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ORIGINAL PAPER

Composition and distribution of the peracarid crustacean fauna along a latitudinal transect off Victoria Land (Ross Sea, Antarctica) with special emphasis on the Cumacea

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Abstract The following study was the first to describe composition and structure of the peracarid fauna systematically along a latitudinal transect off Victoria Land (Ross Sea, Antarctica). During the 19th Antarctic expedition of the Italian research vessel "Italica" in February 2004, macrobenthic samples were collected by means of a Rauschert dredge with a mesh size of 500 μm at depths between 85 and 515 m. The composition of peracarid crustaceans, especially Cumacea was investigated. Peracarida contributed 63% to the total abundance of the fauna. The peracarid samples were dominated by amphipods (66%), whereas cumaceans were represented with 7%. Previously, only 13 cumacean species were known, now the number of species recorded from the Ross Sea increased to 34. Thus, the cumacean fauna of the Ross Sea, which was regarded as the poorest in terms of species richness, has to be considered as equivalent to that of other high Antarctic areas. Most important cumacean families concerning abundance and species richness were Leuconidae, Nannastacidae, and Diastylidae. Cumacean diversity was lowest at the northernmost area (Cape Adare). At the area off Coulman Island, which is characterized by muddy sediment, diversity was highest. Diversity and species number were higher at the deeper stations and abundance increased with latitude. A review of the bathymetric distribution of the Cumacea from the Ross Sea reveals that most species distribute across the Antarctic continental shelf and slope. So far, only few deep-sea records justify the assumption of a shallow-water–deep-sea relationship in some species of Ross Sea Cumacea, which is discussed from an evolutionary point of view.

Keywords Diversity · Cumacea · Benthos · Antarctica · Ross Sea

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Introduction

Five of the seven peracarid orders are known to occur in Antarctic waters. Amphipoda are most diverse with 821 species in the Southern Ocean (De Broyer and Jazdzewski 1996), while 365 species of Isopoda are known for this area (Brandt 1999). Cumacea are represented with 66 species (87 including the Magellan area, Mühlenhardt-Siegel 1999), whereas Mysidacea and Tanaidacea are represented with 59 and 36 species, respectively (Brandt et al. 1998; Schmidt and Brandt 2001).

First research on Antarctic cumaceans started with the descriptions of Zimmer (1902, 1907a, b, 1908, 1909, 1913) and Calman (1907, 1917, 1918). Further work followed (e.g., Hale 1937; Gamô 1959, 1987; Lomakina 1968; Ledoyer 1973, 1977; Petrescu (1991); Petrescu and Wittman 2003), and a total of 58 species were mentioned by Ledoyer (1993). Mühlenhardt-Siegel

(1999) summarized 66 cumacean species known from Antarctica. During the last years ten further species, such as *Gynodiastylis jazdzewskii* (Błażewicz and Heard 1999) from the Ross Sea, were described.

In "The fauna of the Ross Sea" (Jones 1971) merely ten cumacean species were mentioned; only two additional species were recorded during the last decades (Roccatagliata and Heard 1992; Błażewicz and Heard 1999). The species *Makrokylindrus baceskei* (Lomakina 1968) was reported from 2,937 m at the Balleny Islands only, but is counted as a Ross Sea species in this study. Thus prior to the present study, the number of cumacean species known from the Ross Sea was 13. Approximately 30 cumacean species are known from other high Antarctic regions (Mühlenhardt-Siegel 1999; Corbera 2000). The great difference in species numbers known from different high Antarctic localities can be attributed to the little work, which has so far been accomplished on the deeper benthic environment of the northern Victoria-Land coast and the eastern Ross Sea (Waterhouse 2001) as well as the gear used for sampling. Conventional gear, such as dredges, trawls, and corers, most likely does not sample the cumacean fauna adequately (Jones and Sanders 1972). During previous expeditions to the Ross Sea, predominantly nets with wide mesh sizes were used for sampling. Cumaceans are small peracarids ranging between 0.1 and 3.5 cm in size (mostly less than 1 cm). Therefore, most of the animals will be washed out of nets with mesh sizes of 1 cm and more.

The present study deals with the distribution of the peracarid orders along a latitudinal and depth transect and the faunistic composition of the cumaceans from the waters of the northern Victoria-Land coast. A Rauschert dredge with a mesh size of 500 µm was used to gain data on abundance, diversity, and bathymetric distribution of the cumacean fauna.

Materials and methods

During the 19th Antarctic expedition with RV "Italica" in February 2004, 18 samples were taken along a latitudinal transect in the four areas of Victoria-Land coast Cape Adare, Cape Hallett, Coulman Island, and Cape Russell (Fig. 1; Table 1). Station Santa Maria Novella (Terra Nova Bay) and the stations off Cape Russell were pooled for further analysis since these stations were sampled in the same region. A depth gradient was sampled at each area: samples of area Cape Hallett were obtained from two depths transects inside and outside Cape Hallett Bay. Owing to severe ice conditions off Coulman Island, only two samples were taken in this area.

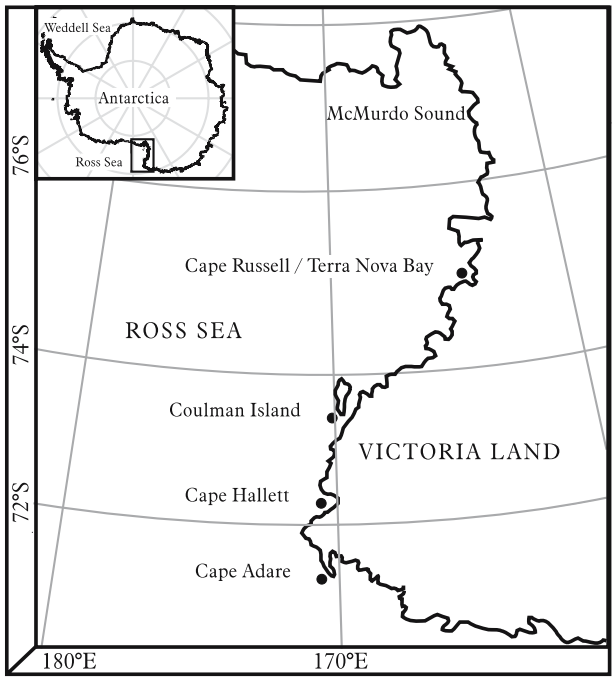

Fig. 1 Victoria-Land coast (Ross Sea, Antarctica); sample areas: Cape Adare, Cape Hallett, Coulman Island, and Cape Russell

A modified Rauschert dredge (Lörz et al. 1999) with a mesh size of 500 µm and an opening of 0.5 m was used to take samples from water depth between 84 and 515 m. A second inner net with a mesh size of 1 cm was used to keep larger objects out of the 500 µm net. The dredge was hauled over the ground at a mean velocity of one knot. Haul lengths varied from 59 to 575 m. For comparison between stations, samples were standardized for 1,000 m^2 hauls. Before the material was preserved in 90% precooled ethanol and kept in −25°C for later DNA extraction, it was sieved on a 500 µm mesh. Afterwards in the laboratory a stereomicroscope was used to sort the samples into major taxonomic groups. Cumacea were identified to species level.

We applied univariate measures of diversity, the Shannon-Wiener index (H′) (log base) (Shannon and Weaver 1949), and evenness (J′) (Pielou 1966). A Multidimensional Scaling (MDS) analysis was carried out with the software package Primer (v. 5.1.2) of the Plymouth Marine Laboratory using Bray-Curtis Index to analyse the distribution of cumacean species assemblages in the study area. Because of the semi-quantitative nature of data derived from the dredge samples, arc-sin transformed relative abundances were used for analysis.

Due to technical problems during processing, a sample taken at station R4 was only analysed qualitatively. Additional material collected onboard of the New Zealand RV "Tangaroa" was analysed in order to

Table 1 Rauschert dredge stations of the Victoria-Land transect cruise (Ross Sea, Antarctica) taken from onboard RV "Italica"

Station north to south	Date	Position		Depth	Haul length	Sediment
		latitude (S)	longitude (E)	(m)	(m)	
Cape Adare						
A1	15/02/2004	71°15.5′	170°41.9′	515	358	Sand with few pebbles and stones
A2	14/02/2004	71°17.3′	170°39.2′	421	298	Sand and gravel
A3	14/02/2004	71°18.7′	170°29.2′	305	257	Sand
A4	14/02/2004	71°18.4′	170°28.9′	230	376	Sand and pebbles
A5	15/02/2004	71°18.7′	170°25.5′	119	59	Sand with pebbles and stones
Cape Hallett						
H out 1	09/02/2004	72°15.7′	170°24.8′	458	375	Mud and pebbles
H out 2	11/02/2004	72°17.5′	170°29.4′	353	375	Sandy mud and stones
H out 4	12/02/2004	72°18.5′	170°26.8′	235	194	Sand
H in 2	10/02/2004	72°16.9′	170°12.2′	391	186	Coarse sand and small gravel
H in 3	16/02/2004	72°17.0′	170°13.1′	316	194	Muddy sand with stones
H in 4	16/02/2004	72°17.1′	170°14.0′	196	169	Mud and sand
H in 5	16/02/2004	72°17.2′	170°17.9′	84	113	Small gravel
Coulman Island						
C1	18/02/2004	73°24.5′	170°23.2′	474	375	Mud and small gravel
C2	18/02/2004	73°22.7′	170°06.9′	410	153	Mud and pebbles
Cape Russell						
SMN	20/02/2004	74°43.2′	164°13.1′	366	192	Sand with gravel and stones
R2	21/02/2004	74°49.0′	164°18.1′	364	575	Fine sand
R3	20/02/2004	74°49.3′	164°11.5′	330	565	Rock, sand, mud and pebbles
R4	20/02/2004	74°49.3′	164°11.5′	208	97	Rock, mud and large stones
R4	22/02/2004	74°50.2′	164°05.5′	216	-	Rock, mud

enhance the species inventory list of the Ross Sea cumacean fauna.

Results

Distribution of the peracarid fauna off Victoria Land

During the Victoria-Land cruise 63% of the collected macrobenthic fauna were peracarid crustaceans. In total 45,087 specimens of Peracarida were collected, 5,286 of which belonged to the order of Cumacea.

Amphipoda were the dominant peracarid taxon (66%) followed by Isopoda (18%), Tanaidacea (8%), Cumacea (7%), and Mysidacea (<1%). Abundance values varied remarkably among stations and peracarid groups (Table 2). The highest total abundance of peracarids was found at the shallowest station (H in 5; 84 m) off Cape Adare.

The Cumacea showed a tendency of increasing relative abundance from north to south (Fig. 2): it ranged from 0.5% in the north at Cape Adare to 36% in the south at Cape Russell. In contrast the proportion of Amphipoda was higher in the northern (Cape Adare 63%, Cape Hallett 69%) than in the southern areas (Coulman Island 27%, Cape Russell 36%). The relative abundance of Tanaidacea was three times higher at Coulman Island (31%) than in the other areas (6–10%). Isopod abundance was highest at Cape Russell, but varied less than in the other peracarid groups (14–26%). Mean abundance of Amphipoda, Isopoda, and Tanaidacea was highest at the shallowest stations, whereas Cumacea and Mysidacea showed maximum abundances at stations from 300 to 400 m (Table 3).

Composition, distribution and diversity of Cumacea off Victoria Land

All five cumacean families known from the Antarctic and 12 genera were represented in the samples. 19 of the 28 cumacean species found in the samples are new records for the Ross Sea. In addition two new records of cumacean species were collected with RV "Tangaroa" (Table 4), thus the number of recorded species totals 34. Leuconidae containing nine species from two genera were the most dominant cumacean family (69%). The genus *Leucon* (6 species) was most abundant (57%). Nannastacidae, comprising nine species of three genera, occurred with 21%. The family Diastylidae (7 species, 4 genera) made up 6% of total cumacean abundance. Only two species of two genera of Bodotriidea and Lampropidae were collected which represented 3% and less than 1%, respectively, of cumacean specimens.

Table 2 Abundance of Peracarida along the Victoria-Land coast

Station north to south	Amphipoda		Cumacea		Isopoda		Mysidacea		Tanaidacea	
	N	N 10^3 m^{-2}	N	N 10^3 m^{-2}	N	N 10^3 m^{-2}	N	N 10^3 m^{-2}	N	N 10^3 m^{-2}
Cape Adare										
A1	244	1,363	2	11	23	128	17	95	40	223
A2	1,567	10,517	0	0	173	1,161	14	94	285	1,913
A3	682	5,307	2	16	605	4,708	4	31	57	444
A4	1,209	6,431	37	197	1,034	5,500	3	16	271	1,441
A5	505	17,119	3	101	68	2,305	1	34	75	2,542
Cape Hallett										
H out 1	636	3,392	114	608	301	1,605	0	0	88	469
H out 2	846	4,512	66	352	277	1,477	0	0	45	240
H out 4	2,357	24,299	65	670	1,050	10,825	6	62	154	1,588
H in 2	159	1,710	107	1,151	78	839	4	43	22	237
H in 3	991	10,216	297	3,062	450	4,639	0	0	181	1,866
H in 4	3,185	37,692	219	2,586	1,449	17,148	0	0	486	5,751
H in 5	10,170	180,000	56	991	882	15,611	0	0	490	8,673
Coulman Island										
C1	57	304	10	53	36	192	3	16	27	144
C2	711	9,294	315	4,116	676	8,837	2	26	838	10,954
Cape Russell										
SMN	1,413	14,719	1,252	13,050	1,080	11,250	42	438	448	4,667
R2	1,016	3,534	1,354	4,706	729	2,536	0	0	75	261
R3	694	2,457	1,374	4,864	516	1,827	26	92	78	276
R4	97	2,000	14	288	41	845	1	21	11	227

N = number of specimens collected per station, *N* 10^3 m^{-2} = number of specimens per station standardized to 1,000 m^2

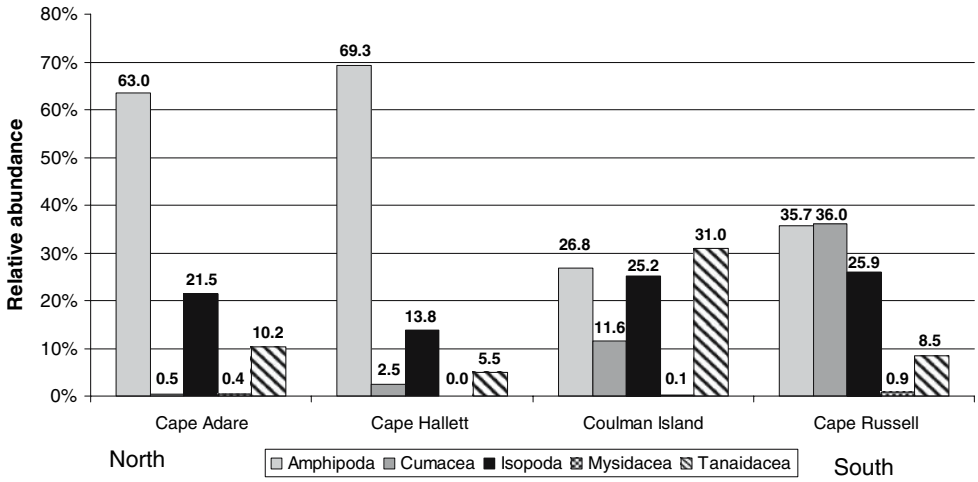

Fig. 2 Relative numbers of peracarid taxa in the sample areas on the Ross Sea shelf, Antarctica

Table 3 Peracarid abundance per 1,000 m^{-2}, averaged across four depth zones off Victoria Land, Ross Sea

Depth range (m)	Amphi	Cuma	Isop	Mysid	Tana
84-200	78,270	1,226	11,688	11	5,655
201-300	4,216	243	3,173	19	834
301-400	6,565	3,886	3,897	86	1,142
401-515	8,195	910	3,791	49	2,549

Amphi Amphipoda, *Cuma* Cumacea, *Isop* Isopoda, *Mysid* Mysidacea, *Tana* Tanaidacea

Most species were found between 200 and 450 m depth. From 100 to about 200 m only six species were found, whereas nine species were confined to depths below 300 m (Fig. 3). Diversity varied considerably (H′:0–2.5; J′:0.45–0.83) and was highest at station C2 off Coulman Island, which also was the station with the highest number of species (20). Diversity was lowest at stations A1, A3, and A5 off Cape Adare, for only one species was represented at these stations (Table 5). Accordingly, Cape Adare was the area with the lowest mean values of diversity, number of species, and abundance, whereas off Coleman Island mean diversity and mean species number were highest. Cumacean mean abundance increased with latitude (Table 6). Mean diversity and evenness showed a tendency to higher values at deeper stations; mean species number,

Table 4 Cumacean species of the Ross Sea; species collected during the expeditions of RV "Italica" (Ita) and "Tangaroa" (Tan) in 2004, *n* = new record from the Ross Sea

Family/Species	Author	Record	
Lampropidae			
Hemilamprops cf. *ultimaspei*	Zimmer (1921)	Ita	n
Hemilamprops cf. *pellucidus*	Zimmer (1908)	Tan	n
Paralamprops rossi	Jones (1971)		
Bodotriidae			
Cyclaspis gigas	Zimmer (1907b)	Ita/Tan	
Vaunthompsonia inermis	Zimmer (1909)	Ita	n
Leuconidae			
Eudorella fallax	Zimmer (1909)	Tan	n
Eudorella gracilior	Zimmer (1909)	Ita	
Eudorella cf. *sordida*	Zimmer (1907a)	Ita	n
Eudorella splendida/similis	Zimmer (1902)		
Eudorella sp. A		Ita	
Leucon antarcticus	Zimmer (1907a)	Ita	
Leucon assimilis	Sars (1887)	Ita	n
Leucon intermedius	Mühlenhardt-Siegel (1996)	Ita	n
Leucon parasiphonatus	Mühlenhardt-Siegel (1994)	Ita	n
Leucon cf. *sagitta*	Zimmer (1907a)	Ita	n
Leucon sp. A	spec. nov.	Ita	n
Nannastacidae			
Campylaspis antarctica	Calman (1907)	Ita	
Campylaspis frigida	Hansen (1908)	Ita	n
Campylaspis ledoyeri	Petrescu and Wittman (2003)	Ita	n
Campylaspis maculata	Zimmer (1907b)	Ita	n
Campylaspis quadridentata	Ledoyer (1993)	Ita	n
Campylaspis quadriplicata	Lomakina (1968)	Ita	n
Cumella australis	Calman (1907)	Ita	
Cumella cf. *emergens*	Corbera 2000	Ita	n
Procampylalspis meridiana	Jones (1971)		
Procampylaspis compressa	Zimmer (1907b)	Ita	n
Diastylidae			
Diastylis corniculata	Hale (1937)	Ita	n
Diastylis enigmatica	Ledoyer (1993)	Ita/Tan	n
Diastylis helleri	Zimmer (1907a)	Ita/Tan	
Diastylis juv. cf. *mawsoni*	Calman (1918)	Ita	n
Diastylopsis goeki	Roccatagliata and Heard (1992)	Ita	
Leptostylis antipus	Zimmer (1907a)	Ita	n
Makrokylindrus baceskei	Lomakina (1968)		
Makrokylindrus inscriptus	Jones (1971)	Ita	
Gynodiastylis jazdzewskii	Błażewicz and Heard (1999)		

abundance, and diversity were highest at stations between 301 and 400 m (Table 7).

After the MDS analysis stations were roughly arranged corresponding to their geographical order (Fig. 4). The only exception was station A1 (Cape Adare), which was clearly different to the remaining stations. Species, which only occurred in one area, were found. Thus the species *Eudorella* sp. A and *Makrokylindrus inscriptus* were only recorded from Cape Hallett. *Leucon parasiphonatus* and *Diastylopsis goeki* solely occurred off Coulman Island. Species confined to Cape Russell were *Campylaspis frigida* and *Diastylis enigmatica*. No species occurred exclusively at Cape Adare.

Discussion

Almost nothing has been known about sub-tidal ecosystems off the northern Victoria-Land coast, and most recent studies of shallow benthic communities in the Ross Sea focused rather on ecological interactions than on classifications (Waterhouse 2001). A first attempt to describe the community structure of smaller macrozoobenthic species along the northern Victoria-Land coast was made onboard of the 19th expedition of RV "Italica" (Rehm et al. 2006).

Gears with small mesh sizes, such as the Rauschert dredge or epibenthic sledges, are very effective for sampling smaller peracarid crustaceans. As the Rauschert dredge (see Rehm et al. 2006) was used for the first time in the Ross Sea, it gave us a first insight into the peracarid community of the northern Victoria-Land coast and helped to considerably improve our knowledge of cumaceans from the Ross Sea.

Comparison of the peracarid fauna

The peracarid community sampled during the 19th Italian expedition with research vessel "Italica" was dominated by amphipods. Isopods represented the second dominant group, followed by Tanaidacea, Cumacea, and Mysidacea. Only few quantitative studies of peracarids sampled with gears with small mesh size were so far carried out in Antarctic waters. Samples taken off the South Shetland Islands at depth between 200 and 400 m and taken with an epibenthic sledge in autumn 2000 showed comparable results in the mean proportions of peracarid orders: 62% Amphipoda, 16% Isopoda, 13% Tanaidacea, 11% Cumacea, and less than 1% Mysidacea (Lörz and Brandt 2003). Nevertheless, samples taken during summer in the southern Weddell Sea and off King George Island in depths ranging from 200 to 400 m showed different values (Linse et al. 2002); Isopoda 60%, Amphipoda 26%, Mysidacea 10%, Cumacea 4%, and Tanaidacea 1% in the Weddell Sea; Cumacea 39%, Amphipoda 31%, Mysidacea 17%, Isopoda 13%, and Tanaidacea 1% off King George Island. Differences in the gear are one explanation for the variations in the results of the different studies. The epibenthos sledge samples from over 20 cm to more than 120 cm above the seafloor (Brandt and Barthel 1995; Brenke 2005), but the Rauschert dredge is bound to the first about 18 cm above the ground. Thus, the increased number of

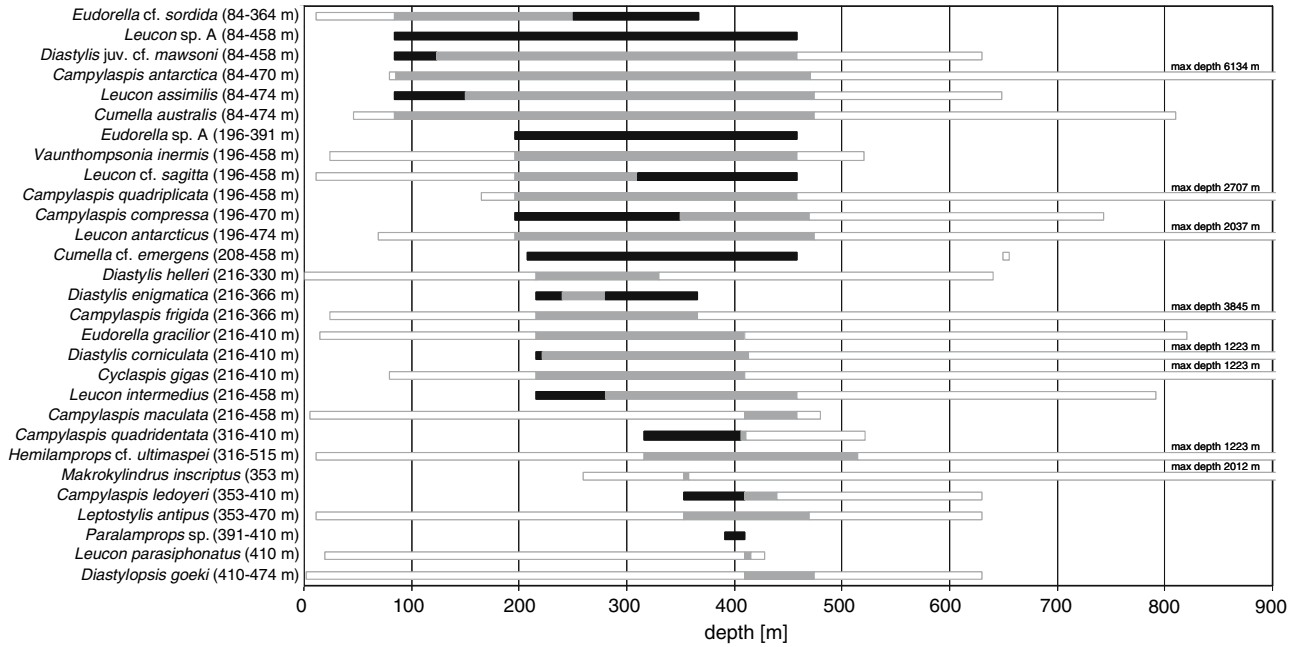

Fig. 3 Bathymetric distribution of the Cumacea collected during the Victoria-Land transect cruise to the Ross Sea, Antarctica (*black shade*); general depth range (*white shade*), data based on Jones (1971, 1984) Ledoyer (1993), Mühlenhardt-Siegel (1999), Corbera (2000), Petrescu and Wittman (2003), Corbera and Ramos (2005); overlapping depth range (*grey shade*)

Mysidacea in the epibenthic sledge samples might be attributed to their suprabenthic life style. However, only few mysids were sampled with the epibenthic sledge in autumn 2000. Variations of the contribution of peracarid orders to the peracarid fauna were high during all studies and the number of samples from shallower water than 500 m depth taken in the Weddell Sea and the South Shetland Islands was limited. Therefore, it is difficult to judge whether differences might result from the patchiness of the fauna obtained, a different compositions of the fauna, or seasonal effects. Further sampling with and comparison of multiple gears will provide more reliable information about seasonal differences and similarities between the different Antarctic areas.

Composition and distribution of the cumacean fauna

In the Weddell Sea as around the South Shetland Islands (Corbera 2000; Lörz and Brandt 2003) most speciose family was the Nannastacidae. In the Ross Sea, the most abundant family was the Leuconidae, whereas the Diastylidae (Lörz and Brandt 2003) or Bodotriidae (Corbera 2000) dominated the cumaceans off the South Shetland Islands. Mean species number off the South Shetland Islands was half of the Ross Sea, whereas total species number varied between 50 (Lörz and Brandt 2003) and 100% (Corbera 2000).

Cumacean diversity index was higher at deeper stations and maximal in a depth of 410 m at station C2, which was one of the stations with muddy sediment. At the South Shetland Islands, cumacean diversity was extremely variable. Nevertheless, a tendency towards higher values at deeper stations was recorded as well; this trend extended to depths below 500 m on the continental slope (Corbera 2000). Density and species number of the Cumaceans of the Beagle Channel was found to increase with depth and reduced grain size of the sediment (Brandt et al. 1999).

During this study one group of species was found ranging from 100 to 500 m, a second group of species was found in between 200 and 500 m, and a third group ranges from 300 to 500 m. From the Weddell Sea, three bathymetric groups of cumaceans were reported between 200 and 500–600 m, below 500 m, and finally between 200 and 2,000 m (Ledoyer 1993). Corbera (2000) described a situation with three groups between 45 and 300 m, 300 and 650 m, 45 and 650 m. Concluding from the three stydies, there appear to be two important changes in cumacean depth distribution around 300 and 500–600 m depth.

The most striking result of this work is the large number of newly recorded cumacean species from the Ross Sea. One reason to explain this remarkable increase in known species can be ascribed to the little previous work from the area under investigation, which has now been accomplished on the deeper benthic environment, between 50 m and the shelf break at 800 m (Clark and Rowden 2004; Waterhouse 2001). The new species

Table 5 Species station list of the Cumacea collected during the Victoria-Land transect cruise; data standardized to 1,000 m^2 hauls; total abundance of families are given in bold numbers; + species present, no quantitative data available

Station	A1	A3	A4	A5	H out 1	H out 2	H out 4	H in 2	H in 3	H in 4	H in 5	C1	C2	SMN	R2	R3	R4	R4
Depth (m)	515	305	230	119	458	353	470	391	316	196	84	474	410	366	364	330	208	216
Species number	1	1	3	1	12	12	4	13	16	12	6	4	20	14	13	13	5	14
Abundance	11	16	197	101	608	351	670	1,152	3,060	2,587	992	53	4,114	13,082	4,705	4,864	289	-
Diversity (H′)	0	0	0.49	0	1.82	1.81	1.13	1.94	2.00	1.56	1.22	1.15	2.50	1.76	1.68	1.92	1.26	-
Evenness (J′)	-	-	0.45	-	0.73	0.73	0.82	0.76	0.72	0.63	0.68	0.83	0.83	0.66	0.65	0.75	0.78	-
Lampropidae	**11**				**27**	**5**		**11**	**10**				**26**					
Hemilamprops cf. *ultimaspei*	11				27	5			10									
Paralamprops sp.								11					26					
Bodotriidae					**5**	**5**		**43**	**51**	**24**			**496**	**229**	**3**	**67**	**165**	**+**
Cyclaspis gigas						5			10				65		3	7		+
Vaunthompsonia inermis					5			43	41	24			431	229		60	165	+
Nannastacidae		**16**	**181**	**101**	**203**	**197**	**567**	**173**	**475**	**945**	**177**	**16**	**1,802**	**1,981**	**173**	**843**	**62**	**+**
Campylaspis antarctica			11			5	196		31	24	159		13	63	42	67		+
Campylaspis frigida														73	45	57		
Campylaspis ledoyerii						5							91					
Campylaspis maculata					11								78					+
Campylaspis quadridentata									41				378					
Campylaspis quadriplicata					5	11		11	51	12			118					
Procampylaspis compressa						32	31	11		59			26	10				
Cumella australis		16	170	101	139	144	340	119	330	850	18	16	993	1,647	83	719	21	+
Cumella cf. *emergens*					48			32	21				105	188	3		41	
Leuconidae			**16**		**341**	**102**		**765**	**1,979**	**1,594**	**602**	**32**	**1,477**	**10,466**	**4,286**	**3,749**	**62**	**+**
Eudorella gracilior									103				92	1,272	1,300	1,030		+
Eudorella cf. *sordida*									103	118	35				80			
Eudorella sp. A						16		97		35								
Leucon antarcticus					48			474	866	260		27	353	4,253	1,926	1,303		+
Leucon assimilis					27			22		12	18	5	353	803	94	85	21	+
Leucon intermedius					16	11		32	10				235	10	97	85		+
Leucon parasiphonatus													13					
Leucon cf. *sagitta*					5				72	106				198	497	333		+
Leucon sp. A			16		245	75		140	825	1,063	549		431	3,930	292	913	41	+
Diastylidae					**32**	**42**	**103**	**161**	**546**	**24**	**213**	**5**	**313**	**406**	**243**	**205**		**+**
Diastylis corniculata													52	10				+
Diastylis enigmatica														396	243	198		+
Diastylis helleri									175							7		+
Diastylis juv. cf. *mawsoni*					32			31	371	24	213							
Diastylopsis goeki												5	78					
Leptostylis antipus						37	103	129					183					
Makrokylindrus inscriptus						5												

Table 6 Average measurements of cumacean diversity by latitude (Victoria-Land transect, Ross Sea)

Sample area north to south	S mean/total	N	H′	J′
Cape Adare	2/4	81	0.45	0.12
Cape Hallett	11/24	1,346	0.72	1.64
Coulman Island	12/20	2,084	0.83	1.82
Cape Russell	11/17	5,727	0.71	1.65

S species number, *N* abundance per 1,000 m^2 , *H′* diversity, *J′* evenness

Table 7 Average measurements of cumacean diversity by depth (Victoria-Land transect, Ross Sea)

Depth range (m)	S mean/total	N	H′	J′
84–200	6/12	1,227	0.92	0.65
201–300	4/15	243	0.87	0.61
301–400	12/26	3,885	1.59	0.71
401–515	8/23	1,091	1.32	0.80

S species number, *N* abundance per 1,000 m^2 , *H′* diversity, *J′* evenness

Leucon sp. A shows that the area is truly undersampled, as the species was one of the most common species with up to 2,000 specimen per square meter in the present study. Only *Leucon antarcticus* occurred more frequently. *Leucon sp.* A was found along the whole Victoria-Land coast and it was missing only at the deepest samples below 460 m. In addition, this species is very easy to distinguish from other species of the genus *Leucon*. Nevertheless, there has been no data published about this species before. What might be even more important for the many species newly recorded from the Ross Sea was the use of a Rauschert dredge, as this gear is specially designed to catch animals of small size. In the case of the Cumacea, the number of species, which were reported for the Ross Sea before, increased from 13 to 32 species. Moreover, two further species, *Hemilamprops* cf. *pellucidus* and *Eudorella fallax* were found on the parallel cruise with RV "Tangaroa". Thus, 34 species are recorded in total for the Ross Sea. We expect that investigations of the other peracarid orders will lead to similar results.

A summary of the Antarctic cumacean species and their distribution in the Antarctic and Subantarctic regions was given by Mühlenhardt-Siegel (1999). The highest numbers of cumacean species were recorded from the East Antarctic (32), the Magellan region (31), and the Weddell Sea (29). In the Scotia region numbers varied between 15 and 20 species, whereas, in the Ross Sea only 11 species were recorded. Here we documented that the Ross Sea harbours more cumacean species than the other high Antarctic regions, although it was formerly regarded as the poorest Antarctic area concerning cumacean species richness. This finding highlights the need for more explorative sampling in the Ross Sea area and in deeper waters off the continental slope off Antarctica.

Most species from the Ross Sea show a wide range of geographic distribution (Table 8). Fifteen species occur in Antarctic regions, seven species are restricted to high Antarctic regions. Antarcto-Magellan species divide into a Subantarctic/Antarctic (6) and a Subantarctic/high Antarctic (2) group. The species of the latter group are probably also Subantarctic/Antarctic. After all, seven species making up 21% of the species from the Ross Sea occur in the Magellan area as well as in the Ross Sea. The species

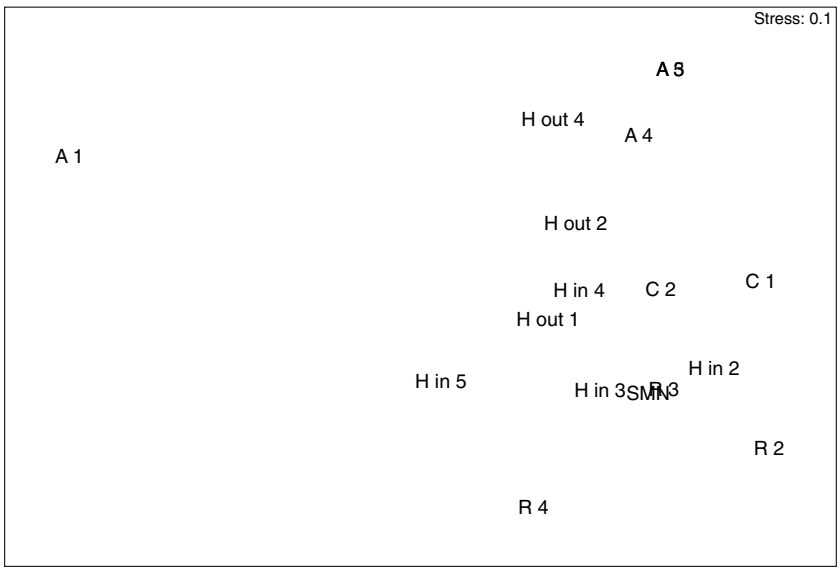

Fig. 4 MDS-plot of Ross Sea Cumacea; *A* Cape Adare, *H* Cape Hallett, *C* Coulman Island, *R* Cape Russell, *SMN* Santa Maria Novella

Table 8 Biogeography of cumacean species from the Ross Sea; data based on Hansen (1908), Mühlenhardt-Siegel (1999), Petrescu and Wittman (2003), Corbera and Ramos (2005), the present study and unpublished data from the BENTART-06[1] cruise (J. Corbera, pers. comm.) and the ANT XXI-2[2] cruise with RV "Polarstern"

Species	Subantarctic		Antarctic						
	Magel	Kerg	S Geo	S Ork	S Shetl	Ant P	Wedd	BS	E Ant
Subantarctic and Antarctic									
Campylaspis maculata	+		+	+	+	+	+		+
Campylaspis antarctica	+				+		+	+[1]	+
Eudorella splendida/similis		+	+		+				
Hemilamprops ultimaspei	+				+		+		
Leucon assimilis	+	+			+	+	+		+
Leucon sagitta	+	+	+	+	+	+			+
Antarctic									
Cumella australis			+	+	+	+	+	+	+
Cumella cf. *emergens*					+		+[2]	+[1]	
Cyclaspis gigas			+		+	+	+	+	+
Diastylis corniculata				+	+		+		+
Diastylopsis goeki				+	+	+	+		+
Diastylis helleri			+	+	+	+	+		+
Eudorella fallax			+	+	+	+			+
Eudorella gracilior			+	+	+	+	+		+
Eudorella cf. *sordida*			+						
Hemilamprops cf. *pellucidus*					+	+	+		+
Leptostylis antipus			+	+	+	+	+		
Leucon antarcticus				+		+	+		+
Leucon intermedius					+	+	+[2]		+
Leucon parasiphonatus					+		+		
Vaunthompsonia inermis			+	+	+	+	+	+	+
high Antarctic									
Campylaspis ledoyeri							+		
Campylaspis quadridentata							+		+
Diastylis enigmatica							+		
Diastylis juv. cf. *mawsoni*							+	+	+
Makrokylindrus inscriptus							+		
Paralamprops rossi							+		+
Procampylaspis compressa							+	+	
Subantarctic and high Antarctic									
Campylaspis frigida	+	+						+	
Campylaspis quadriplicata	+						+	+	
Ross Sea									
Leucon sp. A									
Procampylalspis meridiana									
Makrokylindrus baceskei									
Gynodiastylis jazdzewskii									

Ant P Antarctic Peninsula, *BS* Bellingshausen Sea *E Ant* East Antarctic, *Kerg* Kerguelen, *Magel* Magellan Area, *S Geo* South Georgia, *S Ork* South Orkneys, *S Shetl* South Shetlands, *Wedd* Weddel Sea

of both areas total to 66. An overlap of 11% is the same rate as reported for the Magellan area and Antarctica (Mühlenhardt-Siegel 1999). Four species (11%) are endemic to the Ross Sea, the rate of endemism is less than in the Weddell Sea (28%) and in the East Antarctic (13%) (Corbera 2000). In conclusion, not only species number but also biogeographical connection to the Magellan area of the cumaceans of the Ross Sea resembles that of other high Antarctic regions. Still, the rate of endemism is the lowest of high Antarctic areas and similar to the East Antarctic only.

In several cases the determination of the species was difficult, as some of the original descriptions show only parts of the animal or the drawings are vague. We believe that good re-descriptions are necessary to simplify future work on Antarctic cumaceans. Another problem was that some of the species showed slight but consistent differences to specimens from original descriptions. It is rather likely these species show geographic variations, but there is also a chance that we found sibling species. Genetic analysis of the Antarctic isopod species *Ceratoserolis trilobitoides* demonstrated that sibling species, which were described as variations

before (Wägele 1986), were even found in the same location (Held 2003). Possibly this is true for other Antarctic peracarid crustaceans as well. The Ross Sea is the southernmost ocean on earth and in contrast to most other Antarctic regions it is characterized by a very wide continental shelf. Furthermore, the Ross Sea polynya encloses the most productive phytoplankton primary production found in Antarctica (Smith et al. 1996), which might particularly foster benthic diversity.

Morphological variability in the Antarctic Cumacea and cryptic speciation, as already proven in Antarctic peracarid isopods (Held 2003; Held and Wägele 2005), are an indication of recurrent isolation processes of populations on an evolutionary timescale. Considering that most species of the Ross Sea Cumacea have a limited depth distribution that only covers the Antarctic continental shelf and slope, the deep-sea might not have served as refuge for many species during glacial ice advance in Antarctica (Thatje et al. 2005). This again poses the question of isolated shallow water refuges for benthic fauna in glacial periods and under severest environmental conditions (for discussion see Thatje et al. 2005). Such geographically isolated shelters, in addition, might have driven speciation process in the Peracarida, which have flourished in Antarctica. Molecular studies are needed to unravel this important and controversial question in the evolution of the Antarctic fauna.

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