13. OSTRACODS

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INTRODUCTION

Material was kindly provided by Karen Luise Knudsen from samples prepared in Aarhus Universitet for foraminiferal study, thus numbers of ostracods and foraminifers are directly comparable as they are complete assemblages from the same samples. As ostracods, unlike foraminifers, cannot be successfully concentrated by flotation methods the specimens were picked by hand from light and heavy flotation fractions following removal of the foraminifers. Ostracods were common: Brastad core – 37 samples studied of which 7 were barren, Solberga core – 65 samples studied of which 16 were barren. In the case of the Moltemyr core time did not permit examination of the same samples for both foraminifers and ostracods. In this latter core 30 samples were studied of which 9 were barren.

THE OSTRACODA

Living ostracods inhabit all aquatic environments, in the benthos and as marine zooplankton. In the present material only benthic forms occurred and no freshwater/non-marine species were found. The distribution patterns and ecological preferences of many of the species are well known (see Appendix) as they are extant and have been recorded, for example, by G.O. Sars (1865, 1922–1928) off Norway, by O. Elofson (1941) off south-western Sweden and by A. Rosenfeld (1977, 1979) from the Baltic Sea. It is, however, surprising that many species have uncertain modern records, a problem compounded by reworking of fossil material into Recent assemblages. In many older records (e.g. Brady 1868, Brady and Norman 1889) it is impossible to tell if the specimens were alive at the time of collection or only isolated valves and carapaces which may have been reworked. Certain species are known living only from high-latitude waters (*Rabilimis mirabilis, Baffinicythere emarginata,* etc.) or as fossils from apparently cold-water deposits (*Cytheropteron biconvexa, C. montrosiense, Roundstonia globulifera,* etc.). Other species have a wide arctic and boreal distribution at the present day and are common in most assemblages (*Acanthocythereis* *dunelmensis, Elofsonella concinna, Heterocyprideis sorbyana, Eucytheridea bradii, E. punctillata, Palmenella limicola,* etc.). Similarly, certain species do not occur in modern high-latitude waters but are characteristic of the southern Norwegian, Baltic and Celtic/Britannic areas (*Leptocythere* species, *Cytheromorpha* species, certain *Semicytherura* and *Loxoconcha* species, etc.). Some ten of the species found are common in brackish waters, but only *Xestoleberis nitida* is essentially restricted to brackish conditions (15–30°/∞). Many of the marine forms are to some extent euryhaline (cf. Rosenfeld 1977 on Baltic Sea distributions).

The core study has been particularly valuable as it has provided a *stratigraphical* record of ostracods in the late Pleistocene and Holocene and this aspect of the work will be described fully elsewhere. The material contained two new species of *Cytheropteron (C. brastadensis, C. elofsoni)* and specimens assigned to *'Cytherura' complanata* Brady, Crosskey & Robertson, a species unrecorded since its original description in 1874.

BRASTAD

Assemblages from Brastad (Fig. 13:1) core contain 37 species of which 13 belong to the genus *Cytheropteron,* a taxon common in Quaternary Boreal and Arctic faunas (see Whatley and Masson 1979).

At the bottom of the sequence poor assemblages reflect cold, shallow-water essentially arctic conditions, but from 13.00 m below surface a more temperate, Boreal element is present and density/diversity increase. From 11.50 m conditions apparently deteriorated, culminating in a poor cold, shallow-water assemblage at 10.50 m. Between 10.50 and 6.50 m assemblages increase in size and diversity with some temperate/southerly species present, generally indicative of open-marine boreal-arctic conditions. From this point the number of specimens in the assemblages declines and temperate species disappear, the Arctic element in the fauna fluctuates while the widespread Boreal-Arctic species remain a more-or-less constant element. This suggests a gradual cooling of the waters, perhaps associated with some change in water-circulation patterns, however, the change is not dramatic and maximum diversity occurs at 3.50 m (just before maximum foraminiferal diversity) despite decreasing numbers of specimens. Above 3.50 m there is a rapid decline in diversity and density and above 2.30 m only a few specimens occur suggesting cold, shallow-water conditions. It is curious that the highest percentage of Boreal foraminifers should occur at 2.75 m when the ostracod assemblages have already declined.

The proportion of extinct to extant species and the assemblage compositions suggest that much of the section of the Brastad core below 2.30 m

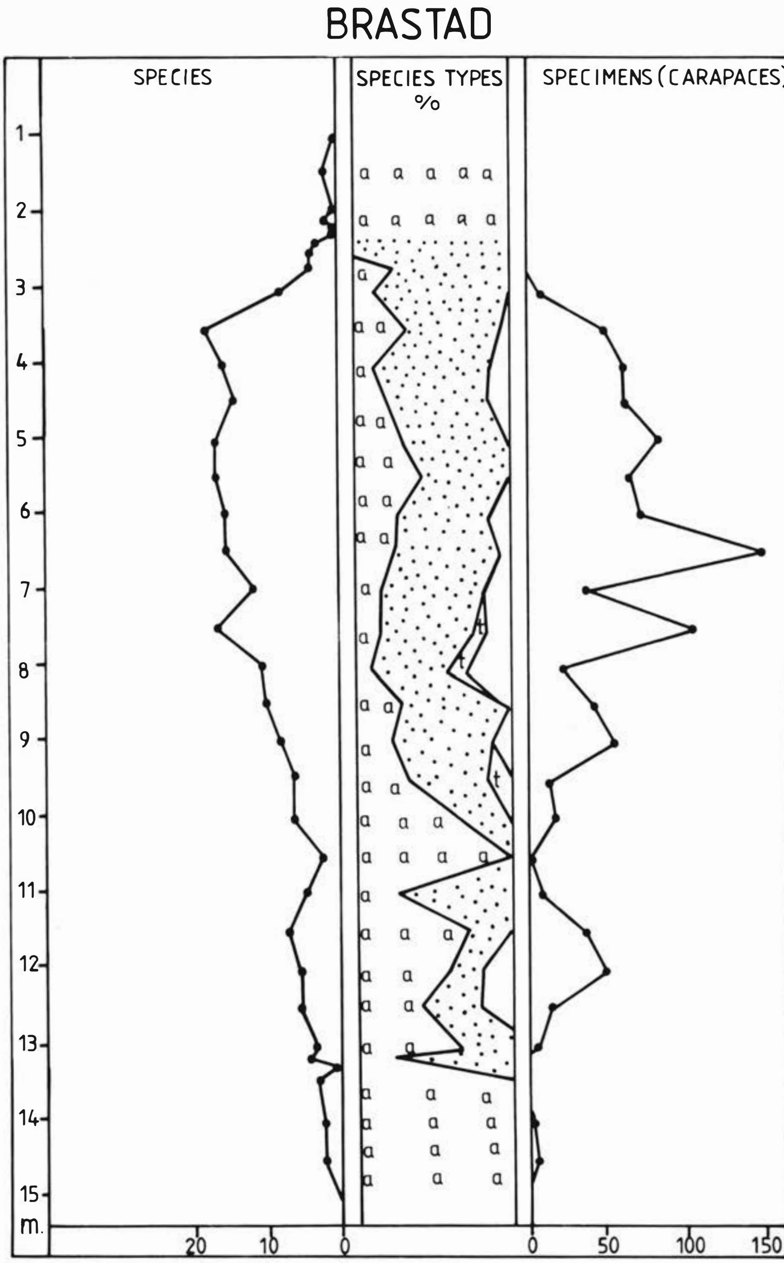

Fig. 13:1. Brastad core density and diversity plots and assemblage analyses. Note diversity refers to total number of species present. a = Arctic/cold water species, dotted area = wide spread Arctic and Boreal species, t = temperate/southerly species, blank = indeterminate and miscellaneous juveniles.

reflects a relatively temperate episode during the late Weichselian. The sharp break at 2.30 m, seen also in the sediments, *etc.*, indicates a non-sequence possibly associated with a meltwater or ice event and the few ostracods found in the top part of the section may well be reworked.

SOLBERGA

Assemblages from Solberga (Fig. 13:2) core contain 40 species of which 6 belong to *Cytheropteron.* The bottom part of the core sequence, below 26.0 m, contains good Arctic cold-water assemblages, but from 25.50 m more temperate influences are demonstrated by the appearance of *Semicytherura* and *Cytheromorpha* species. This somewhat warmer water element is present in most other assemblages from the core although varying in importance. The cold, high Arctic species continue to occur in the samples until 17.50 m. The overall trend in the lower half of the core is thus towards replacement of cold water forms by more temperate species, the same broad pattern can be seen in foraminiferal distributions where really cold water types disappear at about 18.0 m and the proportion of Boreal species increases strongly at about the same level. There are variations in this trend, with relatively small cold-water assemblages at certain levels (25.0, 23.0, 22.0, 20.0 m). The richest sample was at 18.25 m, which coincides with the most diverse foraminiferal assemblage. It is worth noting that rich and diverse assemblages can occur at high latitudes, as demonstrated by the Subrecent fauna described by Neale and Howe (1975) from Novaya Zemlya with 45 species and over 4 000 specimens. Above 17.0 m the assemblages decline in numbers of species and specimens, with an essentially barren interval between 10.0 and 4.50 m and good ostracod faunas occur again between 4.50 and 2.50 m. These final and youngest assemblages could occur in the western Baltic (see Rosenfeld 1977) or Øresund (see Hagerman 1965) at the present day, with the important exception of *Paracyprideis fennica* (Hirschmann) which is widespread in living faunas with a salinity range of 3–25°/∞. It should be noted that the majority of species present in the youngest assemblages also occur sporadically in the poor, low-diversity samples between 17.0 and 10.0 m. It would thus appear that the most modern faunas were being established from approximately 17.0 m, but that the general trend has been interrupted.

The sequence of ostracod assemblages documents a change from arctic cold-water to warmer water conditions approaching those found in the area at the present day. Most of the species are still extant and those which are extinct, or probably so, all occur in the oldest part of the sequence. The leptocytherid *Cluthia cluthae,* a high-latitude, cool shallow-water species, is

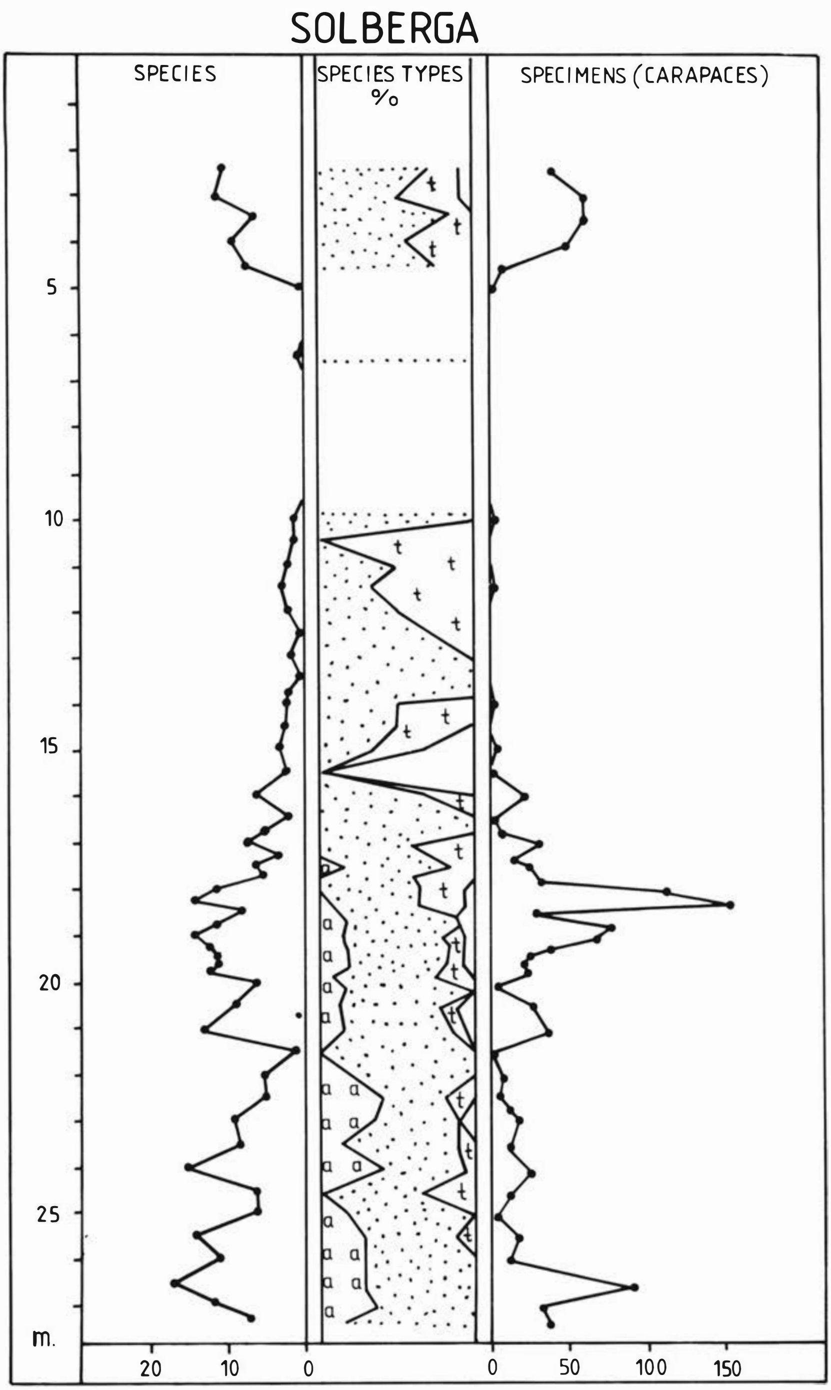

Fig. 13:2. Solberga core density and diversity plots and assemblage analyses. The key to the signs appears at Fig. 13:1.

replaced at *c.* 18.0 m by its more southerly, warmer water relations *Leptocythere tenera* and *L. pellucida.* Other high latitude/cool-water species disappear in the lower part of the core, e.g. *Rabilimis mirabilis* at 26.50 m, *Cytheropteron pseudomontrosiense* at 22.50 and *C. arcuatum* at 23.50 m. The high-latitude loxoconchid *Roundstonia globulifera* disappears at 22.0 m and is replaced in the more temperate assemblages at the top of the sequence by *Loxoconcha granulata.* The appearance of more temperate, effectively modern faunas can be recognized at *c.* 18.50 m where *Leptocythere* first occurs accompanied by *Hirschmannia tamarindus.*

MOLTEMYR

Assemblages from Moltemyr (Fig. 13:3) core contain 43 species of which 11 belong to *Cytheropteron.*

At the bottom of the sequence, below 4.7 m, assemblages reflect cold-water arctic conditions, especially the two bottom samples which contain *Cytheropteron montrosiense, C. simplex, C. biconvexa, Roundstonia globulifera* & *'Cytherura' complanata.* Other cool-water forms occur at 5.7 m *(Rabilimis mirabilis, Krithe glacialis, C. elofsoni),* but the number of specimens increases steadily until 4.7 m where high densities occur. Three samples at 4.6–4.7, 4.35–4.40 and 4.15–4.20 m are not only rich and diverse but are also distinguished by the appearance of more temperate, warmer water forms, viz. *Hirschmannia* species, *Leptocythere* species, *Xestoleberis* and *Cytheropteron latissimum.* Certain of these forms may reflect shallow-water conditions. A barren level at 3.95–4.0 m is followed by poorer assemblages with no new appearances. Diversity and density are good between 3.8 and 3.5 m but above this only relatively poor assemblages occur and above 2.66 m the samples were barren. Many or all of the specimens from the 3.5 to 2.66 m interval are clearly reworked and the sporadic occurrences of a number of species probably have little environmental significance.

The Moltemyr sequence shows cold, high-latitude assemblages being replaced by richer, more temperate ones. The barren level at 3.95–4.0 m is curious and is matched by a decrease in foraminiferal density and diversity at 3.9 m. The marked decline in ostracods at *c.* 3.5 m is matched by a similar reduction in foraminifers. The upper part of the sequence reflects possibly meltwater influences. No non-marine ostracods were found, only species already recorded which appear to have been reworked. Generally the Moltemyr sequence duplicates the lower part of Solberga and the upper barren part compares with the poorly fossiliferous and barren mid-part of the latter site (Fig. 13:4). The appearance of temperate forms accompanied

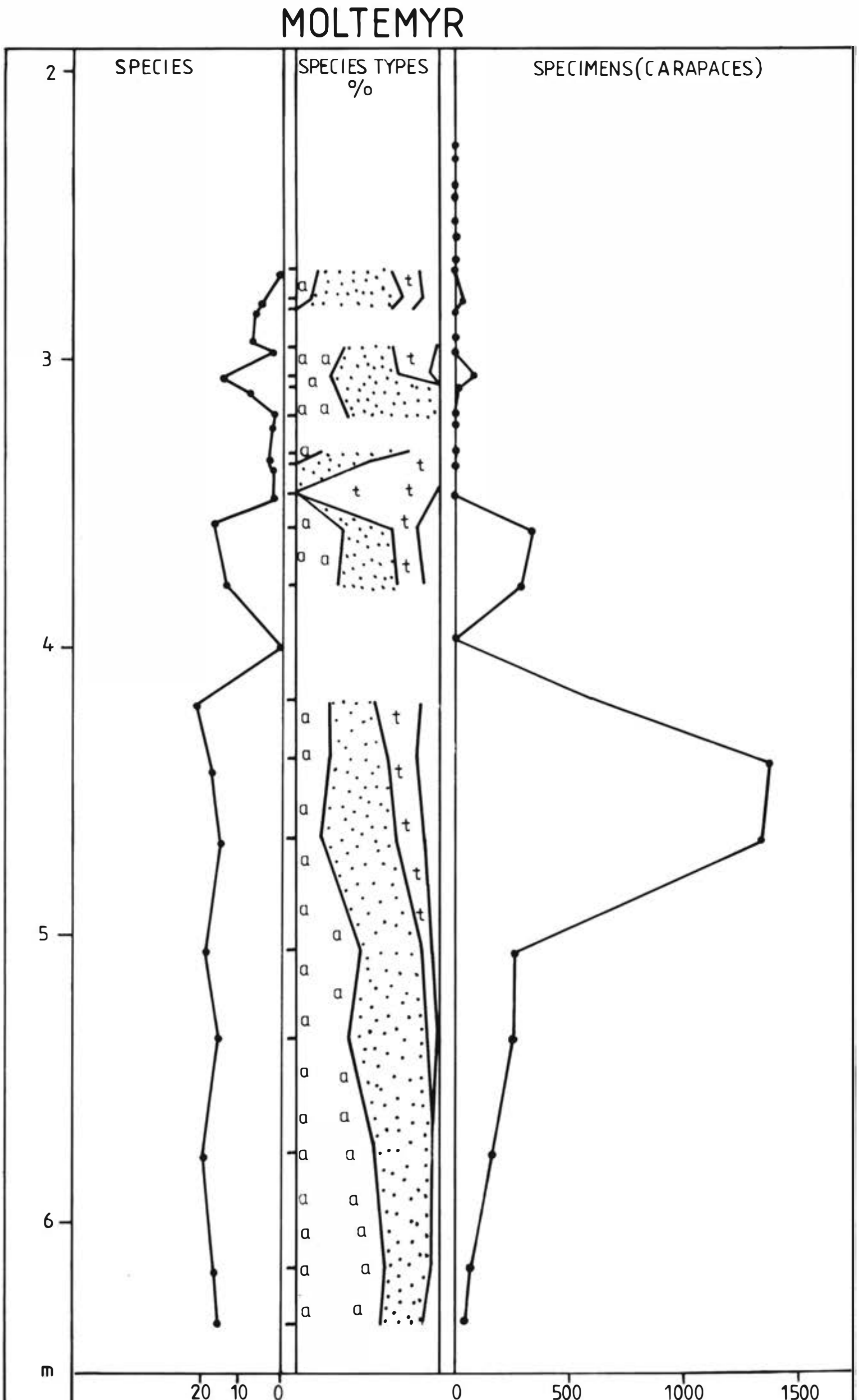

Fig. 13:3. Moltemyr core density and diversity plots and assemblage analyses. The key to the signs appears at Fig. 13:1.

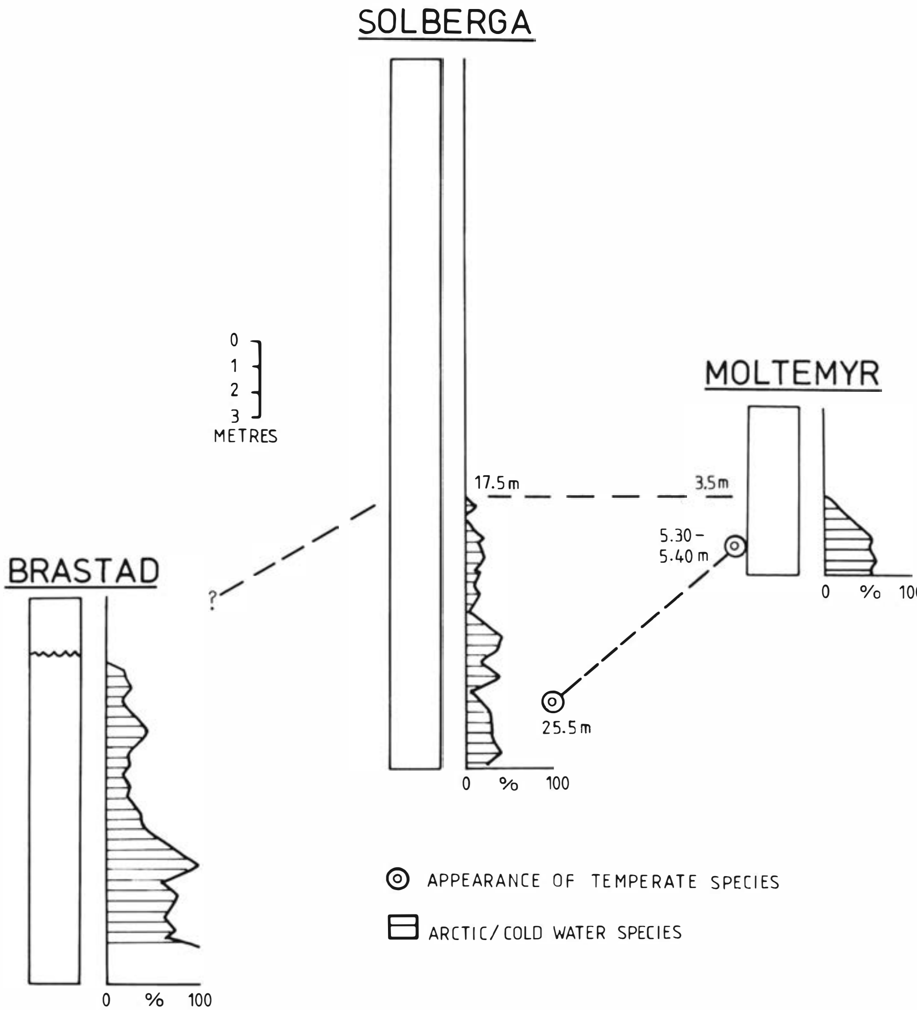

Fig. 13:4. Comparison of ostracod assemblages between the Brastad, Solberga and Moltemyr core.

by high faunal density and diversity at *c.* 4.5 m is matched by similar features at *c.* 18.25 m at Solberga. The cold assemblages at the bottom of the Moltemyr core compare with those from Brastad (Fig. 13:4). The Moltemyr sequence thus overlaps those penetrated at Solberga and Brastad. A clear level, where temperate, more southerly species occur, replacing Arctic, cold-water forms, can be recognized at both Solberga and Moltemyr. The Brastad core contains an essentially arctic series of ostracod assemblages which is suddenly terminated at the top of the sequence.

APPENDIX

THE OSTRACODA

The following species occur in the cores (with annotations to indicate generalised distributional/ecological preferences – p = phytal, i = interstitial, l = littoral, n = neritic, m = full marine, b = brackish. Distributions: A = Arctic, B = Baltic, C = Celtic/Britannic, N = Norwegian. * living; $^{+}$ extinct; ° uncertain living).

Acanthocythereis dunelmensis (Norman)*	n, m, A, B, C, N, etc.
Argilloecia conoidea Sars*	l, m, A, N
?*Baffinicythere howei* Hazel*	n, m, A, Nova Scotia
Baffinicythere emarginata (Sars)*	n, m, A, N
Bythocythere constricta Sars*	n, m, A, C, N
Cluthia cluthae (Brady, Crosskey & Robertson)*	n, m, A, B, C, N, etc.
Cythere lutea O.F. Müller*	p, l, n, m, A, B, C, N, etc.
Cytheromorpha fuscata (Brady)*	l, m/b, B (?), C, N
C. robertsoni (Brady)*	l/n, m/b, B, C, N
Cytheropteron arcuatum B., C. & R.°	m (cold-fossil)
C. biconvexa Whatley & Masson^{+}	n, m (cold-fossil)
C. brastadensis Lord^{+}	l/n, m (cold-fossil)
C. dimlingtonensis Neale & Howe°	m, A (subrecent)
C. elofsoni Lord^{+}	l/n, m (cold-fossil)
C. inflatum B., C. & R.*	n, m, A, C, N
C. latissimum (Norman)*	l, m/b, B, C, N
C. montrosiense B., C. & R.$^{+}$	l/n, m (cold-fossil)
C. nodosoalatum Neale & Howe*	l, n, m, A
C. nodosum Brady*	n, m, C, N
C. cf. *C. pipistrella* Brady^{+}	m
C. pseudomontrosiense Whatley & Masson°	m, A
C. simplex Whatley & Masson^{+}	l, m (cold-fossil)
C. cf. *C. subcircinatum* Sars*	l, n, m, C, N
'*Cytherura*' *complanata* B., C. & R.$^{+}$	m (? cold-fossil)
Elofsonella concinna (Jones)*	n, m, A, B, N, etc.

Eucytheridea bradii (Norman)*	n, m, A, B, C, N, etc.
E. punctillata (Brady)*	n, m, A, B, C, N, etc.
Finmarchinella (Barentsovia) angulata (Sars)*	n, m, A, C, N, etc.
F. (B.) barentsovoensis Mandelstam*	n, m, A
?*F. (B.) curvicosta* Neale*	n, m, A
Finmarchinella (Finmarchinella) finmarchica (Sars)*	n, m, A, C, N, etc.
Hemicytherura cf. *H. clathrata* (Sars)*	l/n, m, A, C, N
Heterocyprideis sorbyana (Jones)*	n, m, A, B, C, N, etc.
Hirschmannia viridis (O.F. Müller)*	p, l, m/b, A, B, C, N
H. tamarindus (Jones)*	p, l, m/b, B, C, N, etc.
Jonesia simplex (Norman)*	n, m, A, B, C, N
Krithe cf. *K. bartonensis* (Jones)*	l/n, m, C, N
Krithe glacialis B., C. & R.°	l/n, m (cold-fossil/ subrecent)
Leptocythere castanea (Sars)*	i, l, m, B, C, N
Leptocythere pellucida (Baird)*	p/i, l, m, B, C
Leptocythere tenera (Brady)*	i, l, m/b, B, C, N
Loxoconcha granulata Sars*	p, l, m/b, B, C, N
Loxoconcha cf. *L. rhomboidea* (Fischer)*	p, l, m, C, N
Normanicythere leioderma (Norman)*	n, m, A, C, N
Palmenella limicola (Norman)*	n, m, A, B, C, N, etc.
Polycope areolata Sars*	n, m, N
Rabilimis mirabilis (Brady)*	n, m, A
Robertsonites tuberculata (Sars)*	n, m, A, B, C, N, etc.
Roundstonia globulifera (Brady)+	l, m (cold-fossil)
Semicytherura cf. *S. affinis* (Sars)*	m, N
Semicytherura ?*nigrescens* (Baird)*	p, l, m/b, B, C, N
S. similis (Sars)*	p, l, m/b, B, C, N
S. undata (Sars)*	p, l, m/b, B, C, N
Xestoleberis nitida (Liljeborg)*	b, B, C, N

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