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ABSTRACT

Distribution of an Arctic Ostracode fauna in space and time

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If one finds a particular type of fossil organism which at present is restricted to a certain geographic locality several hundred or thousand kilometers away, what can be said about the paleoenvironment of the fossil locality? Can a chronology of events be established for the fossil locality?.

A fossil locality on the Pembina Upland, in southern Manitoba (Delorme, 1971) contains three or four ostracode species (seed shrimp) near the base of the deposit. Two of these ostracodes, Candona rectangulata and Cyclocypris globosa are found alive only in the northern parts of the Northwest and Yukon Territories of Canada. Both species are indicative of subarctic forest tundra and alpine tundra. Their position in the lower 69 cm of the deposit indicates that, as the glacial ice thinned over the upland and retreated from the Agassiz basin, a tundra-like environment existed with the potential for tundra vegetation to develop.

A reverse situation occurred in the Northwest Territories based on ostracode fossils from a peaty marl deposit at the east end of Jiggle Lake. Seven species were found in the deposit. As reported by Delorme et al. (1977) for other similar sites, the strikig element is the absence of true Arctic ostracodes. The majority of the species live very successfully further south in Manitoba and Saskatchewan at the present time.

In a survey of freshwater ostracodes in Canada, a total of 6720 biological freshwater samples were collected. The lakes, ponds, and streams sampled were in the provinces of British Columbia to the Ontario/Quebec border, and north into the Northwest and Yukon Territories. The area sampled in the north was along the Mackenzie Valley Transportation corridor. From the total samples collected, the species *Candona rectangulata* and *Cyclocypris globosa* occur only in the Canadian Territories. The species *Cytherissa lacustris* occurs south of latitude 60°, and is restricted in the provinces to large, cold-water lakes. *Cyclocypris globosa* has been recovered to about a latitude of 65° and *Candona rectangulata* as far south as latitude 62°.

The climatic zones in which these species live, are taiga and alpine (forest-tundra). Between 62° and 65° latitude, there is the entry of the sub-boreal (Burns, 1973) climatic zone. Within the area referred to, the mean annual temperature varies between -11.95 to 6.9°C, annual precipitation varies from 12.1 to 47.6 cm, and the potential evapotranspiration is from 34.4 to 56.2 cm. According to Brown (1970), the area lies within both the continuous and discontinuous permafrost zones.

The three species listed above are found in these climatic zones. All but *Cytherissa lacustris* are restricted to it. Table 1 indicates the ranges for the climatic parameters for each species according to the number of times they have been found in the environment.

Table 1. Mean annual temperature, annual precipitation, and potential evapotranspiration ranges for Candona rectangulata, Cyclocypris globosa and Cytherissa lacustris.

Ostracode species	Mean annual Temperature	Annual Precipitation	Potential Evaportranspiration
	(°C)	(cm)	(cm)
Candona rectangulata	-11.9 - (-7.4)	12.1 - 41.1	34.4 - 43.7
Cyclocypris globosa	- 9.9 - (-7.1)	30.1 - 47.6	41.2 - 45.1
Cytherissa lacustris	-10.1 - (+9.5)	20.0 - 99.8	39.0 - 66.3

The chemical characteristics of the habits in which these species live are given in Table 2.

Table 2. Chemical range for Candona rectangulata, Cyclocypris globosa, and Cytherissa lacustris.

Species	Calcium	Magnesium	Sodium
Candona rectangulata	2 - 118*	0.7 - 95*	0.3 - 1080*
Cyclocypris globosa	10 - 20	1.2 - 6.2	0.4 - 3.4
Cytherissa lacustris	2 - 50	0.0 - 16.8	0.3 - 30.7

* mg/L

Species	Bicarbonate	Sulphate	Chloride
Candona rectangulata	3.7 - 366*	3.0 - 300*	2.0 - 1900*
Cyclocypris globosa	24.4 - 73.2	5.0 - 14.0	3.0 - 3.0
Cytherissa lacustris	3.7 - 183	1.0 - 55.0	1.6 - 33.0

* mg/L

Species	TDS	Conductivity	pH
Candona rectangulata	11.2 - 3526*	25 - 6590+	6.5 - 8.5
Cyclocypris globosa	45.2 - 81.9	76 - 145	6.7 - 7.6
Cytherissa lacustris	11.2 - 215	25 - 370	6.4 - 8.8

* mg/L
\+ micromhos

In general it can be seen that the three species are truly fresh-water forms. Candona rectangulata has a broad tolerance range to sodium chloride, as it is found in some coastal ponds which receive sea spray. The other two species do not have this tolerance to sodium chloride.

Somerset Site

In 1971, Delorme enumerated the ostracode fauna obtained from a core near Somerset, Manitoba. The core was obtained from a pond on the Pembina Upland, some 24 kilometers west of the eastern edge of the Glacial Lake Agassiz basin. Three ostracode species Candona rectangulata (noted as

C. willmani in the paper, now in synonomy with C. rectangulata), Cyclocypris globosa, and Cytherissa lacustris identified what Delorme referred to as zone 1, subzone A.

The lacustrine sediments of subzone A are in juxtaposition to glacial till and overlain by 2.53 metres of additional lacustrine sediments. The sediments of subzone A therefore represent the first deposited sediments in the lake as the glacial ice melted around it, around 12,500 years B.P. It is not unexpected that the first faunal elements to colonize the lake were those that had a preference for cold water and a cold climate. The climatic ranges interpreted for this subzone are given in table 3.

Table 3. Paleoclimatic interpretation of subzone A.

Subzone	Mean annual Temperature	Annual Precipitation	Potential Evapotranspiration
	(°C)	(cm)	(cm)
A	-9.9 - (-7.1)	30.1 - 41.1	41.2 - 43.7

The method used to interpret the paleoclimate is the same as that used by Delorme et al. (1977). The interpreted chemical parameters are given in table 4. Determination of these ranges was done using the same method as used in interpreting the paleoclimate.

Table. 4. Paleolimnologic interpretation of subzone A.

Parameter	Range	Parameter	Range
Calcium (mg/L)	10.4 - 20.0	Chloride (mg/L)	3.0 - 5.0
Magnesium (mg/L)	1.2 - 6.2	Total Solids (mg/L)	45.2 - 81.9
Sodium (mg/L)	0.4 - 3.4	Conductivity (micromhos)	76.0 - 145.0
Bicarbonate (mg/L)	24.4 - 73.2	pH	6.7 - 7.6
Sulphate (mg/L)	5.0 - 14.0		

The interpreted climatic environment based on fossil ostracodes clearly reflects the modern climatic conditions of where the three species currently live. As previously mentioned, the three species are not found in the area of the fossiliferous site today. The present climate at the Somerset site is much different with a mean annual temperature of 2.5°C, annual precipitation of 73.9 cm, and a potential evapotranspiration of 54.0 cm. This means that the temperature of subzone A was about 11°C colder than present, that there was 38 cm of precipitation less and the potential evapotranspiration was smaller by 11 cm.

Based on the subzone A paleoclimatic interpretation, it is reasonable to assume that during this time period the landscape would have supported a subarctic forest (open woodland) tundra. The modern analogue is located at latitude 67.39°, longitude 134.39°.

Fossil warm water fauna at a present day cold water site

Seven ostracode species (table 5) are also known from the ostracode survey. The modern representatives of these species have been found in lakes, ponds, and streams in the Canadian provinces and territories. The ranges for the climatic parameters for each species (table 5) are very broad. Their modern analogues range from latitude 41° to 69° which explains the broad ranges. It is entirely possible that these species exist in similar habitats south of the Canada/United States border.

Table 5. Mean annual temperature, annual precipitation, and potential evapotranspiration ranges for seven ostracode species.

Ostracode Species	Mean annual Temperature	Annual Precipitation	Potential Evapotranspiration
	(°C)	(cm)	(cm)
Candona candida	-11.5 - (9.6)	13.8 - 118.4	34.8 - 66.5
Candona decora	- 9.5 - (8.9)	20.7 - 90.3	43.3 - 65.4
Candona paraohioensis	-10.1 - (8.5)	25.2 - 100.3	40.0 - 62.7
Cyclocypris ampla	-10.1 - (9.1)	17.7 - 124.8	40.0 - 64.5
Cyclocypris sharpei	- 9.7 - (9.3)	17.8 - 117.6	39.8 - 65.0
Cypridopsis vidua	- 9.7 - (9.9)	17.7 - 128.0	40.1 - 68.2
Limnocythere itasca	-10.1 - (8.0)	22.8 - 126.6	40.0 - 61.6

Jiggle Lake Site

In 1977, Delorme et al. identified ostracodes and molluscs from several fossiliferous sites north of latitude 65°. Another such site, Jiggle Lake, occurs at latitude 67°41', longitude 132°07' (Zoltai, 1975, personal comm.). The site has exposed 282 cm of sediments containing 22 cm of peaty marl. The fossil bearing segment (sampled every centimetre) contains the seven ostracode species listed above. The paleoclimatic interpretation (table 6) agrees very well with the interpretation given by Delorme et al. (1977) for the nearby sites. The mean annual temperature is interpreted as 1.2°C, the annual precipitation at 51.3 cm, and the potential evaportranspiration at 52.6 cm. The only major discrepancy is in the annual precipitation with values ranging from 44.2 to 48.0 cm for sites 1 to 4. The higher precipitation values for the Jiggle Lake site may be the result of a slightly different ostracode fauna. The Jiggle Lake site provides considerably more detail during the 250 to 300 year deposition period than did the other sites described by Delorme et al. (1977). Zoltai (1975, personal comm.) has indicated that the peaty marl is bracketed by two dates (7200 ± 60 yrs - BGS148 and 8610 ± 100 yrs - BGS149). Based on the paleoclimatology, the area immediately surrounding the site had the potential for supporting a forested vegetational association, the major elements being either closed coniferous or a mixed coniferous-deciduous forest.

There are two modern analogues for the fossiliferous deposit. The interval 206 to 191 cm has a modern equivalent of the habitat at

Table 6. Distribution of ostracodes and paleoclimatic interpretation of the Jiggle Lake site.

Depth cm	Candona candida	Candona decora	Candona paraohioensis	Cyclocypris ampla	Cyclocypris sharpei	Cypridopsis vidua	Limnocythere itasca	Mean Annual Temperature C	Annual Precipitation cm	Potential Evapotranspiration cm
184-185	2							-11.5(-0.4)9.6	13.8(50.8)118.4	34.8(50.9)68.5
185-186	12		3	27		12		- 9.7(1.5)8.5	25.2(54.5)100.4	40.1(52.9)62.7
186-187	58		66	91	6	50	25	- 9.7(1.2)8.0	25.2(52.2)100.4	40.1(52.7)61.6
187-188	179		71	136	28	89	104	- 9.7(1.2)8.0	25.2(51.3)100.4	40.1(52.6)61.6
188-190	225		101	136		30	15	- 9.7(0.9)8.0	25.2(51.9)100.4	40.1(52.4)61.6
190-191	118		137	110	7	92	114	- 9.7(1.2)8.0	25.2(51.7)100.4	40.1(52.7)61.6
191-192	194		57	128	19	109	99	- 9.7(1.2)8.0	25.2(51.3)100.4	40.1(52.6)61.6
192-193	266		77	171	24	183	218	- 9.7(1.2)8.0	25.2(51.0)100.4	40.1(52.8)61.6
193-194	406		154	245	28	210	294	- 9.7(1.1)8.0	25.2(51.1)100.4	40.1(52.6)61.6
194-195	226		87	202	19	183	120	- 9.7(1.2)8.0	25.2(51.6)100.4	40.1(52.7)61.6
195-196	313		23	205	9	201	168	- 9.7(1.2)8.0	25.2(51.0)100.4	40.1(52.7)61.6
196-197	258	5	62	210	33	186	134	- 9.5(1.3)8.0	25.2(48.9) 90.3	43.3(52.7)61.6
197-198	429	15	62	315	10	253	155	- 9.5(1.3)8.0	25.2(48.9) 90.3	43.3(52.7)61.6
198-199	224		42	262	28	164	84	- 9.7(1.3)8.0	25.2(51.5)100.4	40.1(52.7)61.6
199-200	253	5	32	272	18	106	42	- 9.5(1.2)8.0	25.2(49.1) 90.3	43.3(52.7)61.6
200-201	113		50	207	27	94	39	- 9.7(1.3)8.0	25.2(51.8)100.4	40.1(52.8)61.6
201-202	185		45	405	45	115	30	- 9.7(1.3)8.0	25.2(51.7)100.4	40.1(52.8)61.6
202-203	130			189	17	46	21	- 9.7(1.3)8.0	22.8(50.7)117.6	40.1(52.7)61.6
203-204	135	7	15	120	7	22	7	- 9.5(1.1)8.0	25.2(48.9) 90.3	43.3(52.5)61.6
204-205	95		13	76		23	16	- 9.7(1.1)8.0	25.2(51.3)100.4	40.1(52.5)61.6
205-206				12		4		- 9.7(2.1)9.1	17.7(54.8)124.8	40.1(53.6)64.5

latitude 52.57°, longitude 104.17°. The mean annual temperature of this analogue is 1.3°C, annual precipitation of 45.9 cm and potential evapotranspiration of 52.7 cm. The upper portion of the deposit, 191 to 185 cm, has a modern analogue located at 49.54°, longitude 95.56°. The mean annual temperature of this analogue is 1.7°C, annual precipitation of 61.5 cm and potential evapotranspiration of 52.7 cm. As the ranges for the climatic parameters on which the interpretation is based are rather broad, the selection of modern analogues becomes more difficult. The would-be modern analogues, from north of latitude 65°, have the ostracode species _Candona protzi_ which is missing from the fossil assemblages. This absence disqualified the sites as modern representatives. Would-be modern analogues from east of longitude 96° and south of latitude 49° have the following species which are not found in the fossil assemblage:

Candona crogmaniana	_Physocypria globula_
Darwinula stevensoni	_Physocypria pustulosa_

The absence of these species from the fossil assemblage eliminated the sites as modern analogues.

The Jiggle Lake site provides more detailed paleoenvironmental interpretation than the other four sites previously interpreted by Delorme _et al._ (1977), however, the interpretation remains essentially unchanged. The mean annual temperature at the time of deposition of the peaty marl was about 11°C warmer than at present, annual precipitation 21.5 cm more and the potential evapotranspiration 13 cm more than at present.

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