

Acanthocardia sliggersi spec. nov. (Bivalvia, Cardiidae) from the Late Pliocene and Early Pleistocene of The Netherlands

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A new species of *Acanthocardia*, *A. sliggersi*, is described from Late Pliocene (Piacenzian) and Early Pleistocene (Gelasian) deposits of the North Sea Basin. The species is closely related to *Acanthocardia echinata* (Pliocene-Recent, north-eastern Atlantic region). A possible recent occurrence of *A. sliggersi* in the Russian arctic cannot be excluded.

Key words: Bivalvia, Cardiidae, *Acanthocardia*, taxonomy, new species, Pliocene, Pleistocene, North Sea Basin, The Netherlands.

INTRODUCTION

During an inventory of the fossil shells from beaches and estuaries of Zeeland our attention was drawn to shells of an *Acanthocardia* species washed ashore at Domburg (Zeeland, The Netherlands), originally identified as *A. echinata* (Linnaeus, 1758). Because of their atypical shell morphology, we thoroughly compared them with the Recent *A. echinata* and also with the related *A. paucicostata* (Sowerby, 1841). We describe the fossil shells as *A. sliggersi* spec. nov. The new species appears to be endemic to the southern North Sea Basin during the Late Pliocene (Piacenzian) and Early Pleistocene (Gelasian).

Abbreviations: BMNH, British Museum (Natural History), London, United Kingdom; KZGW, Koninklijk Zeeuwisch Genootschap der Wetenschappen, Middelburg, The Netherlands; RGM, National Museum of Natural History, Naturalis, Department of Palaeontology (Cainozoic Mollusca) (formerly Rijksmuseum van Geologie en Mineralogie), Leiden, The Netherlands; TNO-NITG, Netherlands Institute of Applied Geosciences, Utrecht, The Netherlands; ZMA, Zoological Museum, University of Amsterdam, Amsterdam, The Netherlands. Additional abbreviations: H, height; L, length; LV, left valve; RV, right valve.

SYSTEMATICS

Family Cardiidae Lamarck, 1809
 Subfamily Cardiinae Lamarck, 1809

Acanthocardia Gray, 1851.

Type species (designated by Stoliczka, 1870: 207): *Cardium aculeatum* Linnaeus, 1767.

Acanthocardia sliggersi spec. nov. (figs 1-3, 5)

Cardium echinatum Linnaeus; Wood, 1853 (?): 152, pl. 14 fig. 3 a-b; 1882: 12; Heering, 1950: 117, pl. 10 figs 23, (24), 25-26.

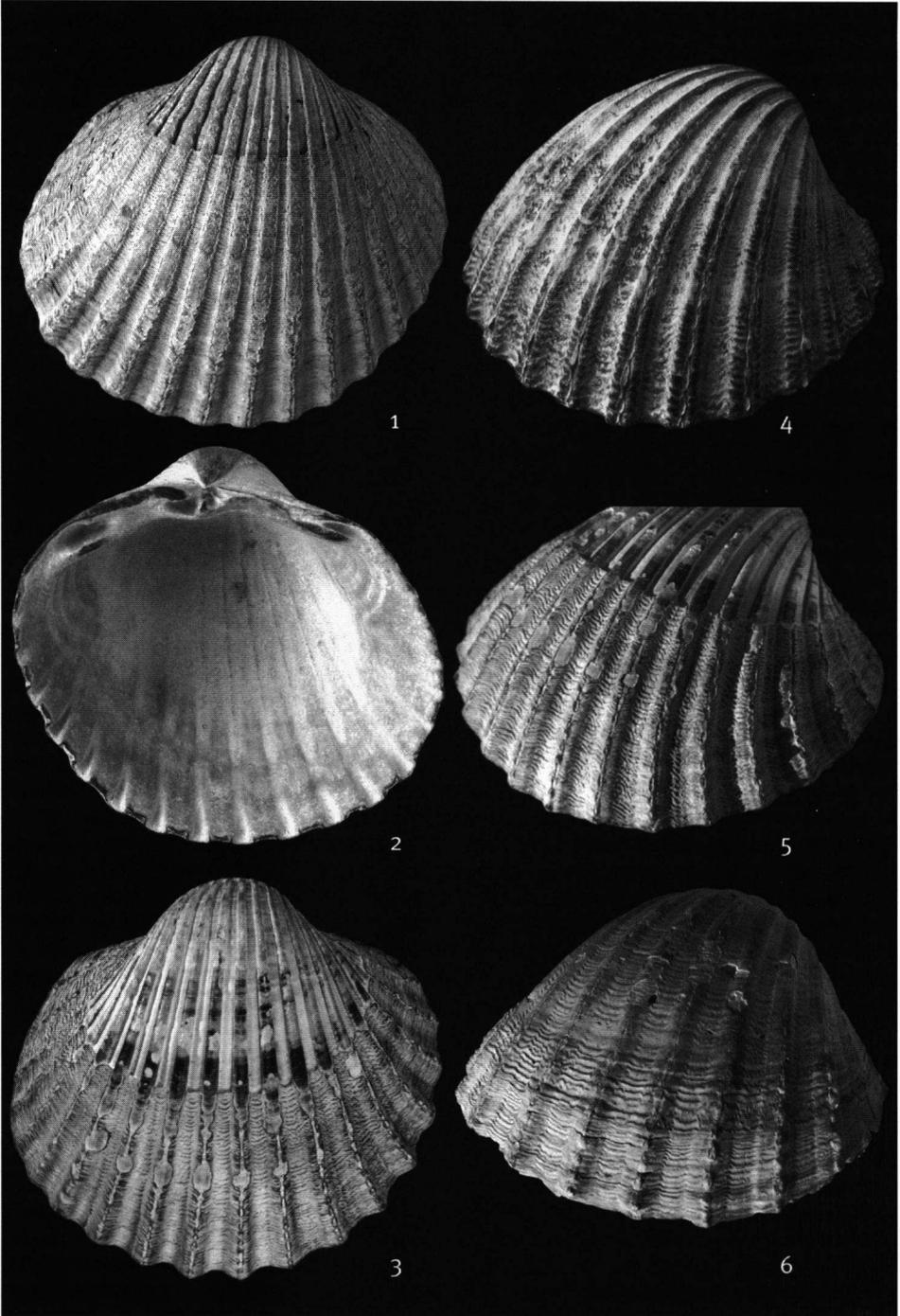
Type material. – Holotype: RGM 456319 (formerly NITG collection), right valve (RV), Maassluis, Zuid-Holland, The Netherlands, borehole 37B25, 112-115 m below surface, Maassluis Formation, Gelasian (figured in Heering, 1950: 117, pl. 10 figs 25-26, here figs 1-2).

Paratypes: RGM 456320 (formerly NITG collection), juvenile valve (LV), Oudewater, Utrecht, The Netherlands, borehole 38B26, 154-158 m below surface, Maassluis Formation, Gelasian (figured in Heering, 1950: pl. 10 figs 23-24); RGM 456321, Domburg, Zeeland, The Netherlands, 14 valves, washed ashore on beach between Domburg and Westkapelse zeedijk, presumably derived from Maassluis Formation deposits (Gelasian), leg. M.I. Gerhardt (fig. 3, 5); KZGW 4263, 1 valve, same locality, leg. P.W. Moerdijk, 13.iv.2003; ZMA 4.06.002, 1 valve, north-west beach of Walcheren, Zeeland, The Netherlands, presumably derived from Maassluis Formation deposits (Gelasian), leg. W. Kimpe, 28.viii.1935.

Other material: Mr. T. Meijer (formerly TNO-NITG) and mr. F.P. Wesselingh (National Museum of Natural History, Naturalis) listed *A. sliggersi* from boring-samples in the NITG- resp. RGM-collection and in internal reports on borings in the Dutch subsoil. Given are subsequently, boring identification, boring name, boring intervals (depth in metres below OD), age of sample, source (C1, Collection NITG; C2, Collection RGM; R1, Internal NITG report; R2, Internal RGM report; P, published paper), original identification of the sample, publication and remarks.

05A84, West Terschelling, 344.70-346.20; 359.90-361.70, Early Pleistocene, R1, as *A. 'echinata'*, eroded; 10C157, Breezanddijk, Wonseradeel, 316.00-320.00, Early Pleistocene, C1, R1, as *A. echinata*, fragments; 14E110, Hippolytshoef, 320.00-321.00, Early Pleistocene, C1, as *A. 'echinata'*, eroded; 19E101, Sijbekarspel, 244.00-245.00; 317.00-318.00; 359.00-360.00; 362.00-363.00; 378.00-379.00; 379.00-380.00; 380.00-381.00; 381.00-382.00; 382.00-383.00; 392.00-393.00; 395.00-396.00, Early Pleistocene, R1, *A. 'echinata'*, fragments; 19E101, Sijbekarspel, 378.00-379.00; 379.00-380.00, Early Pleistocene, C1, as *A. 'echinata'*, well preserved; 19E101, Sijbekarspel, 419.00-420.00, Late Pliocene, C1, as *A. 'echinata'*, well preserved;

Figs 1-6. *Acanthocardia* spec. 1-3, 5, *A. sliggersi* spec. nov.; 1-2, holotype, Maassluis, province of Zuid-Holland, The Netherlands, 112-115 m below surface, RGM (NITG colln) 456319, length 40.9 mm; 3, 5, paratype, beach between Domburg and Westkapelse zeedijk, province of Zeeland, The Netherlands, derived from probably Early Pleistocene deposits, leg. M.I. Gerhardt, RGM 456320, length 41.1 mm. 4, *A. echinata*, beach of Schiermonnikoog, province of Friesland, The Netherlands, 24.viii.1999, Holocene-Late Pleistocene deposits, leg. and coll. J.J. ter Poorten, NL1406, length 38.7 mm. 6, *A. paucicostata*, Amsterdam, IJburg, raised site with sediments originating from Lake IJsselmeer, province of N. Holland, The Netherlands, Eemian deposits, leg. and coll. J.J. ter Poorten, NL2096, length 36.5 mm. Photographs: figs 1-3, F.P. Wesselingh, RGM; 4-6, J.J. ter Poorten.



21A38, Schokland, 229.40, Early Pleistocene, C1, as *A. echinata*, well preserved; Schokland, 269/144?, depth?, C1, as *C. edule*, referred to in Heering, 1950, strongly eroded; 26D5, Eemnes, 219.25-223.75, Early Pleistocene, R1, as *A. echinata*; 26D42, Zuid Flevoland, 270.00-271.00; 328.00-329.00; 352.00-353.00, Early Pleistocene, R1, as *A. 'echinata'*; 26F1, Harderwijk, 313.73-315.90 (layer 90), Early Pleistocene, C1, as *A. echinata*, well preserved; 27D53, Twello, 202.00-203.00, Late Pliocene, R1, as *A. echinata*; 27G35, Deventer, 123.40-127.40, Late Pliocene, R1, as *A. echinata*; 28C127, Espelo, 65.20-66.50, Late Pliocene, R1, as *A. echinata*; 30F470, Noordwijk, 148.25-149.55; 156.75-157.75; 212.75-213.75; 213.75-214.75; 214.75-215.75; 215.75-216.75; 216.75-217.75; 271.75-272.75; 303.10-304.10; 304.10-305.10, Early Pleistocene, R1, as *A. sliggers*; 30G34, Den Haag, Drinkwaterleiding, Bor. O, 135.04-146.68, Early Pleistocene, C1, as *A. echinata*, referred to in Heering, 1950, well preserved; 31G147, De Meern, 245.00-246.00; 265.00-266.00, Early Pleistocene, R1, as *A. echinata*; 32A323, Hilversum De Schans, 202.00-203.00; 219.00-220.00; 220.00-221.00; 223.00-224.00; 224.00-225.00; 226.00-227.00; 227.00-228.00; 231.00-232.00; 232.00-233.00; 233.00-234.00, Early Pleistocene, R1, as *A. echinata*; 32D114, Austerlitz, 151.45-154.50, Early Pleistocene, C1, R1, as *A. echinata*, well preserved; 32E74, Barneveld-I (Olieboring), 250.00-260.00,, C1, R1, as *A. echinata*; 37B25, Maassluis, 109.00-115.00, Early Pleistocene, C1, P, as *C. edule*, referred to in Heering, 1950, strongly eroded; 37B25, Maassluis, 161.41-168.45, Early Pleistocene, C1, P, as *A. hostei*, referred to in Heering, 1950; 37D134, Brielle, 127.00-143.00; 158.00; 166.00; 243.00, Early Pleistocene, C2, R2, as *A. echinata*; 38B26, Oudewater, 154.00-158.00, Early Pleistocene, C1, R1, P, as *A. echinata*, referred to in Heering, 1950, well preserved; 38C385, Hendrik Ido Ambacht, 127.00-128.00; 144.00-145.00; 159.00-160.00, Early Pleistocene, R1, as *A. 'echinata'*; 38E225, Benschop, 172.00-173.00, Early Pleistocene, C1, as *A. sliggersi*, well preserved fragment of a non-adult specimen; 38H178, Asperen, 146.00-147.00, Early Pleistocene, C1, R1, as *A. 'echinata'*; 39H25, Druten-V, 76.50-83.25 (layers 62-68), Late Pliocene, C1, as *A. echinata*; Haamstede, 54.00-55.50, Early Pleistocene, C1, R1; Schouwen, ?, "Fauna 3", C1, as *C. edule*, strongly leached; Schouwen, ?, "Oudere Zone", C1, as *C. edule*, strongly eroded; 42G22, Schelphoek, 54.00-57.00; 84.00-85.50, Early Pleistocene, C2, R2, as *C. echinatum*; 42G40, Colijnsplaat, 63.50-67.00, Early Pleistocene, C2, R2, as *C. echinatum*; 42H20, Ouwkerk, 70.50-71.50; 77.50-82.50, Early Pleistocene, C2, R2, as *C. echinatum*; 43A8, Sommeldijk, 63.50-63.80, Early Pleistocene, C1, R1, as *C. edule*, strongly eroded; 43A8, Sommeldijk, 63.50-85.20, Early Pleistocene, C1, R1, as *C. edule*, strongly eroded; 43A8, Sommeldijk, 112.30-131.20, C1, R1, as *C. edule*, well preserved; 43A8, Sommeldijk, 112.30-143.00, C1, R1, as *C. edule*, strongly eroded; 43A8, Sommeldijk, ?, C1, R1, as *C. edule*, strongly eroded, complete, adult specimen; 43A46, Dirksland, 86.00-98.00; 121.00-125.00, Early Pleistocene, C2, R2, as *C. echinatum*; Beers, Proefbor. 53 (former ID: 571/1), 40.00-74.50,?,C1, as *C. edule*, strongly eroded; 44A155 or 44B10, Biesbosch, Dubbeldam, well III or VIII, ?, ?, C1, P, as *C. echinatum*, referred to in Heering 1950, well preserved non-adult specimen.

Diagnosis. – An oval, subequilateral cardioid shell of up to about 40 mm in length with ca. 21 triangular, radial ribs which are about twice as broad as their interstices. On the ribs a knobbed keel is present. The shell surface is ornamented with fine, irregular, commarginal striae.

Description. – The holotype (figs 1-2) is a solid, rather inflated right valve. The shell has a broadly oval outline and is slightly inequilateral. The length is exceeding the height. The umbones are located before the midline and are clearly prosogyrate. The shell is ornamented with about 20 primary radial ribs (range 19–23, average 21) that have a low triangular cross profile on the anterior and posterior quarter. The triangular ribs become more prominent on the middle region of the shell. On the anterior and median part the ribs are twice as broad as the interstices. On the posterior quarter they are weakly developed, more closely set, with one tiny secondary riblet. The rib sculpture – only slightly preserved near the margins – consists of an irregular, thin ridge, with tiny, blunt and close set nodules. The shell-surface shows a delicate, undulating commarginal pattern, that includes the flanks of the ribs. The growth-stages are clear. The hinge is rather strongly

developed. The right valve has two equally sized cardinal teeth; two anterior lateral teeth and one posterior; the left valve (paratypes) has two cardinal teeth of similar size; one anterior and one posterior lateral tooth. The length of nymph is ca. 2/3 of the posterior dorsal margin. The margins have deep crenulations; the furrows are not extending far inside the shell, developing into slight elevations and forming riblets towards the umbonal cavity. The adductor muscle scars are somewhat depressed.

Variability. – The shell morphology seems to be rather constant. The intraspecific variation in the studied material is mainly related to a change in the cross-section of the ribs during ontogeny: in adult specimens the ribs are triangular, whereas in juveniles the ribs generally exhibit a trapezoid shape. In this respect juveniles of *A. sliggersi* closely resemble those of *A. echinata*, which illustrates their close relationship. In well-preserved specimens the rib sculpture extends more towards the top, forming a continuous papillated ridge with, however, the umbo invariably worn off.

Dimensions (mm). –	L	H	semidiameter	rib number
RGM 456319 (holotype, figs 1-2)	40.9	37.0	13.7	20
RGM 456320 (paratype)	19.3	17.3	6.8	19
RGM 456321 (paratype)	41.0	38.5	14.4	22
RGM 456321 (paratype, figs 3, 5)	41.1	37.3	15.2	20
KZGW 4263 (paratype)	38.0	35.2	13.1	21
ZMA 4.06.002 (paratype)	39.6	37.5	14.2	22

Derivatio nominis. – Named after Bert Sliggers, former palaeontologist at the National Geological Survey of The Netherlands, for his recognition of this *Acanthocardia* as an undescribed taxon.

Differentiation. – *Acanthocardia sliggersi* is similar to *A. echinata*. It differs mainly by its triangular instead of quadrangular ribs, lacking a central furrow. Related to the width of the interstices, the ribs are relatively broader than in *A. echinata*. Besides, it differs by its rib ornamentation which is more crowded, much less pronounced and of a less variable nature. Its concentric, secondary ornamentation is more delicate and densely placed. On average, *A. sliggersi* is smaller, reaching a maximum of about 45 mm, whereas the maximum length of *A. echinata* is about 75 mm. In some characters the new species is quite similar to *A. paucicostata* (Sowerby, 1841), but the latter is decidedly more fragile; its ribs are less in number and of a more flattened triangular shape. A comparison between the three species is given in table 1.

Distribution. – Late Pliocene (Piacenzian, Reuverian, mollusc-zone Mol C of Spaink, 1975) and Early Pleistocene (Gelasian, Praetiglian-Tiglian, mollusc-zones Mol A and Mol B of Spaink, 1975) of the southern North Sea Basin (we here refer to the Pliocene-Pleistocene boundary at ca 2.6 Ma, following suggestions outlined in Gibbard et al., 2005). The species is fairly common in the Early Pleistocene Dutch Maassluis Formation. Apart from the Dutch records, this species is known from the Red Crag of Sutton and Felixstowe (Suffolk, Great Britain, see discussion below). Both deposits belong to the Red Crag of Newbourn (Harmer, 1914, 1920), which can be correlated to part of the Dutch Early Pleistocene (which is named 'Amsteliën' by Harmer, 1896) deposits. The species is not known outside the North Sea Basin.

Table 1. Comparison between the specific characters of *Acanthocardia echinata*, *A. sliggersi* and *A. paucicostata*.

	<i>A. echinata</i>	<i>A. sliggersi</i>	<i>A. paucicostata</i>
Solidity	solid	solid	rather thin-shelled
Outline	oval	oval	oval, sometimes posteriorly slightly elongated
Dimensions	length to ca. 75 mm	length to ca. 45 mm	length to ca. 45 mm
Amount of ribs (average)	18-22 (21)	19-23 (21)	14-18 (17)
Shape of ribs	well-developed, quadrangular or slightly trapezoid, with a central groove	well-developed, pointed, triangular	low, flattened triangular
Rib ornament	central groove, with rather large, distantly placed spoon or cusp like spines connected to each other at their base, spines often curved towards the posterior end	thin ridge/cord, ornamented with tiny, densely placed, blunt nodules	ridge with tiny blunt nodules or spines or (anteriorly) spoon like spines
Ribs – interstices	ribs ca. 1-1.5 x the interstices	ribs ca. 2 x the interstices	ribs ca. 2 x the interstices
Radial ornament on posterior part of shell	always with an irregular riblet	always with an irregular riblet	sometimes with an irregular riblet
Commarginal ornament	quite coarse, more so on the ribs	fine	fine, occasional nearly smooth
Internal reflection of the ribs	in majority visible towards the umbo	developing into slight elevations towards the umbo	always visible towards the umbo

Discussion. – Within *Acanthocardia*, the shape of the ribs is a constant feature, thus forming a relevant diagnostic marker, whereas the nature of the rib ornamentation may vary to a certain degree. Therefore we conclude that *A. sliggersi* represents a separate taxon. Shells identified as *A. echinata* from the Pliocene of Iceland (*Maetra*-horizon: > 2.55 Ma, the age given for the top of the overlying *Serripes*-horizon by Buchardt & Simonarson, 2003) and illustrated by Gladenkov et al. (1980) show clearly quadrangular ribs with a central furrow and obviously belong to *A. echinata*. The occurrence of *A. echinata* earlier than or contemporarily with *A. sliggersi* is another argument to judge the latter different at specific level. *Acanthocardia sliggersi* probably evolved from *A. echinata*. We can assume that the drastic cooling down of North-western Europe during the Late Pliocene and Early Pleistocene caused the geographical isolation that accommodated the development of *A. sliggersi*.

Wood (1882), discussing a shell of *A. echinata* from the Red Crag of Sutton (Suffolk, Great Britain), made the observation, that “The Crag shell has triangular ribs (unlike the common recent species, on which the ribs are quadrate)”. This is in accordance with *A. sliggersi*. The shell illustrated by Wood (1853, pl. 14 fig. 3a-b) is deposited in BMNH, but unfortunately was not available for loan. However, relying on the illustration and description we can assume that it belongs to the new species under discussion. In Wood’s view (Wood, 1882: 12) his shell “... belongs probably to the variety called *ovata* by Dr. Jeffreys ...”. Jeffreys (1863: 271) introduced *Cardium echinatum* var. *ovata*, based on material with a length of less than 4 mm. The main mentioned feature distinguishing the var. *ovata* from typical *A. echinata* (“ribs sharp”) may fit within the conchological characters of *A. sliggersi*. Jeffreys’ name has remained enigmatic ever since its introduction: as far as we know it has only once been cited in literature (Wood, 1882: 12). Furthermore it is not accompanied

by an illustration, nor any reference to one. No type locality has been designated and no type material could be found (Warén, 1980). *Cardium echinatum* var. *ovata* is therefore considered both a *nomen dubium* and a *nomen oblitum*.

Acanthocardia sliggersi is found in well samples in The Netherlands of Late Pliocene (Piacenzian) and Early Pleistocene (Gelasian) age, where it occurs in boreal molluscan assemblages (Spaink, 1975) of the Maassluis Formation. In beach-samples from Domburg, shells of *A. sliggersi* are always totally fossilised (recrystallised) and of a grey-blue, sometimes brown or white colour. As far as cardiids are concerned, material from *Serripes groenlandicus* (Mohr, 1786) and *Ciliatocardium ciliatum* (Fabricius, 1780), both having a Recent panarctic and high boreal distribution, shows the same kind of preservation and colour.

The shell surface of the examined material of *A. sliggersi* is invariably partly decorticated, especially in the umbonal region. Next to the margins, the shell as a rule is intact, and between umbo and ventral margin some commarginal ridges and/or zones of the outer shell layer are usually preserved. Similar decorticated zones are present in two fresh specimens of *A. echinata*, trawled off Iceland from a depth of about 120 m (coll. J.J. ter Poorten). Corrosion of the umbonal region during the life span of the animal is a common phenomenon in (sub)arctic bivalves. This is caused by the relatively high HCO_3^- -concentration of cold, (sub)arctic waters, which dissolves the calcium carbonate of the bivalve shell and especially affects the aragonite components (Vermeij, 1978). We suspect that these aspects are involved in this character of *A. sliggersi*.

Some cardiid species commonly suffer loss of the outer shell-layer during the life span of the animal. For instance, this has been proved for the Pliocene *Laevicardium decortatum* (Wood, 1849). However, the presence of decorticated *Laevicardium*-specimens in warm-temperate assemblages in Piacenzian deposits in the southern North Sea Basin, indicates that decortication not necessarily needs to result from cold water temperatures.

Acanthocardia sliggersi has not been found in fosilliferous Pleistocene deposits younger than ca 1.8 Ma, that are rare in the North Sea Basin anyway. However, we cannot exclude that the species still lives in the Russian Arctic. A.I. Kafanov (pers. comm., 06.2002) states that *A. echinata* lives sympatric with *Ciliatocardium ciliatum* in the Barents Sea. The illustrations of a specimen by Filatova (1948: pl. 109 fig. 4) of a shell identified as *A. echinata*, probably originating from the Barents Sea, might in fact refer to *A. sliggersi*. The ribs look triangular in shape, without a central groove and the rib-ornament is not orientated to the posterior side of the shell as in the majority of *A. echinata*. The line drawings do not provide absolute certainty. Despite various efforts, we have been unable to retrace the material.

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