RECENT *CYRTODARIA* AND ITS FOSSIL OCCURRENCE IN GREENLAND

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The genus *Cyrtodaria* belongs to the family Hiatellidae of the desmodont pelecypods. It comprises only two living species; *C. siliqua* (Spengler, 1793) and *C. kurriana* Dunker, 1862, but several extinct species have been described. The recent species are discussed and their recent distribution, ecology, and fossil occurrences are dealt with. The fossil occurrences in Greenland are thoroughly discussed, and it is maintained that in Greenland *C. siliqua* has been met with only in interglacial deposits. It is concluded that *C. siliqua* did not spread northwards to West Greenland during the Holocene climatic optimum, as stated by some authors. The species was driven southwards to the Newfoundland – Nova Scotia – Cape Cod area due to a Pleistocene glaciation and did not return to Greenland.

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The genus *Cyrtodaria* Reuss, 1801, is rarely mentioned in scientific literature and is familiar to only a few taxonomists. The scarce data on *Cyrtodaria* are scattered, and there are only two short papers which exclusively deal with the genus. Nesis (1965) gave an account of the distribution and ecology of the recent species and, moreover, discussed the history of *Cyrtodaria,* whereas Korobkow & Mironowa (1965) described a new fossil species. The most thorough examination of the genus was made by Strauch (1972).

The genus *Cyrtodaria,* which belongs to the family Hiatellidae of the desmodont pelecypods, comprises only two living species; *C. siliqua* (Spengler, 1793) and *C. kurriana* Dunker, 1862. These species have sometimes been erroneously regarded as one, e.g. by Friele (1878), Friele & Grieg (1901), Dautzenberg & Fischer (1912), and Lamy (1913, 1926). Several extinct species belonging to the genus have been described, the oldest of which, *C. rutupiensis* (Morris, 1852), appears in Palaeocene deposits in Spitsbergen and England (Strauch, 1972 p. 98–101). Thus, the genus apparently ranges from the Palaeocene to Holocene (here denoting the last 10.000 years). According to Strauch (1972 p. 101) it evolved from the genus *Panopea* Menard, 1807, during the transition of the Cretaceous to the Tertiary.

Cyrtodaria siliqua and *C. kurriana* – two distinct species

As already mentioned the two living species of *Cyrtodaria* have sometimes been regarded as one. Therefore I think it useful to consider some characteristic features of those species.

Cyrtodaria siliqua (pl. 1, figs. 1–3) attains a rather large size; up to 100 mm in length. The shell is elongate, with dorsal and ventral edges parallel and equally rounded. The surface of the shell is smooth. Distinct concentric growth lines are visible and faint striae may sometimes be seen to cross them on the anterior and posterior ends. The beak is nearer to the posterior end (pl. 1, fig. 2). Teeth are absent, but a prominent ligament list is present on the posterior dorsal edge. There are two muscle scars on the inside of the shell, and a small pallial sinus indicates the sinupalliat character of the species (pl. 1, fig. 3). The shell is twisted round the length axis.

Nesis (1965 p. 198–200) pointed out the peculiar outward appearance of *C. siliqua:* "The shell sits on the body of the mollusk like a tight coat on a fat man, gaping in front, from below and from behind and the valves closing only near the beak." The mantle lobes are grown together, only leaving an opening in front for the small and weak foot. The united siphons cannot extend greatly, as indicated by the small pallial sinus.

Although there is a strong resemblance between *C. siliqua* and *C. kurriana* (pl. 1, figs. 4–6) they may be distinguished on the basis of some adult characteristics, amongst which is the considerably smaller size of the latter, for the maximum length of *C. kurriana* is only about 40 mm. Further, *C. kurriana* differs from *C. siliqua* in being comparatively more elongated, in having a thinner shell with a more prominent beak in a more equilateral position, in having somewhat more distinct growth lines on the surface of the shell, and in having a less twisted shell.

The differences between *C. siliqua* and *C. kurriana* cannot be regarded as variation within the range of one species. They must therefore be regarded as two distinct species (cf. Ockelmann, 1958 p. 143; Nesis, 1965 p. 201; Strauch, 1972 p. 89–92).

Recent distribution and ecology of *Cyrtodaria siliqua* and *C. kurriana*

Nesis (1965 p. 198–201) has given a detailed account of the recent distribution and ecology of *C. siliqua.* According to him the species is distributed in the Newfoundland – Nova Scotia – Cape Cod area (text-fig. 1), where it has been found on the Great Newfoundland Bank and the Ban-

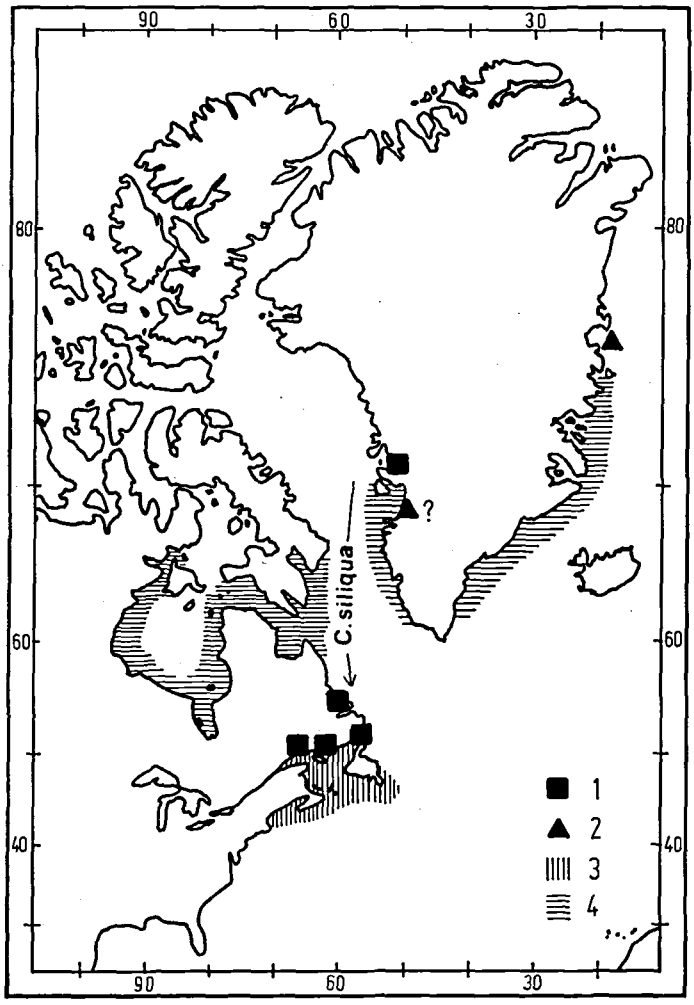

Fig. 1. Distribution of *Cyrtodaria siliqua* and *C. kurriana* in Greenland and Northeast America. 1. Fossil *C. siliqua*. 2. Fossil *C. kurriana*. 3. Recent *C. siliqua*. 4. Recent *C. kurriana*. *C. siliqua* has not been met with, either fossil or recent, outside the mapped area. The species migrated southwards from West Greenland to the Newfoundland-Nova Scotia-Cape Cod area due to a Pleistocene glaciation.

quereau Bank, in the Gulf of St. Lawrence, the Gulf of Maine, and on the Georges Bank off Cape Cod. The species does not occur north of the Great Newfoundland Bank or on the Flemish Cap Bank which is separated from the former by a 1200 m deep strait. Thus, *C. siliqua* is a West Atlantic north boreal species in its distribution. *C. siliqua* is a suspension feeder and inhabits a bottom of fine sand down to 500 m, but prefers

depths of 50–150 m. The species has been observed at temperatures from ÷1.0°C to +5.7°C. It has been found at salinities from 32.3 ‰ to 34.2 ‰.

Amongst those who have dealt with the distribution and ecology of *C. kurriana* are Ockelmann (1958), Nesis (1965), and Strauch (1972). The species is known from Spitsbergen, Jan Mayen, Franz Josef Land, Novaya Zemlya, the Petchora estuary, the Kara Sea, the Laptev Sea, the East Siberian Ice Sea, the northern coast of Chukchi peninsula, the Anadyr estuary, the Amur estuary, Norton Sound, Alaska east of Point Barrow, Hudson Bay, Hudson Strait, and Ungava Bay. Furthermore, *C. kurriana* has been found at West Greenland off Godhavn, Egedesminde, and Godthaab (Thorson, 1951 p. 106), and at East Greenland, where it is distributed from Sabine Ø in the north to Kap Tordenskjold in the south (Ockelmann, 1958 p. 143) (see text-fig. 1). From the above it is evident that *C. kurriana* is panarctic and circumpolar. It is, however, mainly high-arctic in its distribution. The species is a suspension feeder which burrows in sandy bottom and seems to prefer shallow coastal water (Ockelmann, 1958 p. 143; Nesis, 1965 p. 201–203). The vertical range recorded is from 1–9.5 m (East Greenland) to 19–56 m (Jan Mayen).

Fossil occurences of *Cyrtodaria siliqua* and *C. kurriana*

Fossil specimens of *C. siliqua* have been recorded in Pliocene – Lower Pleistocene deposits in Holland (Tesch, 1912), in Pliocene – Lower Pleistocene beds on the Tjörnes peninsula in North Iceland (Winkler, 1863; Mørch, 1871; Schlesch, 1924; Bárdarson, 1925; Áskelsson, 1941; Strauch, 1963), in Late Wisconsin – Holocene sediments in West Greenland (Rink, 1852; Nordenskiöld, 1871; Steenstrup, 1883; White & Schuchert, 1898; Laursen, 1944), and in Late Wisconsin – Holocene deposits in East Canada in the area where it now lives (Packard, 1867; Dall, 1898; Richards, 1962).

Nesis (1965 p. 204) and Strauch (1972 fig. 21) summarized the fossil occurrence of *C. kurriana*. According to them it has been recorded in Pleistocene and Holocene sediments in Arctic Soviet from the Urals in the west to the Chukchi peninsula in the east and in Western and Northern Alaska. Neither Nesis nor Strauch were aware of Jensen's record from Northeast Greenland where the species was recorded in an apparently Holocene clay deposit (cf. Jensen, 1917 p. 625).

C. siliqua recorded in Pliocene – Lower Pleistocene deposits in Holland is now referred to *C. angusta* (Nyst & Westendorp, 1839) which is found in Middle Miocene to Lower Pleistocene sediments in the North Sea area (cf. Strauch, 1972 p. 102–103).

The presence of *C. siliqua* in the Tjörnes beds (North Iceland) has been questioned by some authors. Thus, Soot-Ryen (1932 p. 28) was of the opinion that the *Cyrtodaria* in these deposits were in reality *C. kurriana.* MacNeil (1957 p. 119) has correctly pointed out that this interpretation is in disagreement with the fact that the species is supposed to have an undisputable northern relationship. Áskelsson (1960a p. 20–21; 1960b p. 29), on the other hand, considered the *Cyrtodaria* in the Tjörnes beds as *C. angusta.* Finally, Strauch (1972 pag. div.) regarded the *Cyrtodaria* in the Tjörnes deposits as partly *C. angusta,* and partly *C. jenisseae* Sachs, 1953. The latter species is widely distributed in Middle and Upper(?) Pleistocene sediments in Arctic Soviet and, according to Strauch (1972 fig. 21), it also occurs in Late Wisconsin deposits in Newfoundland.

I have compared correctly identified *C. siliqua* with fossil *Cyrtodaria* from Tjörnes and am of the opinion that it has not been met with in the Tjörnes deposits. Hence, the fossil occurrence of *C. siliqua* is restricted to West Greenland and East Canada (see also Strauch, 1972 fig. 21). The records from West Greenland will be further discussed in the following.

Fossil *Cyrtodaria* in Greenland

The first record of fossil *Cyrtodaria* from Greenland was given by Rink (1852 p. 96) who reported *C. siliqua* (naming it *Glycimeris siliqua* Spgl.) in the marine Quaternary deposits at Pátorfik on the north coast of the Nûgssuaq peninsula, West Greenland. The next contribution was that of Nordenskiöld (1871 p. 1018) who recorded the same species from Pátorfik and Lerbugten in the southeastern part of the Disko Bugt. S. Lovén determined the fossils that Nordenskiöld brought from West Greenland and concluded (in Nordenskiöld, 1871 p. 1019) that all the species are now living in "the Ice Sea". From Lovén's concluding remark it is, however, evident that he did not distinguish between *C. siliqua* and *C. kurriana,* as the former does not occur in "the Ice Sea" at present. Steenstrup (1883 p. 235) and White & Schuchert (1898 p. 349) also reported *C. siliqua* in the Pátorfik deposits.

Laursen (1944), who undertook comprehensive investigations within the Quaternary of West Greenland, has recorded *C. siliqua* from three localities on the coast of West Greenland, viz. Pátorfik, Sarpiussat, and Lerbugten. It is evident from Laursen's paper (1944 p. 59, pl. 2a) that his records from Sarpiussat and Lerbugten are cited from Nordenskiöld (1871 p. 1018). When studying Nordenskiöld's fauna-list it is, however, quite clear that he did not record the species from Sarpiussat, i.e. Laursen's citation was erroneous.

In 1949 Harder, Jensen & Laursen published their work on the marine Quaternary sediments in the Disko Bugt. Among other localities, they investigated Lerbugten and wrote (p. 80): "Nordenskiöld, who was in this locality in 1870, recorded among others *Cyrtodaria siliqua* (Spgl.). This species was also found, but not fossil; recent specimens alone were observed washed up on the beach from the bay, where it lives." As mentioned before, *C. siliqua* does not live at Greenland now, whereas *C. kurriana* occurs both at West and East Greenland, for instance in the Disko Bugt (see text-fig. 1). Thus, these authors obviously did not distinguish between the two species. The question now arises; whether *C. siliqua* recorded by Nordenskiöld was also washed up from the bay. In any case, *C. kurriana* is the only *Cyrtodaria* known to live in "the Ice Sea" and Lerbugten at present. Therefore a revision of Nordenskiöld's material was needed. The material was found in the collections of Naturhistoriska Riksmuseet, Paleozoologiska Sektionen, Stockholm, and placed at my disposal. An examination of the material revealed that Nordenskiöld's *C. siliqua* from Lerbugten must be referred to *C. kurriana* (Pl. 1, fig. 4). The valves (two left and two right valves) are well preserved, with fresh periostracum, and might have been washed up on the beach from the bay. *C. siliqua* must therefore be omitted from the list of Quaternary fossils from Lerbugten.

A re-examination of the *Cyrtodaria* in the Pátorfik deposits has confirmed the occurrence of *C. siliqua* (pl. 1, figs. 1–3). The specimens are rather well preserved and large; up to 70 mm in length. The material from Pátorfik has, furthermore, been examined with respect to finding *C. kurriana* or *C. jenisseae,* but with a negative result.

Jensen (1917 p. 625) has recorded fossil *C. kurriana* from Store Koldewey Ø, Northeast Greenland, where it was met with in a clay deposit about 120 m above sea level. The deposit appears to be of Holocene age, but no radiocarbon date has been obtained on material from this locality.

The age of the Quaternary deposits at Pátorfik and in Lerbugten must be discussed. Laursen (1944, 1950) regarded them as Late Wisconsin – Holocene, i.e. younger than the maximum of the Wisconsin glaciation. Already in 1938 A. Rosenkrantz had noticed the consolidation and brecciation of the marine Quaternary deposits at Pátorfik which are known to contain a rich molluscan fauna with a decidedly modern aspect. Because of this consolidation and brecciation he had an idea that they might be interglacial (Rosenkrantz, 1968 p. 147). In the summer of 1964 E. Nordmann and A. Rosenkrantz collected fossil shells at Pátorfik to be analysed radiometrically. The shells were dated as more than 35.000 years old (Rosenkrantz, 1968 p. 147). In 1968 I had the opportunity to collect fossil shells in the Pátorfik beds. A sample from the uppermost part of the deposits was dated (as the other one) by H. Tauber, Carbon-14 Dating Laboratory, National

Museum, Copenhagen. These shells were also dated older than 35.000 years. The marine Quaternary beds at Pátorfik must therefore be regarded as older than 35.000 years which, considering the field relations and the faunal dependence on the water temperature, must represent an interglacial. This conclusion had already been arrived at by Rosenkrantz in 1968 (p. 147). The modern character of the fauna and flora (S. Funder, personal communication) as well as the field relations suggest that the interglacial deposits at Pátorfik can be no older than Middle Pleistocene. An Upper-Pleistocene age (Sangamon-Eemian) seems most probable but, at the present state of knowledge, it is not possible to determine the interglacial stage in question with any accuracy. This problem is currently under study.

Radiocarbon dates from the inner Disko Bugt furnish a Holocene age (younger than 10.000 years) for the marine Quaternary deposits in Lerbugten (Weidick, 1968 p. 115–118).

It is therefore established that in Greenland *C. siliqua* has only been found in the interglacial deposits at Pátorfik (West Greenland), whereas fossil specimens of *C. kurriana* have been collected on Store Koldewey Ø (Northeast Greenland) in an apparently Holocene deposit, and the species may also have been met with in Holocene sediments in Lerbugten (West Greenland) (cf. text-fig. 1). The extinct species of *Cyrtodaria* are unknown from Greenland.

Remarks on the migration of *Cyrtodaria siliqua*

Nesis (1965 p. 203–205) has discussed the history and migration of the genus *Cyrtodaria*. According to him it is of Atlantic origin and descended in the early Neogene from the ancestral form living in the South Russian geosyncline. The genus then spread in the North Atlantic and Arctic by the end of the Neogene and broke up into a number of species. These species became extinct in Europe during the Pleistocene, and the West Atlantic *C. siliqua* was driven southwards to the area where it now lives. Furthermore, Nesis (1965 p. 204) stated: "During the postglacial period *C. siliqua* rapidly spread to the north and at the period of climatic optimum it appeared off the coasts of Greenland. After the end of the warmer period it moved back to Newfoundland."

However, Strauch (1972) is of the opinion that *Cyrtodaria* had a northern centre of development and expanded in the early Cenozoic to the south. According to him (1972 p. 114) the ancestors of *C. siliqua* migrated westwards from the North Sea region between Scotland and the Faroes and evolved into true *C. siliqua* reaching the Newfoundland – Nova Scotia – Cape Cod area during the Quaternary. Then Strauch wrote (1972 p.

123): "Während *C. jenisseae* mit jeder Abkühlung des Pleistozäns nach S verschoben wurde, konnte zur Zeit des postglazialen Wärmeoptimums (Laursen 1950: 2°C höher als heute) hingegen *C. siliqua* bis an die Küsten Labradors und des mittleren Westgrönlands vorstossen."

Thus, both Nesis (1965) and Strauch (1972) stated that *C. siliqua* spread to West Greenland during the Holocene climatic optimum. However, nothing supports this opinion as it has already been demonstrated that in Greenland the species is met with only in the interglacial deposits at Pátorfik. Outside West Greenland fossil specimens of *C. siliqua* have been found only in Late Wisconsin – Holocene deposits in East Canada, as already mentioned.

Considering that all known occurrences of fossil and recent *C. siliqua* are in areas in the North Atlantic region the species is probably of Atlantic origin. Indeed, the species seems to be most closely associated as to origin with *C. angusta* and *C. jenisseae* (cf. Nesis, 1965 p. 203; Strauch, 1972 p. 114). Palaeontological data available suggest that the species first invaded the West Greenland shelf, whence it migrated southwards in the Pleistocene to the area where it now lives. On the other hand, it seems impossible, at the present state of knowledge, to acertain the route along which *C. siliqua* reached Greenland.

As *C. siliqua* has been met with in Greenland only in interglacial deposits it is concluded that the species did not spread northwards to West Greenland after the Wisconsin glaciation. The species was driven south to the Newfoundland – Nova Scotia – Cape Cod area due to a Pleistocene glaciation and did not return to Greenland (see text-fig. 1). In fact it could not reach Greenland again during the Holocene on account of the vast areas of deep sea surrounding the island and the strong south-moving

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Plate 1

Cyrtodaria siliqua (Spengler).

Fig. 1. External view of a right valve in a concretion. Interglacial. Pátorfik, West Greenland. × 1.

Fig. 2. Dorsal view of another specimen. Interglacial. Pátorfik, West Greenland. × 1.

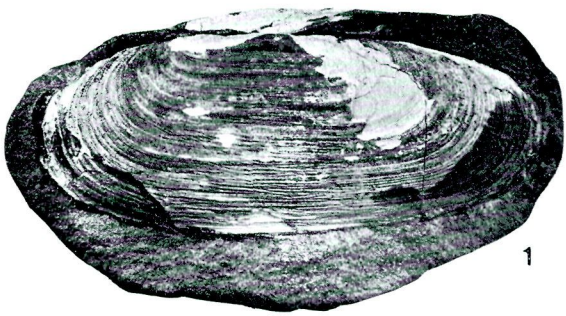
Fig. 3. Internal view of a fragmentary right valve showing adductor scars, pallial sinus, and the hinge. Interglacial. Pátorfik, West Greenland. × 1.

Cyrtodaria kurriana Dunker.

Fig. 4. External view of a right valve. Lerbugten, West Greenland. Nordenskiöld's coll. × 1.

Fig. 5. External view of a right valve. Recent. Jan Mayen. × 1,7.

Fig. 6. External view of a right valve (the same as in fig. 5). Recent. Jan Mayen. × 1.



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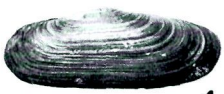

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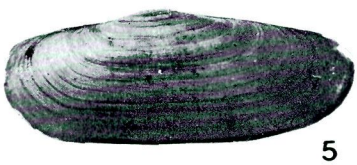

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cold Labrador current which represented barriers to the larvae of this southern infauna pelecypod.

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Dansk sammendrag

Muslingeslægten *Cyrtodaria* tilhører den desmodonte familie Hiatellidae. Denne atlantiske slægt indeholder to nulevende arter, *C. siliqua* (Spengler, 1793) og *C. kurriana* Dunker, 1862, samt nogle uddøde arter. De nulevende arter diskuteres og der gives en oversigt over deres recente og fossile udbredelse samt deres økologi. Der lægges særlig vægt på de to arters fossile udbredelse i Grønland og det påvises, at *C. siliqua* her kun er fundet i de interglaciale aflejringer ved Pátorfik på Nûgssuaqhalvøens nordkyst. Det er forfatterens anskuelse, at *C. siliqua* ikke migrerede til Vestgrønland under det varmeste afsnit af Holocænet som antaget af nogle forfattere. Arten migrerede sydpå fra Vestgrønland til Newfoundland – Nova Scotia – Cape Cod området på grund af nedsat vandtemperatur i forbindelse med en nedisning i Pleistocæn, og den nåede ikke til Grønland igen.

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