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Benthic scavengers collected by baited traps in the high Arctic

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Abstract Baited traps were deployed in the coastal areas of Svalbard (0–175 m), Franz Josef Land (15 and 20 m), Northeast Greenland (6 and 20 m) and Ellesmere Island (2–145 m). The samples were dominated by Lysianassidae (Amphipoda). In the most extensively sampled locality (Hornsund, Svalbard), differences between the necrophagic fauna of the outer and inner basins were observed. Clear depth separations of closely related species of the *Anonyx* and *Onisimus* genera were found between 0 and 175 m in Hornsund. *Anonyx nugax* and *Onisimus edwardsi* were the only species found in all of the examined localities.

Introduction

The scavenging behaviour of sea animals is well known and has been exploited for a long time in trap fishery. Baited traps have been used extensively for investigating shallow-water scavenging fauna (Busdosh et al. 1982; Sainte-Marie 1986; Slattery and Oliver 1986; Sainte-Marie et al. 1989). Material obtained in this way has provided supplementary quantitative and qualitative data and has been used for morphological, developmental and behavioural studies. As has been observed, lysianassid amphipods are usually numerically dominant in baited traps, both in the deep ocean and in shallow waters (Dahl 1979; Thurston 1979; Busdosh et al. 1982; Sainte-Marie 1986). Recent studies on Arctic food webs, conducted with the use of the stable isotope technique, placed carrion-feeding amphipods almost at the top of the food web (K. Hobson, personal communication).

It is common knowledge that scavengers are important members of benthic communities at high latitudes (Arnaud 1977; Slattery and Oliver 1986; Britton and Morton 1994). Although northern seas carrion-feeding amphipods have been well studied (Busdosh et al. 1982; Oliver and Slattery 1985; Vader and Romppainen 1985; Sainte-Marie 1986, 1987; Sainte-Marie et al. 1989), the scavenging fauna of the high Arctic has not yet been described. The aim of this paper is to present data on the composition of necrophagic fauna in four high-Arctic localities.

Materials and methods

The main sampling region on the Svalbard archipelago was Hornsund Fjord at 77°N, 15°E (Spitsbergen) (Fig. 1). This glaciated fjord is exposed to both Atlantic waters of the West Spitsbergen Current and local Arctic waters of the East Spitsbergen (Sorkapp) Current. Sampling was conducted from the shallow hard bottom to the glacial clay bottom at 175 m. The hydrology and biota of this fjord have been described in detail by Węsławski et al. (1991).

Franz Josef Land was studied at Tikhaia Bay (Hooker Island, 80°N, 51°E, Fig. 1). This is an area characterised by Arctic water, year-round negative temperatures and permanent pack ice. Sampling was conducted in muddy and stony sublittoral habitats with *Laminaria* vegetation. The study area has been described by Barr (1995).

The Northeast Greenland locality (Eskimonaes, 80°N, 15°W, Fig. 1) is situated on the fast-ice edge of the Northeast Water Polynya (NEW-Polynya) influenced by the East Greenland Current. Sampling was conducted on shallow water banks 20-30 m in depth on mixed gravel and stony bottoms. A detailed description of the study site has been presented by Węsławski et al. (1997).

The Ellesmere Island site is situated on Rosse Bay at Cape Hershel (78°N, 74°W, Fig. 1). Sampling was carried out in a large open bay 10 km in diameter and at a depth of up to 150 m, on a glacial, clay bottom. The area is influenced by Arctic waters from the North Water Polynya.

The material was collected in Hornsund, Spitsbergen, in the summers of 1977 and 1979, and during two winters from August 1981 to September 1982 and from September 1984 to June 1985. Most of the 77 samples were taken from depths not exceeding 30 m (Table 1).

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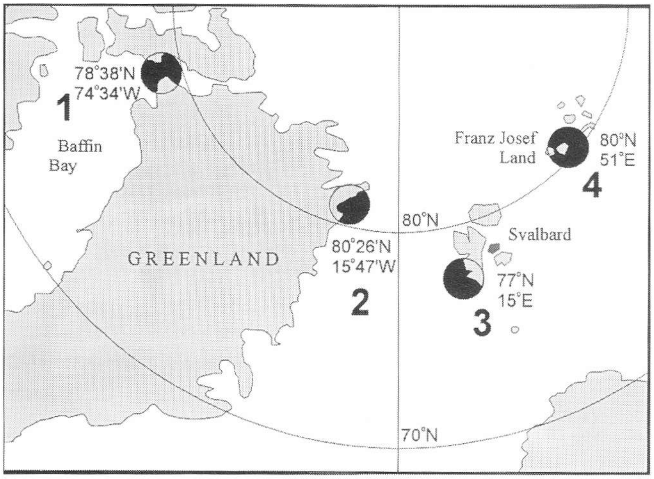

Fig. 1 Sampling areas: *1* Cape Hershel, *2* Eskimonaes, *3* Hornsund, *4* Tikhaia Bay

Additional samples were collected from Franz Josef Land (two samples in September 1992), Northeast Greenland (two samples in June 1993) and Ellesmere Island (nine samples in May 1998).

Two different types of traps were used. The first one, used only in summers 1977 and 1979 (13 samples were taken) in the outer part of Hornsund, was an open, conical net 50 cm in diameter, 1 m in length with 1-mm mesh. All other samples were taken by a cylindrical closed net, 70 cm in length and 40 cm in diameter with 5-mm mesh in the main part and 1-mm mesh in the two conical entrances (elliptical openings at one per 5 cm). Approximately 0.3 kg of bird or fish meat per trap was used as bait.

The baited traps were deployed on the sediment for different time periods (Table 1). Samples were washed in filtered seawater, preserved in 4% formaldehyde and subsequently, after several months, identified in the laboratory.

A portion of the animals was caught accidentally as they were attracted by the net as a substrate or was caught during the net lift-up. To distinguish truly necrophagic species, high frequency and abundance in the traps were interpreted as the distinctive features of scavengers. Empty nets were lowered on some occasions to identify animals attracted to the net as a substrate.

Results

Almost 19,500 specimens of 26 taxa were found in the Spitsbergen samples (Table 2).

Six lysianassid amphipod species, *Anonyx nugax*, *A. sarsi*, *Onisimus edwardsi*, *O. caricus*, *O. litoralis* and *Orchomene minuta*, occurred at a high frequency (over 30%) and made up 95% of the total number of animals caught. Among the remaining species, *Anonyx laticoxcae* and two decapod species, *Hyas araneus* and *Eualus gaimardi*, occurred quite frequently in the trap samples although they were not abundant. Relatively numerous *Gammarus* spp. were collected using all kinds of gear exposed in shallow water, but they were not observed feeding on carrion. The gastropod *Buccinum undatum*, known for its scavenging habits, as well as the carrionfeeding polychaete *Anaitides groenlandica*, were recorded in low numbers and frequencies. Significant differences between the species composition in the material obtained by means of "open" and "closed" traps were not found. The same holds true for 17 samples collected in winter (from November to March) and 60 remaining samples taken during other seasons (Table 2).

The faunal abundance in traps varied considerably and did not correlate with the time of exposition. Only 3 traps collected over 1000 animals; a maximum of 1784 specimens were captured in a single trap.

Over 1900 specimens of 20 taxa were found in the samples from Ellesmere Island. From the dozen specimens found in the material from the two remaining sites, six taxa were described for Northeast Greenland and five for Franz Josef Land. The results are thus clearly related to the sampling effort. The species attracted to the baited traps consisted mainly of Lysianassidae (Table 2). The scavenging feeding habits of most prominent species are known from the Hornsund samples and from data in the literature. *Anonyx nugax* and *Onisimus edwardsi* were the only species found in all the examined localities.

In Hornsund, no ovigerous females were found among the 8933 specimens of *Anonyx nugax*, which were represented by all size classes. Only 24 ovigerous females were found among 4250 specimens of *Anonyx sarsi*. For *Onisimus edwardsi* and *Onisimus litoralis*, about 50 egg-bearing females for each species were found. For *Orchomene minuta*, about 40 ovigerous females were observed. Thirty ovigerous females were found among 482 specimens of *Tmetonyx cicada* from Ellesmere Island.

Extensive sampling in the Hornsund region permit the authors to describe the depth preferences of the most abundant species. Separation caused by depth is

Table 1 Number of traps deployed for different time periods (h) and at different depths (m) (Σ_T total number of traps deployed for given time period; Σ_D total number of traps deployed at different depths; *FJL* Franz Josef Land; *NEG* Northeast Greenland)

Time (h)	Spitsbergen				Σ_T	FJL Depth (m) 3–30	Σ_T	NEG Depth (m) 3–30	Σ_T	Ellesmere Island			Σ_T
	Depth (m)									Depth (m)			
	0–3	3–30	30–100	> 100						3–30	30–100	> 100	
< 1	5	1			6	2	2	2	2				0
1–6	2	20	7		29		0		0				0
6–12	2	9	8		19		0		0				0
12—24		10	11	1	22		0		0	1			1
> 24		1			1		0		0		4	2	6
Σ_D	9	41	26	1	77	2	2	2	2	1	4	2	7

Table 2 Checklist of the taxa and number of individuals found in the material from Spitsbergen, Franz Josef Land (*FJL*), Northeast Greenland (*NEG*) and Ellesmere Island (*EI*) [*N* total number of collected animals, N_w number of individuals collected in winter (17 samples, XI–III), N_o number of individuals collected with the "open" net, *F*(%) the frequency values; *Remarks*: *A* accidental species in the net, *N* necrophagic species, *?* status uncertain]

Taxon	Remarks	Spitsbergen				FJL	NEG	EI
		N	N_w	N_o	*F*(%)	*N*	*N*	*N*
Turbellaria	?	1		1	1.3			
Polychaeta								
Anaitides groenlandica	?	4	1		2.6			
Polychaeta ndet	?	6			1.3			1
Gastropoda								
Buccinum undatum	N	19			3.9			
B. hydrophanum	N							2
Mysidacea								
Mysis oculata	A	2	1		2.6			
Amphipoda								
Anonyx laticoxae	N	36	5		13			76
A. lilljeborgi	N?						1	
A. nugax	N	8933	229	80	56	26	57	29
A. sarsi	N	4250	1052	2473	49	3		1
Anonyx spp.	N?	644		143	5.1			31
Calliopius laeviusculus	A	2	1		2.6			
Caprella septentrionalis	A	1		1	1.3			
Gamarellus homari	A	1		1	1.3			
Gammarus oceanicus	A	21	17	3	5.1			
G. setosus	A	47	13	30	6.4			3
Ischyrocerus anguipes	A	6	3	3	3.9			
Onisimus brevicaudatus	N?						1	
O. caricus	N	359	39		32.4	8		38
O. dubius	N?							4
O. edwardsi	N	2749	1169	777	35	2	1	992
O. litoralis	N	1699	234	1260	35			52
Onisimus spp.	N?							130
Orchomene minuta	N	608	45	178	40.3	3		
O. pinguis	N							86
O. pectinata	N?							7
Paroediceros lynceus	A	13		12	3.9			
Schisturella pulchra	N?						1	
Tmetonyx cicada	N						1	482
Tmetonyx spp.	N?							3
Decapoda								
Eualus gaimardi	N	21	1		14.3			
Lebbeus polaris	N?							3
Eupagurus pubescens	N	6			5.1			
Hyas araneus	N	39			10.3			
Echinodermata								
Ophiura robusta	?							6
Heliometra glacialis	A							3
Strongylocentrotus sp.	N?							4
Urasterias lynckii	?	1			1.3			
Pisces								
Boreogadus saida	?	3	1		3.9			
Myxocephalus scorpius	?	4			3.9			

especially evident among closely related species of the *Anonyx* and *Onisimus* genera (Fig. 2). The results obtained from samples collected in three areas of the Hornsund Fjord suggested that necrophagic invertebrates are also separated by the horizontal zonation of fjords (Fig. 3). In Burgerbukta, an inner basin influenced by massive glacial outflow, the clear predominance of *Anonyx nugax* and *Onisimus caricus* was noted. Samples taken at shallow stations of the outer Hyttevika and Isbjornhamna Bays were dominated by *Anonyx sarsi* and *Onisimus litoralis*. The importance of *Anonyx nugax* increases gradually at depths between 30 and 60 m, while the material from the deepest stations showed that large decapods dominated; the most prominent species was *H. araneus*.

Discussion

The diversity of the scavenging fauna in the Arctic seems to be very low, especially in comparison with the rich Antarctic necrophagic fauna, which is represented by several taxonomic groups of invertebrates (Arnaud

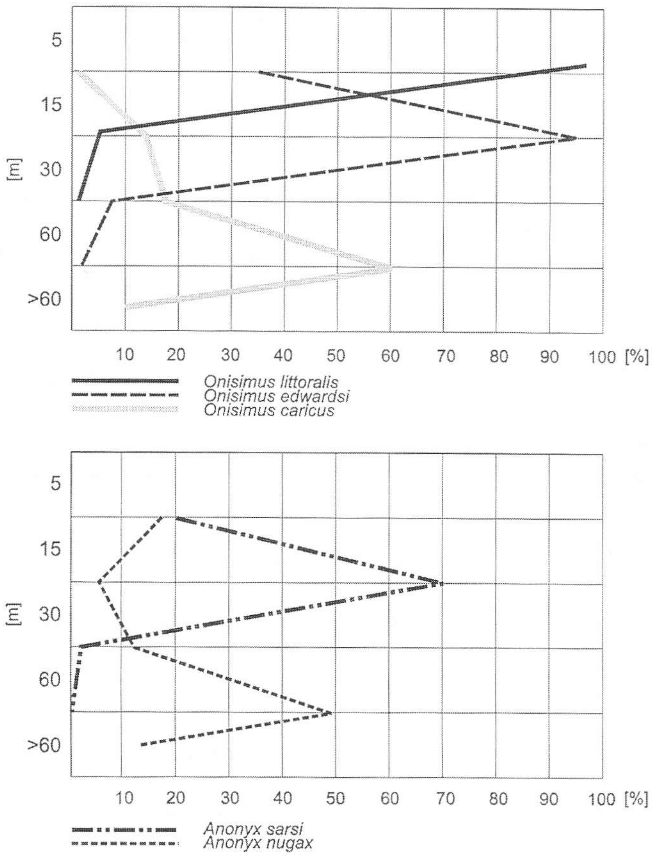

Fig. 2 Depth distribution of five necrophagic amphipod species in Hornsund. Percentages of the specimens (%) in the total abundances of the particular species of *Anonyx* and *Onisimus* genera at different depths (m)

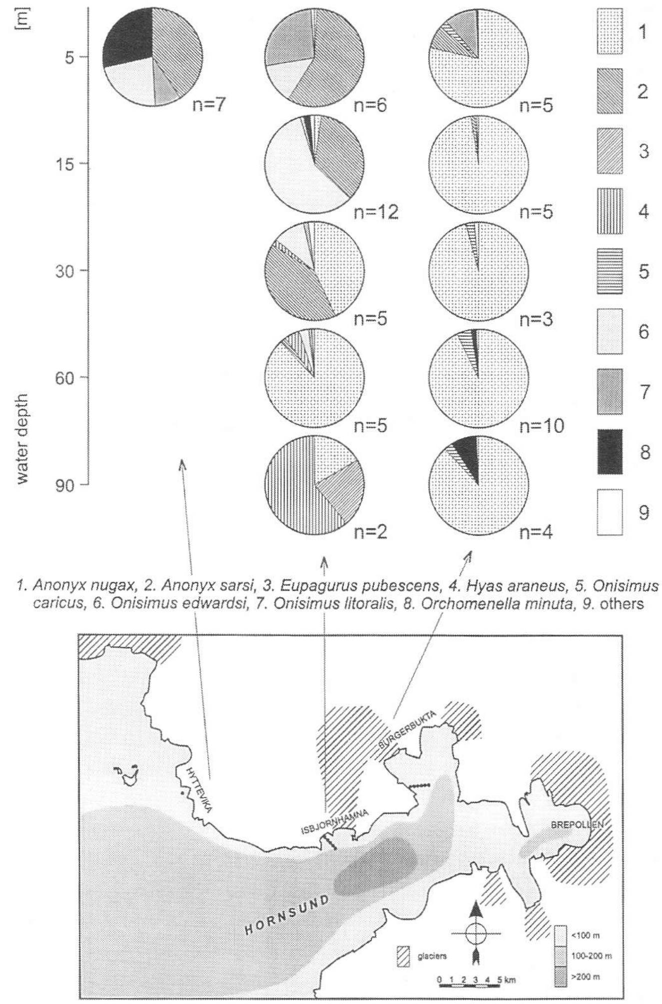

Fig. 3 Horizontal and depth distribution of the most prominent necrophagic species in Hornsund

1977; Presler 1986). It should be stressed, however, that our results do not provide comprehensive information on the necrophagic fauna in the examined localities. The trap types used and the periods of their exposition might have affected the diversity and abundance of the animals collected. Not all of the animals attracted were able to reach the bait, as the dimensions of the openings, in the case of "closed" traps, did not allow large taxa (e.g. large fish and echinoderms) to enter the traps. Such animals, however, were not found in the "open" net deployed in Hornsund either. The other group that might have been underrepresented in the material are slow-moving organisms. Whereas highly mobile organisms like Lysianassidae, with their well-developed chemoreceptors (Dahl 1979; Thurston 1979; Sainte-Marie 1984, 1986), can locate carrion very quickly, other organisms, such as the gastropod *B. undatum*, are unable to reach bait in a short time.

Lysianassid amphipods dominated the fauna attracted to the traps deployed at all sampling sites. Many species of this family are known for their scavenging behaviour (Britton and Morton 1994). In Hornsund, 6 Lysianassid species dominated the material, making up 95% of all specimens which represented 26 taxa. A similar dominance of five species was reported by Sainte-Marie (1986) from the shallow waters of the St. Lawrence Estuary. At the same time, the numbers of amphipods captured during the Spitsbergen sampling were nowhere near as high as those observed by Sainte-Marie.

Bait-attending lysianassids were divided into two groups on the basis of morphological and physiological criteria (Dahl 1979; Sainte-Marie 1992). The first group included species adapted for rapid and efficient feeding. These species can tolerate long periods of starvation, feed intermittently and digest meals very slowly. Members of this group were considered to be carnivores/necrophages. The second group consisted of feeding generalists or detritivores (Sainte-Marie and Lamarche 1985; Sainte-Marie 1986). Having triturative mandibles and smaller guts, they feed slowly and wastefully, but more continuously and are not capable of enduring long periods of starvation.

The significance of the differences described here is visible in the material presented.

Anonyx spp., which are rapid feeders, made up 71–93% of the total number of specimens attracted to the baited traps deployed in Hornsund, Tikhaia Bay and Northeast Greenland. Members of this arcto-boreal genus seem to be especially well adapted for scavenging (Sainte-Marie 1984, 1986; Steele and Steele 1993) and are known for their mass attraction to bait and voracious feeding on dead and injured animals (Oliver and Slattery 1985; Sainte-Marie and Lamarche 1985; Vader and Romppainen 1985). Thus, the low share of *Anonyx* spp. in the total number of specimens found in the Ellesmere Island material is very surprising since several species of this genus are known to be common and numerous in this part of the Arctic (Steele and Brunel 1968). Although specimens of *Onisimus* spp. and *Orchomene* spp., representing the slow feeder group, made up a considerable portion of the total abundance, they were less important at all sampling sites, except at Ellesmere Island.

The absence or low number of ovigerous or brooding females among the amphipods captured in baited traps has been observed in shallow waters (Slattery and Oliver 1986; Moore 1994), as well as in deep seas (Hessler et al. 1978; Thurston 1979). Sainte-Marie (1987) and Sainte-Marie et al. (1989) reported a decrease of average meal size with increasing sexual maturity of *Anonyx sarsi* and *Onisimus litoralis* females, which was attributed to gut constriction caused by the maturation of gonads and brood development (Sainte-Marie et al. 1990). The non-attraction of mature or maturing females to the baited traps has also been connected with the cessation of foraging activity to avoid mortality resulting from predation and cannibalism (Hessler et al. 1978; Sainte-Marie et al. 1990).

The clear domination of *Anonyx nugax* at all depths was observed in Burgerbukta, the inner bay of Hornsund, while the necrophagic species composition of the central and outer parts of Hornsund became more diverse as depth increased. These areas are different with regard to their hydrology, sedimentation rates and bottom character (Gorlich et al. 1987; Węsławski et al. 1991). The differences observed result most probably from dissimilar feeding opportunities in each of the fjord areas. The outer fjord habitats are characterised by higher heterogenity and contain a rich set of benthic and pelagic animals (J.M. Węsławski, unpublished work), while a decrease of benthic fauna diversity and biomass was observed in the inner fjord bays (Gorlich et al. 1987). Large and highly mobile species like *Anonyx nugax* and *Onisimus caricus*, which are capable of reaching carrion that occurs randomly, were common at deeper sites and in the inner fjord basins, while the remaining species were abundant in shallow areas with high inputs of planktonic and benthic food.

While large carrion seems to be an uncommon and dispersed source of food, carcasses of relatively small benthic and pelagic organisms are abundant and frequently accessible (Oliver and Slattery 1985; Presler 1986; Sainte-Marie 1986). The mass mortality of marine zooplankton (copepods and *Themisto* spp.) occurring during summer in glacier bays was probably caused by strong turbidity and reduced salinity, as recently described by Węsławski and Legeżyńska (1998). Sinking dead zooplankton may create predictable food conditions for fjord scavengers.

Of about 300 species of benthic fauna inhabiting Hornsund (Jażdżewski et al. 1996), only a few species, almost exclusively amphipods, were attracted to the baited traps. Well-developed depth and habitat separation of the most prominent necrophagic lysianassid species and their constant presence in baited traps throughout the year suggest importance of scavenging behaviour. While decapod crustaceans (lobsters, shrimps, crabs), fish and gastropods are frequent scavengers at mid-latitudes (Steele and Steele 1993; Britton and Morton 1994), relatively large, highly mobile lysianassid amphipods appear to be responsible for utilising carrion in the high Arctic.

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