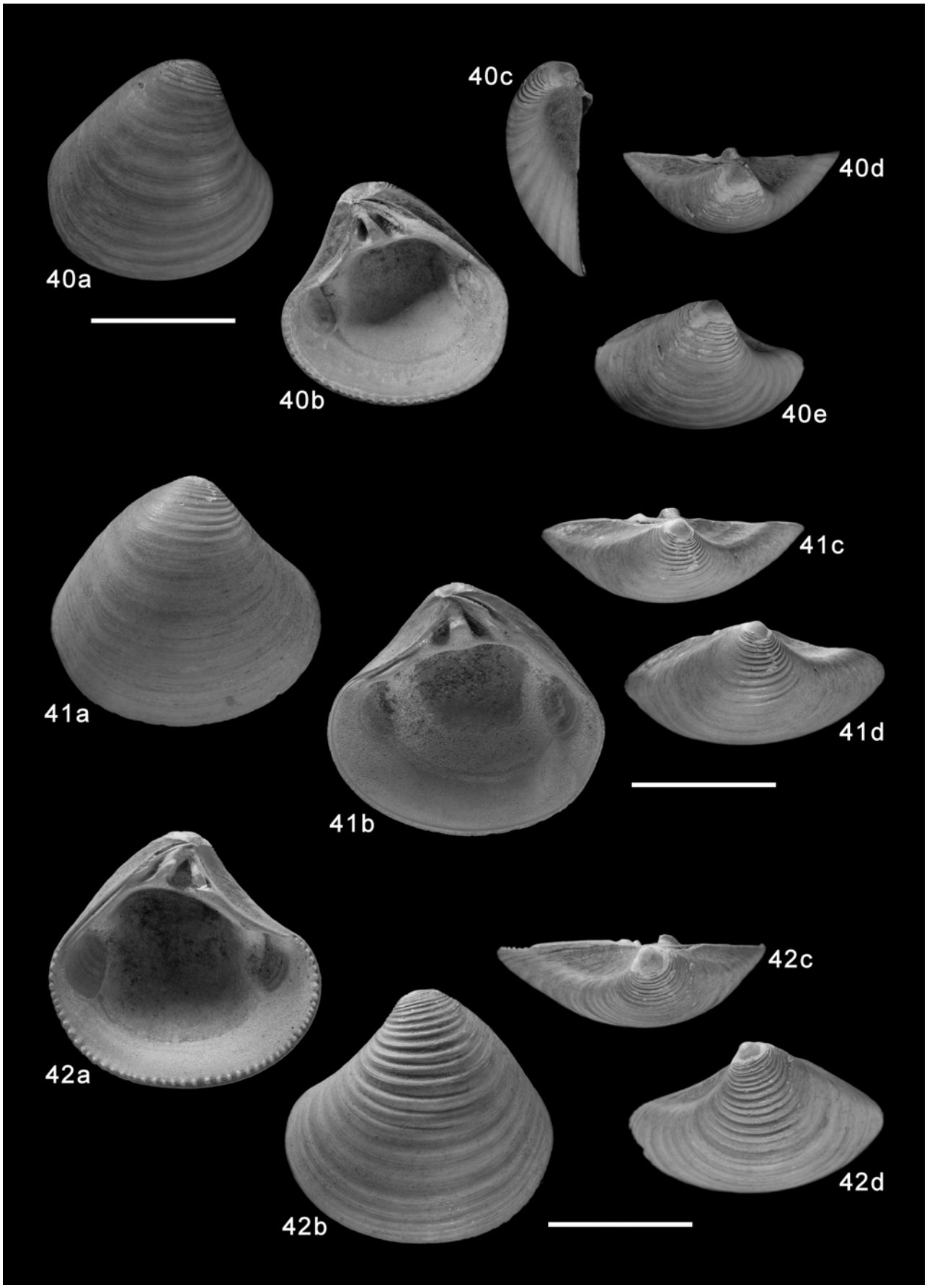

Figure 40-42.

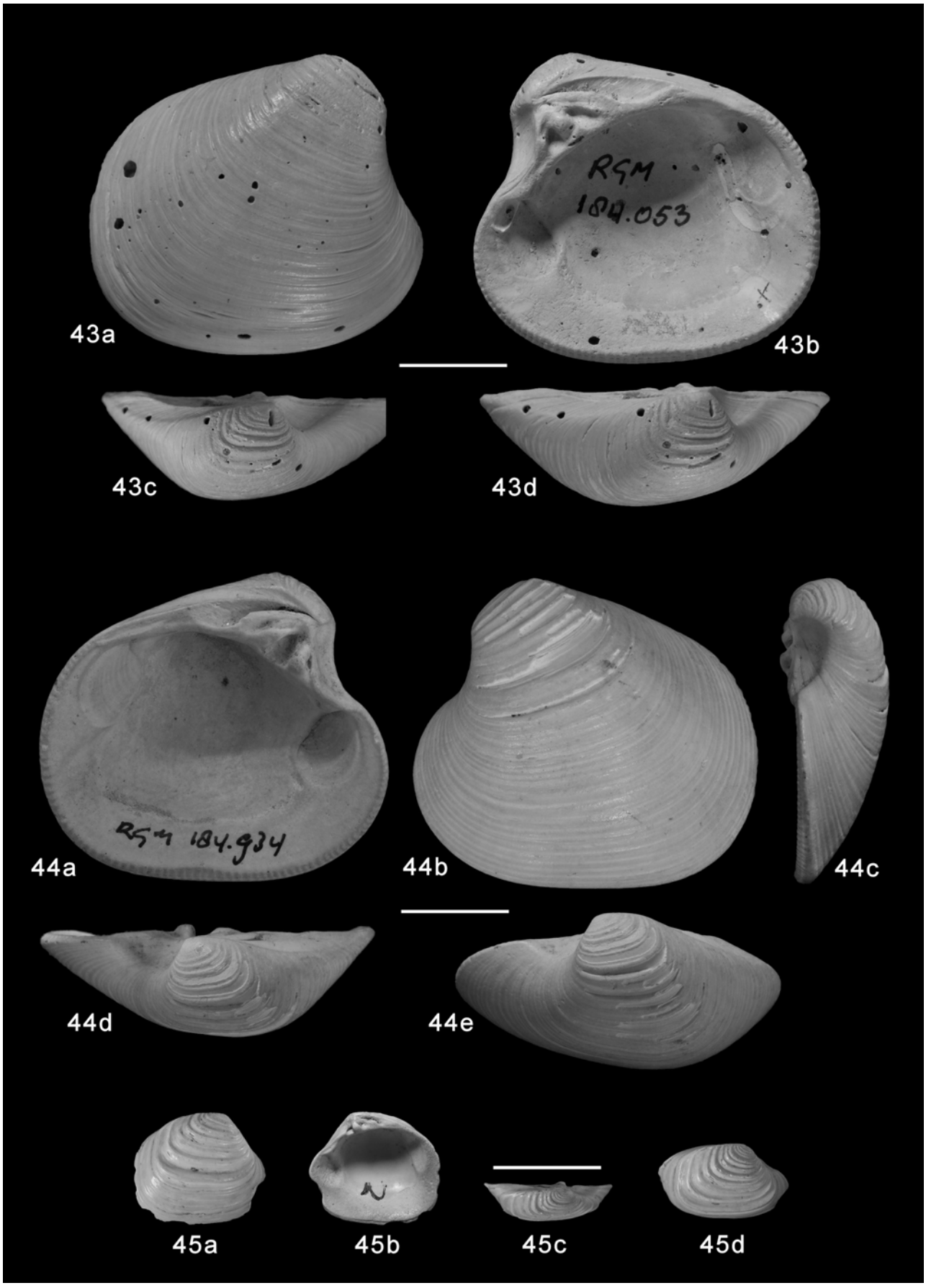
RGM
184.053
43a
43b
43c
43d
RGM 184.934
44a
44b
44c
44d
44e
45a
45b
45c
45d

Figure 43-45.

The shell of the latter form (Figures 40-42) reaches larger dimensions, is slightly thinner and the umbo is more prominent, more prosogyrate and situated further in front of the midline. The lunule is more excavated with a narrower, curved ridge at the margin and furthermore the antero-dorsal margin between the umbo and the transition to the ventral margin is curved inward instead of being straight. The margin of the escutcheon is straight over almost all its length. The ornamentation of the Miocene borehole specimens demonstrates a larger variability. Initially it is finer and sharper, with interspaces that are somewhat narrower than the ribs themselves, after which the elements usually increase more rapidly in strength, the interspaces becoming 1-1½ times as wide as the ribs. In a considerable number of specimens the ribs increase more gradually in strength. Many specimens show irregularities in ornament: some ribs or interspaces are markedly narrower or wider than neighbouring ones. The hinge of the Miocene borehole specimens is typically somewhat less heavily developed.

In spite of these differences between the most abundant forms in the reworked specimens from the south-west and the *in situ* populations from the south-east of The Netherlands, specimens with intermediate characters do occur in both areas. However, the holotype and a large series of paratypes from the Baarlo borehole originate from an interval of no less than 60 m and the observed variability in this material might very well represent an evolutionary development. Therefore, reworked specimens from the province of Zeeland are here indicated as *Laevastarte* cf. *peelensis*. Study of *L. peelensis* from much shorter stratigraphic intervals is indispensable to reveal their mutual relationships.

Laevastarte ariejansseni has a shell that is longer than high, a less prosogyrate umbo and a narrower lunule with its greatest width further from the umbo. Its ornamentation initially is of the same strength but it increases less rapidly. The umbonal angle of that species is wider.

Spaink (1968) interpreted the Miocene taxon as a subspecies of *Astarte (Isocrassina) omalii* (= *L. omalii*), a view adopted by Janssen & Van der Slik (1974a). However, the latter has a much stronger and more rapidly increasing commarginal ornament. As the ribbing on the umbonal part of the shell seems to be a fairly constant feature within species, the observed ornamental differences renders a close relationship improbable and for this reason *L. peelensis* is considered here as an independent species.

Occurrence – *Laevastarte peelensis* is recorded from Middle and Late Miocene deposits of The Netherlands and Germany. Reworked specimens, here indicated as *L.* cf. *peelensis*, are scarce and only known from a few localities in the province of Zeeland, as specified above.

***Laevastarte mutabilis mutabilis* (Wood, 1853)**
Figures 43-45, 49

*1853 *Astarte mutabilis* Wood, p. 179, pl. 16, fig. 1a-b & 1e-h (*non* fig. 1 c-d).
1972 *Astarte mutabilis mutabilis* Wood – Spaink, fig. 2.
1974a *Astarte (Isocrassina) mutabilis mutabilis* (Wood, 1853) – Janssen & Van der Slik, p. 2, pl. 1, figs 1, 3-4; pl. 2, fig. 1.
1974a *Astarte (Isocrassina) mutabilis* aff. *mutabilis* (Wood, 1853) – Janssen & Van der Slik, p. 2, pl. 1, fig. 2.
1974b *Astarte (Isocrassina) mutabilis mutabilis* Wood, 1853 – Janssen & Van der Slik, p. 51, pl. 34, fig. 89.
2005 *Isocrassina mutabilis* (Wood, 1853) – Marquet, p. 33, pl. 19, fig. 1.

Material examined – Province of Zeeland, The Netherlands: **Borssele, De Kaloot**, washed ashore: 2/2 (RGM 485 194, ex coll. M.I. Gerhardt), 1/2 (RGM 485 202, ex coll. J. Janse), 1/2 (RGM 485 217, ex coll. M.I. Gerhardt); **Domburg-Westkapelle**, washed ashore: 1/2 (RGM 485 192, ex coll. M.I. Gerhardt), 2/2 (RGM 485 195, ex coll. Filiaal); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 75 149), 3/2 (RGM 125 992), 2/2 juv. (RGM 125 993), 1/2 (RGM 184 052, ex coll. F.J. Janssen), 1/2 (RGM 184 053, ex coll. F.J. Janssen), 1/2 (RGM 184 933, ex coll. F.J. Janssen), 1/2 (RGM 184 934, ex coll. F.J. Janssen), 29/2 (RGM 485 191, ex coll. F.J. Janssen), 5/2 (RGM 485 193, ex coll. M.J. de Graag), 2/2 (RGM 485 196), 7/2 (RGM 485 197, ex coll. P. Kaas & A.N.Ch. ten Broek), 3/2 (RGM 485 198, ex coll. G.J. van der Velde), 2/2 (RGM 485 199, ex coll. G.J. van der Velde), 1/2 (RGM 485 200, ex coll. D. Van der Mark), 7/2 (RGM 485 201, ex coll. D. Van der Mark), 29/2 (RGM 485 203, ex coll. NITG/Vreede), 4/2 (RGM 485 204), 11/2 (RGM 485 205, ex coll. L. van der Slik), 3/2 (RGM 485 207, ex coll. M. van den Bosch), 1/2 (RGM 485 208, ex coll. L. van der Slik), 1/2 (RGM 485 209, ex coll. A.S. Timmermans), 2/2 (RGM 485 212, ex coll. NITG/Vreede), many valves (RGM 485 213, ex coll. Filiaal), 1/2 juv. (RGM 485 214, ex coll. L. van der Slik), 1/2 (RGM 485 215, ex coll. A.W. Lacourt), 1/2 juv. (RGM 485 216), 1/2 (RGM 485 218, ex coll. D. van der Mark), 1/2 (RGM 485 219), 1/2 (RGM 485 221), 1/2 (RGM 485 223), 1/2 juv. (RGM 577 578, ex coll. F.J. Janssen).

Dimensions – Up to 39 mm long and 36 mm high.

Description – Medium- to large-sized species with a rounded rectangular, convex shell. The central part of the ventral margin is nearly straight, sometimes even con-

Figure 43. *Laevastarte mutabilis* (Wood, 1853). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 184 053, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figure 44. *Laevastarte mutabilis* (Wood, 1853). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 184 934, ex coll. F.J. Janssen. Scale bar = 1 cm.
Figure 45. *Laevastarte mutabilis* (Wood, 1853). Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 578, ex coll. F.J. Janssen. Scale bar = 1 cm.

cave. Juvenile shells of 5 mm high are much longer than high. Shells up to about 10 mm high have a rectangular outline. The ornamented area near the umbones is bordered by two nearly straight margins along lunule and escutcheon, respectively. Together with the nearly straight posterior and ventral margins this gives juvenile shells a very characteristic squared appearance.
The quite blunt umbo is lying far in front of the midline. In juveniles it is moderately prosogyrate and moderately turned inwards whereas in adult shells it is strongly prosogyrate, and protruding, and moderately to strongly turned inwards. In many specimens the umbonal area is somewhat flattened, resulting in a moderately bipartite shell.
The lunule is deep and widely lancet-shaped, 3-4 times longer than wide. The posterior part of the escutcheon is vaguely delimited. It is 6-9 times longer than wide and 1½-2 times longer than the lunule.
The first 2 mm of the umbo has coarse commarginal ribs. Initially the interspaces are much narrower than the ribs themselves, but they increase rapidly in width, and are at a distance of 2 mm from the top already as wide as the ribs. In this stage the ribs have a regular oval shape, as the transition to the posterior area is not or hardly marked. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases very rapidly. The interspaces become 1-1½ times as wide as the ribs and in many specimens the ornamentation becomes irregular. The transition to the posterior area is always marked by a strong, rounded, angular bend of the ribs. Posterior and ventral margins form an angle of about 90°. The ribs on the middle part of the shell suddenly fade at 6-10 mm from the umbo. The remaining part of the shell is not really smooth but covered with low irregular ridges and lines. The ribs on the posterior area are fading at the same moment or a bit earlier.
The cavity for the external ligament is very deep, forming a wide area behind the nymph, about 2 times as wide as the latter. In this species the grooves on the sides of the cardinal teeth are weakly developed, this in contrary to most other species in this group. Only few of the about 100 specimens examined possess those grooves, which are placed perpendicular to the commissure.
The ventral margin of adult specimens is crenulated.

Discussion – This species can easily be recognized by its rectangular outline, the coarse sculpture on the umbones and the wide area behind the nymph. At first glance *Laevastarte bipartita* looks very similar (especially immature specimens), but this species has a triangular shell with a more centrally positioned and not inwards turned umbo and the area behind the nymph is much narrower. *Laevastarte mutabilis altenai* can be distinguished by the larger dimensions of the adult shell and the more rounded, less tumid and less thick-walled shell and less protruding, less prosogyrate and hardly inwards turned umbo. In the Late Miocene Edegem Sand Member (Belgium) some specimens have been found with a form quite similar to *L. mutabilis mutabilis* (Janssen & Van der Slik, 1974a). However, examination of these specimens revealed that the initial ornament of the umbo is very fine, not coarse, and the interspaces are nearly as wide as the ribs themselves. Initially the ornament increases very slowly in strength but at 2 mm the increase is becoming faster. The ornament already disappears at 5-6 mm from the top. Adult specimens have a more tumid, solid shell with a more prominent umbo and a larger height/length ratio than the average specimen of *L. mutabilis mutabilis* from the Dutch beaches and estuaries. These Miocene specimens are closely related to but clearly not the same as *L. mutabilis mutabilis*. Janssen & Van der Slik (1974a) also pointed at the differences between the specimens of *L. mutabilis mutabilis* from the Coralline Crag Formation of East Anglia and those from the Dutch beaches and estuaries, the latter being smaller and having a more squared outline. The larger size of many specimens of *L. mutabilis mutabilis* (including the holotype) from the Coralline Crag Formation seems to connect it with *L. mutabilis altenai*. However, because the differences between the British and Dutch specimens are quite small they all are regarded as belonging to the same species. According to Janssen & Van der Slik (1974a) *L. mutabilis altenai* also occurs in the Coralline Crag Formation and based on this, Marquet (2005) rejected a subspecific status. However, this is not followed here as it is assumed that during the deposition of the Coralline Crag Formation the transition from *L. mutabilis mutabilis* to *L. mutabilis altenai* was taking place. The interrelationship between the Belgian, Dutch and British (sub)species is in need of further study which can only be done on populations of which the stratigraphical origin is known.

Occurrence – *Laevastarte mutabilis mutabilis* is endemic to the North Sea Basin. Near Antwerp it has only been found in the *Petaloconchus* bed of the Kattendijk Sand Member (Pliocene, Zanclean, Kattendijk Formation) (Marquet, 2005). It also occurs in the Coralline Crag Formation of Great Britain, where it can reach larger dimensions. In Zeeland reworked specimens are mainly found in the sucker-dredged material from off Ellewoutsdijk, as specified above.

***Laevastarte mutabilis altenai* (Spaink, 1972)**
Figures 46-47, 49

1878 *Astarte mutabilis* Wood – Nyst, pl. 21, fig. 2a-c (*non* 2d-f).
1881 *Astarte mutabilis* Wood – Nyst, p. 193.
1957 *Astarte (Isocrassina) mutabilis* Wood, 1840 – Glibert, p. 4, pl. 2, fig. 3.
*1972 *Astarte mutabilis altenai* Spaink, p. 26, fig. 5 & 9.
1974a *Astarte (Isocrassina) mutabilis altenai* Spaink, 1972 – Janssen & Van der Slik, p. 2, pl. 2, fig. 2-3.
1974b *Astarte (Isocrassina) mutabilis altenai* Spaink, 1972 – Janssen & Van der Slik, p. 51, pl. 34, fig. 90.
2005 *Isocrassina altenai* (Spaink, 1972) – Marquet, p. 34, pl. 20, fig. 1.

Material examined – Province of Zeeland, The Netherlands: **Axel**, Catharinapolder, Catharinahof, borehole

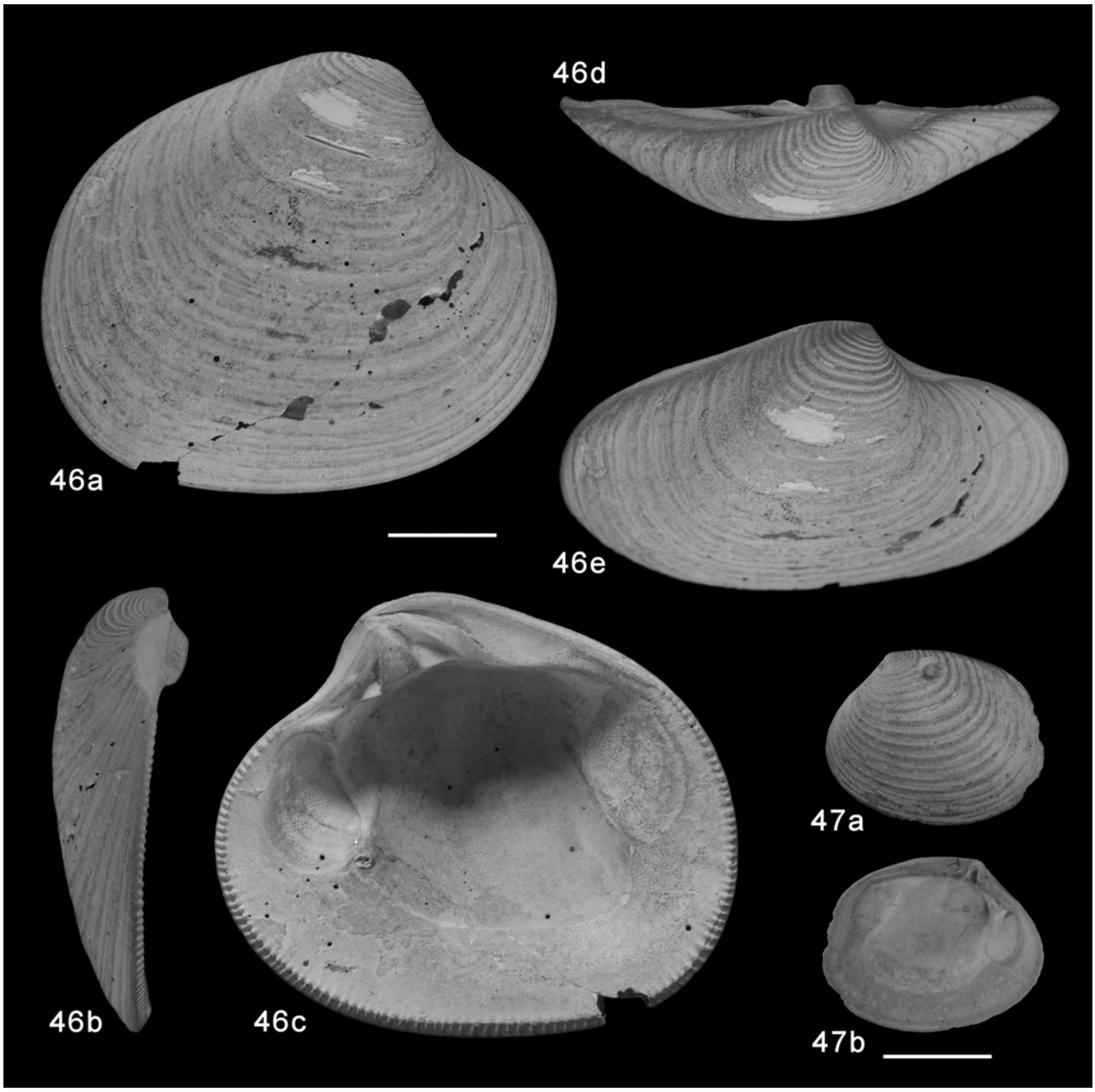

Figure 46. *Laevastarte altenai* (Spaink, 1972). Holotype. Westerschelde (province of Zeeland, the Netherlands), probably near Ellewoutsdijk, dredged. RGM 577 610. Scale bar = 1 cm.

Figure 47. *Laevastarte altenai* (Spaink, 1972). Paratype. Axel (province of Zeeland, the Netherlands), Catharinapolder, Catharinahof, borehole 54F/10 (K43), 11.50-13.20 mbs; Late Pliocene. RGM 577 702, ex coll. NITG/RGD. Scale bar = 1 cm.

54F/10 (K43), 11.50-13.20 m below surface, Late Pliocene: 1/2 juv. (RGM 577 702, ex coll. NITG/RGD, paratype); **Borsele, De Kaloot**, washed ashore: 1/2 (RGM 485 211, ex coll. M.I. Gerhardt); **North Sea, Sluisse Hompels**, "black level", dredged: 1/2 (RGM 485 210); **Westerschelde, near Ellewoutsdijk**, sucker-dredged: 1/2 (RGM 184 054, paratype), 1/2 (RGM 485 206, ex coll. L. van der Slik), 1/2 (RGM 577 610, ex coll. NITG/RGD, holotype), 1/2 (RGM 577 714, ex coll. L. van der Slik).

Dimensions – Up to 48 mm long and 41 mm high.

Description – Large-sized species with a rounded rectangular, rather flat shell. The central part of the ventral margin is regularly curved. Juvenile shells of 5 mm high are much longer than high. Shells up to about 10 mm high have an oval-rectangular outline.

The quite blunt umbo is situated far in front of the midline. It is moderately prosogyrate and not or hardly turned inwards. The umbo of juvenile specimens is not protruding, that of adult specimens is moderately protruding.

The lunule of juveniles is shallow and elongated lancet-shaped. It becomes deeper and wider (3-5 times longer than wide) in adult specimens.

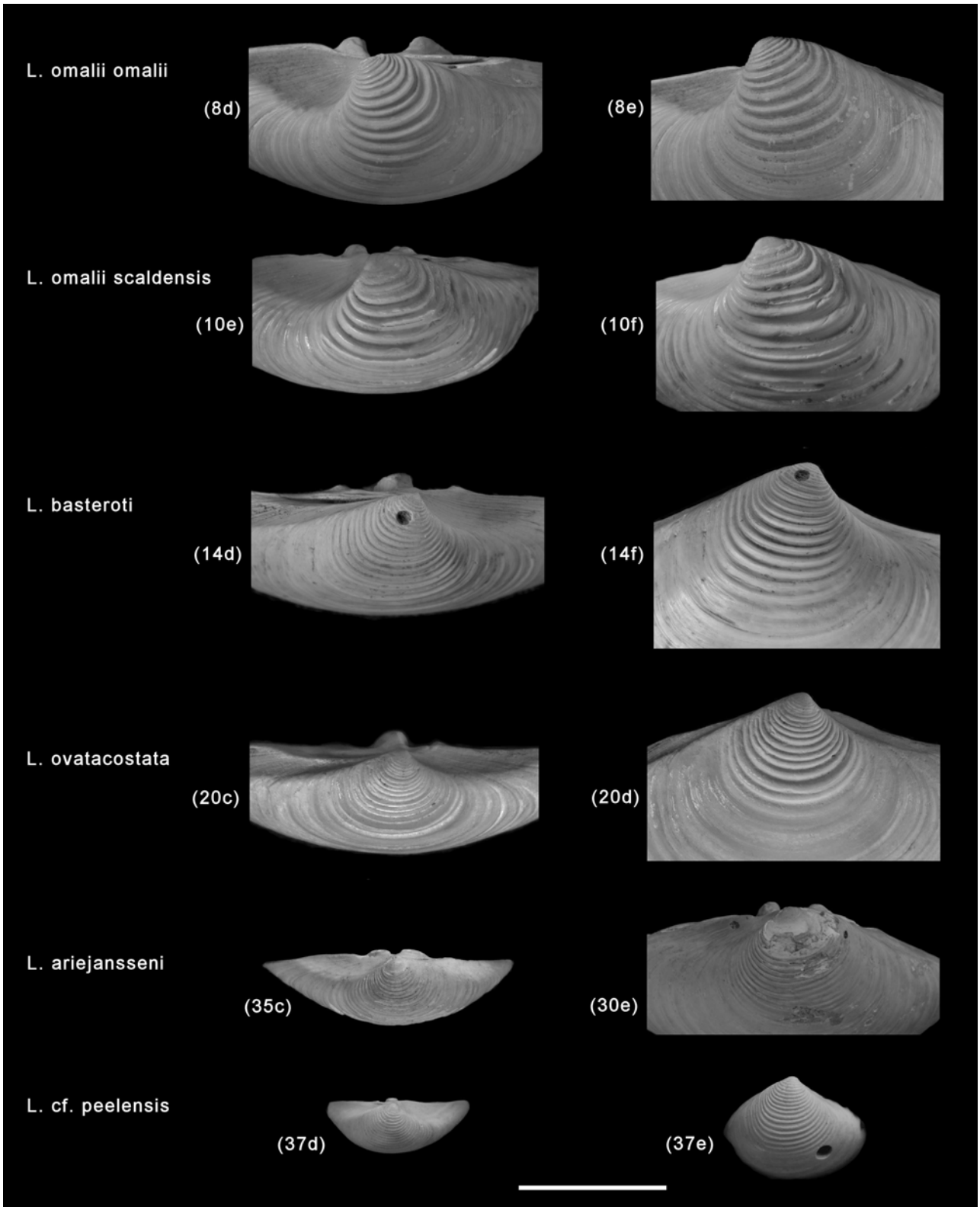

Figure 48. Umbones of various species of *Laevastarte*. The numbers between brackets refer to the figures on the plates on which the species are depicted earlier. Information on locality and register number can be found there. All figures are on the same scale; Scale bar = 1 cm.

The escutcheon is narrow and clearly delimited, 10-12 times longer than wide and 2½ times longer than the lunule.

The first 2 mm of the umbo is covered with coarse commarginal ribs with much narrower interspaces. In this initial stage the ribs follow a regular oval shape as

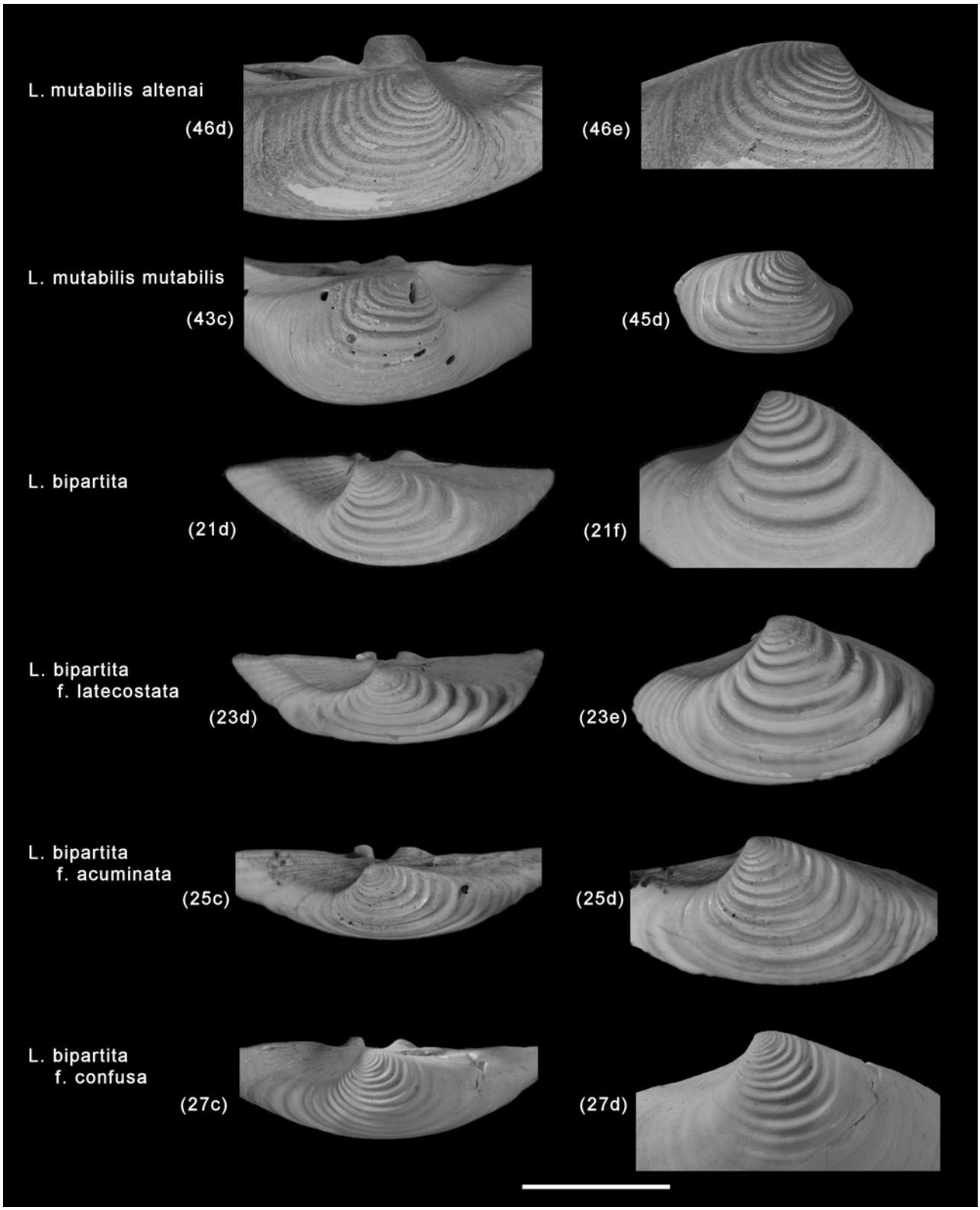

Figure 49. Umbones of various species of *Laevastarte*. The numbers between brackets refer to the figures on the plates on which the species are depicted earlier. Information on locality and register number can be found there. All figures are on the same scale; Scale bar = 1 cm.

the transition to the posterior area is not or hardly marked. Between 2 and up to 10 mm from the umbo the width of the ribs and interspaces increases slowly. The interspaces may become as wide as the ribs themselves. The transition to the posterior area is marked by a wide, rounded bend of the ribs which initially is somewhat angular but becoming less so further ventrally. The ribs on the middle part of the shell suddenly fade at 10-15

mm from the umbo. The remaining part of the shell is not really smooth but covered with low irregular ridges and lines. The ribs on the posterior area fade at the same moment or a bit earlier.
The cavity for the external ligament is very deep, forming a wide area behind the nymph, about 2 times as wide as the latter. In this species the grooves on the sides of the cardinal teeth are weakly developed.
The ventral margin of adult specimens is crenulated.

Discussion – This species is easily recognized by its rounded rectangular outline, the not very strongly protruding umbones, the coarse ornament on the umbones and the wide area behind the nymph. *Laevastarte mutabilis mutabilis* can be distinguished by its more inflated, thicker and even more rectangular shell with a much more protruding umbo and coarser, more rapidly increasing sculpture. Juvenile specimens of *L. bipartita* have a triangular shell with a more centrally positioned umbo and a much narrower area behind the nymph.

Occurrence – Laevastarte mutabilis altenai is an endemic species in the North Sea Basin. Only few specimens have been found *in situ* in the Luchtbal Sand Member (Pliocene, Zanclean, Lillo Formation) and the Oorderen Sand Member (Pliocene, Piacenzian, Lillo Formation) near Antwerp (Marquet, 2005). A juvenile specimen was found in Late Pliocene deposits in the Axel borehole 54F/10. It also occurs in the Coralline Crag Formation of Great Britain. Reworked specimens are very scarce in the dredged material from Zeeland and a bit less scarce on the beaches of Ritthem and De Kaloot (P. Moerdijk, pers. comm.).

Acknowledgements

The enthousiasm, continuous support, fruitful discussions and valuable comments of Dr Frank Wesselingh (NNM Naturalis) were of great help to carry on with this study. The critical review by Arie W. Janssen (Gozo, Malta; formerly NNM Naturalis) greatly improved the manuscript, as did the many discussions we had. Peter Moerdijk (Middelburg) contributed with critical discussions and loan of material. Dr Didier Merle (MNHN) extensively searched for type material of De la Jonkaire in the collections of the Paris museum. Dr Robert Marquet (Antwerp and IRSNB) gave information about the same concerning the Brussels institute and he critically reviewed the manuscript. Professor Klaus Bandel en Dr Wolfgang Weitschat (Universität Hamburg) provided information on the paleontological collections of the Geologisches Landesamt Hamburg. Jeroen Goud and Dr Charles Fransen (NNM Naturalis) provided Recent material from the RMNH collections and valuable information on nomenclature, respectively. Dr Annelise Folie and Alain Dreze (IRSNB) gave access to the collections in Brussels. I would like to thank all sincerely for their help.

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