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Studies on the larval stages of *Euphausia superba* Dana (*Crustacea, Euphausiacea*) in the southern Drake Passage and in the Bransfield Strait in February and March 1981 during the BIOMASS-FIBEX expedition*)

ABSTRACT: Krill larvae distribution and abundance in waters surrounding South Shetland Islands were studied in February and March 1981. Main concentrations of larvae were noted over great depths near the continental slope. High densities of krill larvae were encountered in stations where phytoplankton was moderately abundant.

Key words: Antarctic, *Euphausia superba*, krill larvae

1. Introduction

It is well known that krill — *Euphausia superba* Dana — as a central species of the Antarctic trophic chain, is also a promising object of commercial fishery. This crustacean attracts therefore the attention not only of scientists and this was the reason why the international BIOMASS-FIBEX expedition was organized in 1981 just to study various aspects of the biology and ecology of krill in a hitherto unprecedented scale.

In the Polish part of the expedition, on board of the r/v "Profesor Siedlecki", in February and March 1981 among manifold hydrological and biological investigations zooplankton samples were collected over the whole studied area. In these samples larval stages of *Euphausia superba* occurred sometimes in considerable numbers. In the paper by Jażdżewski, Kittel and Łotocki (1982) where zooplankton studies are presented, the larvae of *E. superba* are only generally treated as calyptopis of furciliae. The aim of the present note is a more detailed presentation of the distribution of *E. superba* larvae in the investigated sector of the Southern Ocean.

*) This study was supported by the Polish Academy of Sciences within the MR-I-29 Project, embracing the Polish part of the BIOMASS-FIBEX expedition headed by Dr. S. Rakusa-Suszczewski.

2. Sampling area and methods

The Polish sector (A) of the BIOMASS-FIBEX expedition was bordered to the west and east by the meridians 66° and 56° W, respectively and it covered an area south of 60° S to 65° S and to the Antarctic Peninsula and d'Urville Island. Therefore this sector included the southern part of the Drake Passage, the vicinities of the Palmer Archipelago and South Shetland Islands as well as the Bransfield Strait (Fig. 1).

Geographical coordinates of stations as well as the dates and hours of samplings are to be found in the paper by Rakusa-Suszczewski (1982).

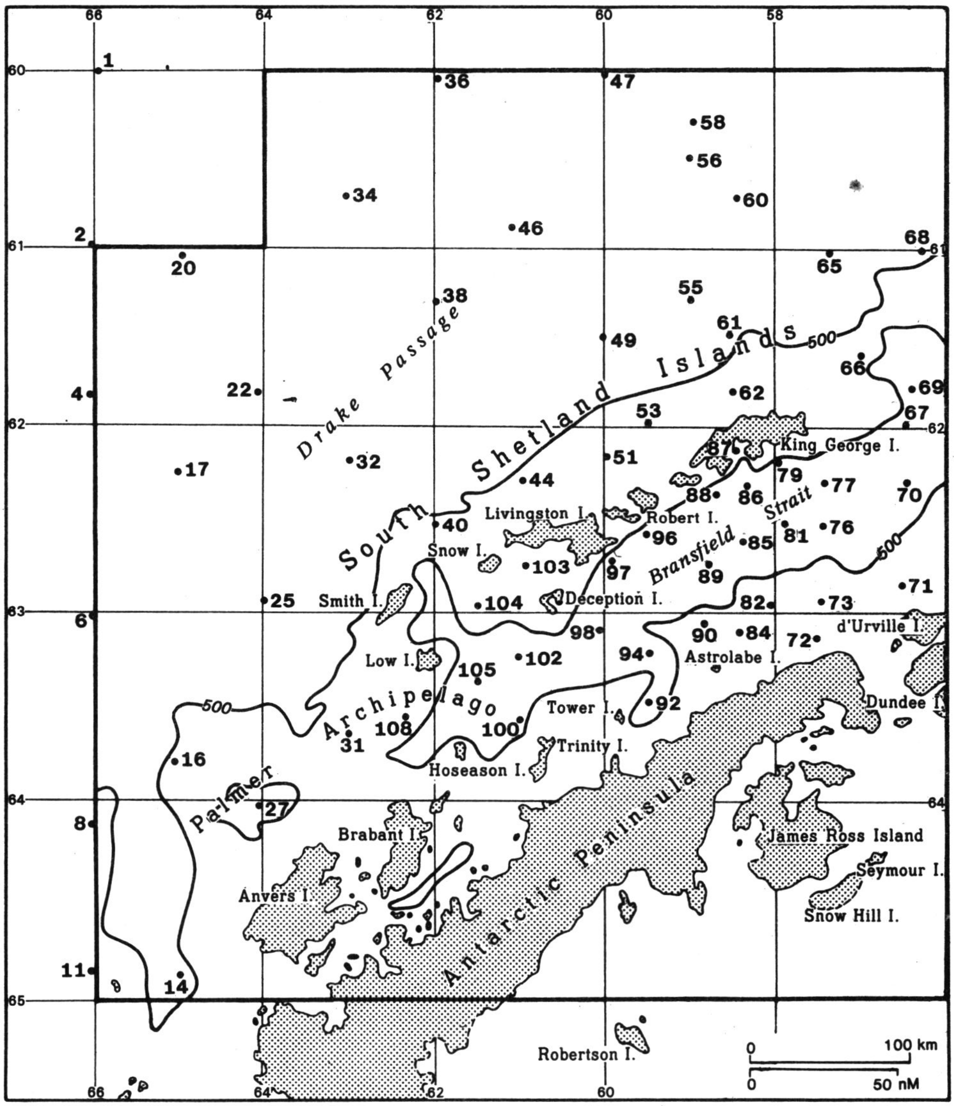

Fig. 1. Sampling stations during the BIOMASS-FIBEX cruise of the r/v "Profesor Siedlecki"

Larval stages of Euphausia superba per 1000 m³ in sector A of the BIOMASS — FIBEX 1981 expedition

Table I.

Station No.	Sounding [m]	100—0								300—100						
		C_I	C_{II}	C_{III}	F_I	F_{II}	F_{III}	F_{IV}	Σ	C_I	C_{II}	C_{III}	F_I	F_{II}	F_{III}	Σ
6*)	3300	1500							1500							
17	3500									1000	1890					2890
22	3500									1300	2900					4200
25	3600	28600							28600		188					188
31	314				30				30							
32	3600	3000	6000						9000	10000	16310					26310
36	3500	20000	15000	25000					60000		90					90
38*)	3600	900	1000						1900							
46	3600		3700						3700		930					930
47	3600		84590		35710				120300							
49	3350		50000	168000	4000				222000		1250	1000				2250
53	188				900				900							
55	3600		2000	30000					32000			750				750
56	3500					15000			15000							
58	3700						100		100					1870		1870
61	1500		8000	30000					38000							
62	191	750					950	30	1730							
65	4000									100	290	110	10	30	100	640
67	1400			8000					8000			180			60	240
68	2150		14000	44000	2000				60000			750				750
69	528			1500					1500							
70	970		2800	5600	500				8900			1500	370			1870
73	535										840					840
76	1500			180	1500				1680							
77	1980				5400	400	1600		7600				570			570
79	550										1410	7510	2820	50	490	12280
81	1800											370	1880	5640		7890
84	900											370				370
86	1450									75	1120	413		1120		2726
87	340		750	3400		1900			6050		3280	13620	1400	1870	460	17350
88	775											1870		750		2620
92	750					200			200							
94	850					300	90		390			370	180	560		1110
97	800											1870		580	190	2640
100	615						40	20	60					190	370	560
102	910					220	70	30	320							
103	156				30				30							
104**)	281						2280		2280	530	830	940	560			2860
108***)	284											52				52

*) mesh size: 180 μm

**) deeper layer: 240—100 m

***) deeper layer: 280—100 m

$C_{I—III}$ — calyptopis.
$F_{I—IV}$ — furcilia.

Our zooplankton samples were collected at 61 stations using a closed Nansen net of 0.38 m^2 mouth opening (70 cm mouth diameter) and of 260 μm mesh size. Because of the temporary damage of the 260 μm mesh size net some few hauls were done with a 180 μm mesh size net; these hauls are marked in the table I with an asterisk. The net was vertically hauled in two layers; 100–0 m and 300–100 m. When the soundings were less than 300 m the net was hauled in the layer from nearly the bottom up to 100 m. The net was lowered with a 40 kg weight and raised with a speed of 0.5 m per second.

For qualitative and quantitative analysis larger organisms (over ± 5 mm) were picked out from the sample and were determined and counted separately. In the Bogorov camera from 2 to 4 subsamples of the rest of the sample were analysed under the stereo-microscope, animals were determined and counted. The volume of the whole sample was estimated in the measuring cylinder. Subsamples were taken from the carefully mixed suspension with a wide-mouthed calibrated pipette. The summarized volume of the analyzed subsamples constituted from 1/5 to 1/50 of the total sample depending on its richness. The amount of animals was calculated per 1000 m^3. Following the paper by Grindley and Lane (1979) we have assumed a filtration efficiency of 70%.

Determination of larval stages of E. superba was carried out according to the papers by Fraser (1936) and by Percova (1976). The diagram in fig. 4 was arranged as in the paper by Fevolden (1980); samples from each day and from both sampling depths at one station were combined and in such a "day sample" the percentage share of each stage was calculated. For the sake of clarity only such of these samples were considered where the combined number of larvae exceeded 100 ind. per 1000 m^3.

3. Results and discussion

In total 61 zooplankton samples in the water layer 100–0 m, 32 samples in the layer 300–100 m and 6 samples in other layers were collected. In 28, 24 and 2 of these samples, respectively, larval stages of *E. superba* were found. We have recognized in this material all three calyptopis stages and furcilia stages I–IV.

Waters around the tip of the Antarctic Peninsula and around the South Shetland Islands are well known as a basic region of krill occurrence. In this area large concentrations of *E. superba* were observed by all authors working there and most of them encountered here sprawning populations (i. a. Marr 1962, Jażdżewski et al. 1978, Witek et al. 1981 b). Marr's (1962) hitherto rather generally accepted hypothesis on the southward returning of young larvae with a deep intermediate current, combined with their further dispersal with circulations of the Weddell Sea and, to a smaller scale, of the Bellingshausen Sea, can explain the presence of high concentrations of larval krill in the area under present study. Such concentrations were observed here rather regularly. Marr (1962) was of the opinion that in this very area we have to do with a summer massing of larvae in surface waters as an annual event. It was recently observed by Nast (1977), I. Hempel and G. Hempel (1978) and Witek et al. (1981 a). It is to be mentioned, however, that Makarov (1974) in February 1967, in many stations situated north, east and south-east of the Elephant and Clarence Islands, i. e. in this "rich" area, has not found krill larvae at all. This author indicated to the important role of thermal conditions of particular year as a factor controlling the time of appearence of larvae in the upper water layers in consecutive seasons.

Worthy mentioning is also Everson's (1981) suggestion that in the Bransfield Strait there might exist a self maintaining krill population.

The distribution and abundance of different krill larval stages in the investigated area found during our study are presented in table I and in figs. 2 and 3. Krill larvae were collected both in oceanic waters and over the shelf. It was noticed, however, a distinct tendency towards the lesser abundance of krill larvae in samples taken in the stations where soundings were less than 500 m. Only in one case (St. 87, Admiralty Bay of the King George Island) where sounding was 340 m, krill larvae were abundant. One should mention, however, that it was a station situated at the end of a deep trench of the South Shetlands' shelf, the trench that forms a branch of the very deep northern part of the Bransfield Strait.

Most of the negative samples (no krill larvae in the plankton) taken in our sector were collected: a) in the north-western part of the sector, i.e. in the part farthest from the continental slope, and b) in the shelf waters of the Palmer Archipelago, South Shetland Islands and the Antarctic Peninsula. One can generalize that the majority of our positive, and especially of abundant krill larvae samples, were collected over great depths but near the continental slope. Similar, if not identical observations were recently noted in the same area by I. Hempel and G. Hempel (1978) and by Witek et al. (1981 a).

The highest abundancies of krill larvae were observed between February 22nd and March 4th 1981 north of the. King George Island. In stations 36, 47, 49 and 68, in the water layer 100–0 m, over 50000 of larvae per 1000 m^3 were recorded with a maximum of 222000 at station 49. These numbers significantly surpass maximal abundancies of I. Hempel and G. Hempel (1978) noted in the beginning of February 1976 in the same region.

Since only two thick water layers were sampled we cannot add much information to the vertical distribution of larvae. The upper 100 m layer in general was richer in larvae of all stages than the layer below 100 m in particular stations. The sampling method did not allow to confirm the vertical diurnal migrations observed by Marr (1962) and Nast (1977). It is only to be mentioned that all instances when the density of krill larvae in particular station in the lower layer (below 100 m) was high (more than 5000 ind./1000 m^3) and distinctly surpassed that of the upper 100 m layer, occurred in the daytime.

In contrast to Marr (1962) who mentioned that furcilia stages live mainly in the upper 50 m, but in accordance with the results of Makarov

(1974), Nast (1977) and I. Hempel and G. Hempel (1978) we have found furcilia stages I to III rather often in the water layer below 100 m, both at night and in the daytime.

Table I and figs. 2 and 3 show a high predominance of one of the larval stages in the samples. In the total of 54 krill larvae samples only in 3 cases the highest dominance of particular stage was less than 50%. This result is in a good agreement with Marr's (1962) observations.

One cannot reject the possibility that the larval populations sampled during the period of our study resulted from the spawnings of different local populations of the adult krill as suggested by Witek et al. (1981 b), especially when considering the special and complicated hydrological regime of the studied area.

Bearing in mind this reservation, but also the impossibility to keep track of a really homogenous krill larvae population in a longer time span, we have decided to present the generalized stage composition of the krill larvae populations in February and March 1981 in the whole investigated sector (Fig. 4). These results show only a very general seasonal age progression of larvae as was observed by I. Hempel and G. Hempel (1978) and by Fevolden (1980).

The general picture presented in fig. 4 shows the gradual replacement of calyptopis stages by furcilias during the period from mid February to mid March. Furcilias I appeared on February 23 rd and calyptopes I expired at the end of February 1981. Calyptopes II in the middle of March formed already an insignificant part of the larval population.

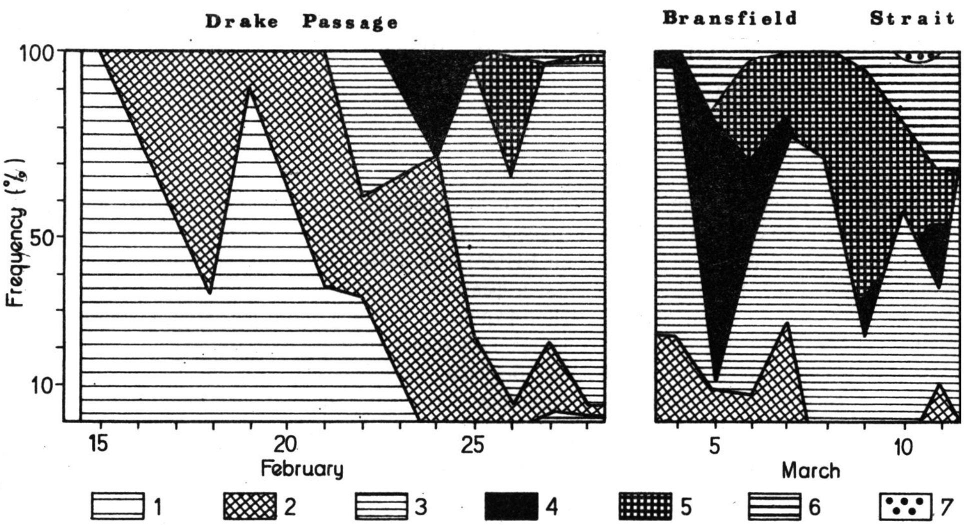

Fig. 4. Stage composition of the krill larvae populations in February (Drake Passage) and March (Bransfield Strait) 1981 in the sector "A" of the BIOMASS-FIBEX expedition 1 — calyptopis I, 2 — calyptopis II, 3 — calyptopis III, 4 — furcilia I, 5 — furcilia II, 6 — furcilia III, 7 — furcilia IV.

In the South Orkneys area Makarov (1974) has noted in 1965 and in 1967 that during one month (mid February to mid March) the proportion of furciliae in the total number of all larvae increased in both years more than 20 times. However this author has noted also that in the same area and in the same time but in different years the composition of larval population differed significantly. For instance the general level of development of the larval population near South Orkney Islands in March 1967 was distinctly retarded when compared with March 1965 and March 1969.

A rough picture of the quantitative distribution of krill larvae is in general accordance with a summer distribution of phytoplankton in the investigated area as it was presented by various authors (Hart 1934, El Sayed 1967, 1970, Witek et al. 1981 b, Kopczyńska and Ligowski 1982). In the 100–0 m layer the higest abundancies both of phytoplankton (usually above 1000 mm^3/m^2 and up 40000 mm^3/m^2) and of krill larvae (up to 222000 ind. per 1000 m^3) occurred to the north and north-west of the South Shetland Islands whereas the waters of the Bransfield Strait were comparatively poor in phytoplankton (about 10—1000 mm^3/m^2) and in krill larvae (max. 8900 per 1000 m^3). However, after close examination of the abundancies of krill larvae as found by the present authors and of phytoplankton as found by Kopczyńska and Ligowski (1982) in the same stations in our expedition, one can see that the highest krill larvae densities (60000—222000 ind. per 1000 m^3) occurred in stations with at most moderate phytoplankton abundancies (from about 20 to about 6000 mm^3/m^2). In one case only (st. 61) a rather high krill larvae abundance was observed (38000 ind. per 1000 m^3) together with a phytoplankton bloom (nearly 40000 mm^3/m^2). These results are in a general agreement with observations by Hardy and Gunther (1936).

4. Резюме

Изучалось распределение и численность личинок криля (*Euphausia superba*) в планктонных материалах, собранных в верхнем 300-метровом слое воды Южного Океана в секторе А международной экспедиции БИОМАСС-ФИБЭКС, а именно, в южной части пролива Дрейка и в проливе Брансфилд в феврале и марте 1981 года. В сборах обнаружено личинки стадий калиптопис I—III и фурцилия I—IV. Самые высокие концентрации личинок обнаружено в океанических водах над большими глубинами, расположенными вблизи материкового склона. Особенно богатые личинками планктонные пробы были собраны к северу от острова Кинг Джордж. Эти многочисленные личинками пробы встречались в общем в районах умеренной концентрации фитопланктона.

5. Streszczenie

Omówiono rozmieszczenie i liczebność larw kryła (*Euphausia superba*) w próbach planktonowych, zebranych w 300-metrowej, górnej warstwie pelagialu Oceanu Południowego w sektorze A międzynarodowego programu BIOMASS-FIBEX, a mianowicie w południowej części Cieśniny Drake'a i w Cieśninie Bransfielda w lutym i marcu 1981 r. W próbach

planktonowych stwierdzono obecność larw w stadiach calyptopis I—III oraz furcilia I—IV. Najwyższe liczebności larw kryla obserwowano w wodach oceanicznych ponad dużymi głębokościami lecz zawsze w pobliżu stoku kontynentalnego. Szczególnie bogate w larwy kryla próby planktonowe były zebrane na północ od Wyspy Króla Jerzego. Największe zagęszczenie larw stwierdzano z reguły w obszarach o umiarkowanej liczebności fitoplanktonu.

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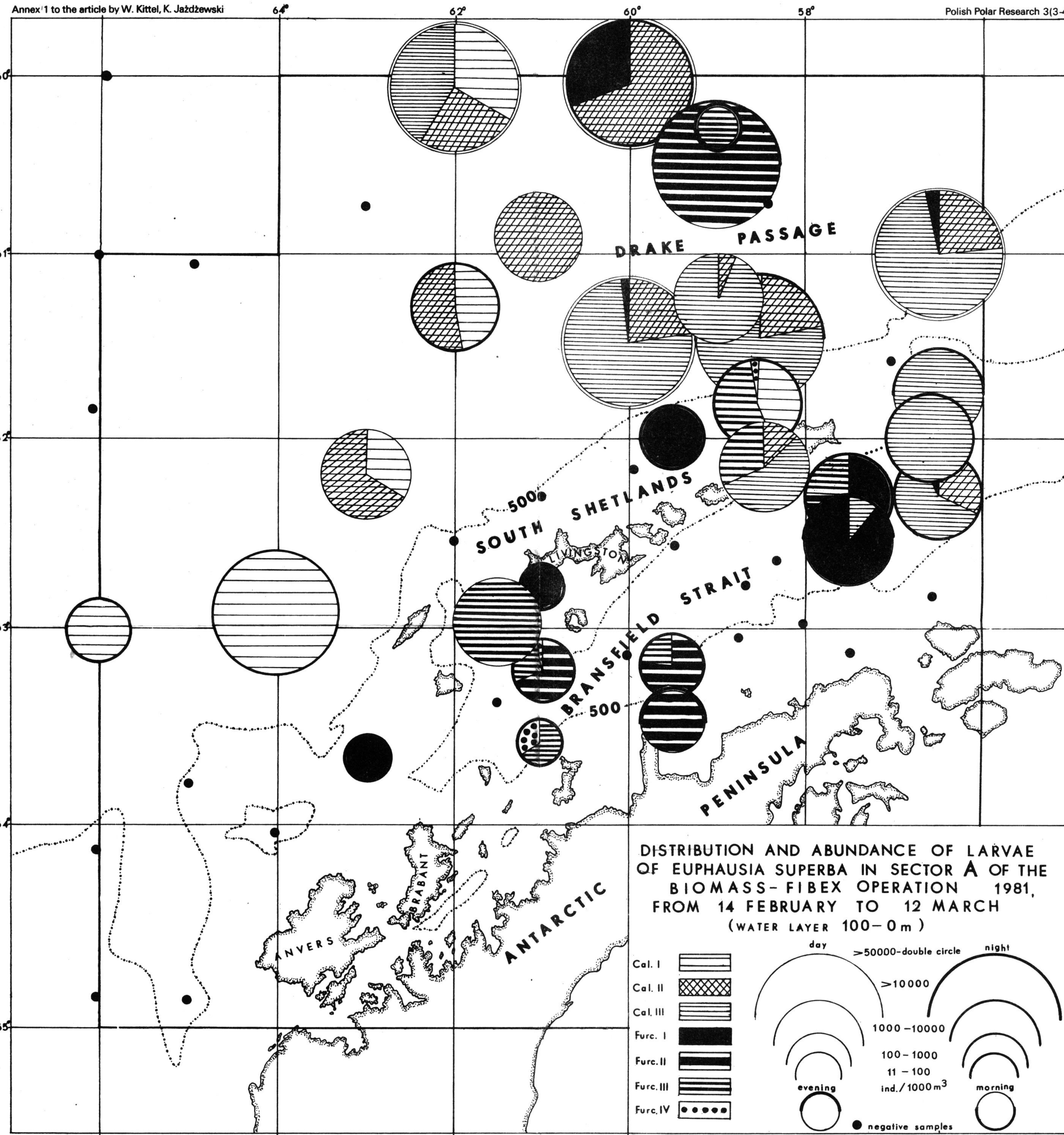

Fig. 2. Distribution and abundance of various larval stages of *Euphausia superba* in the water layer 100–0 m in the sector "A" of the BIOMASS-FIBEX expedition

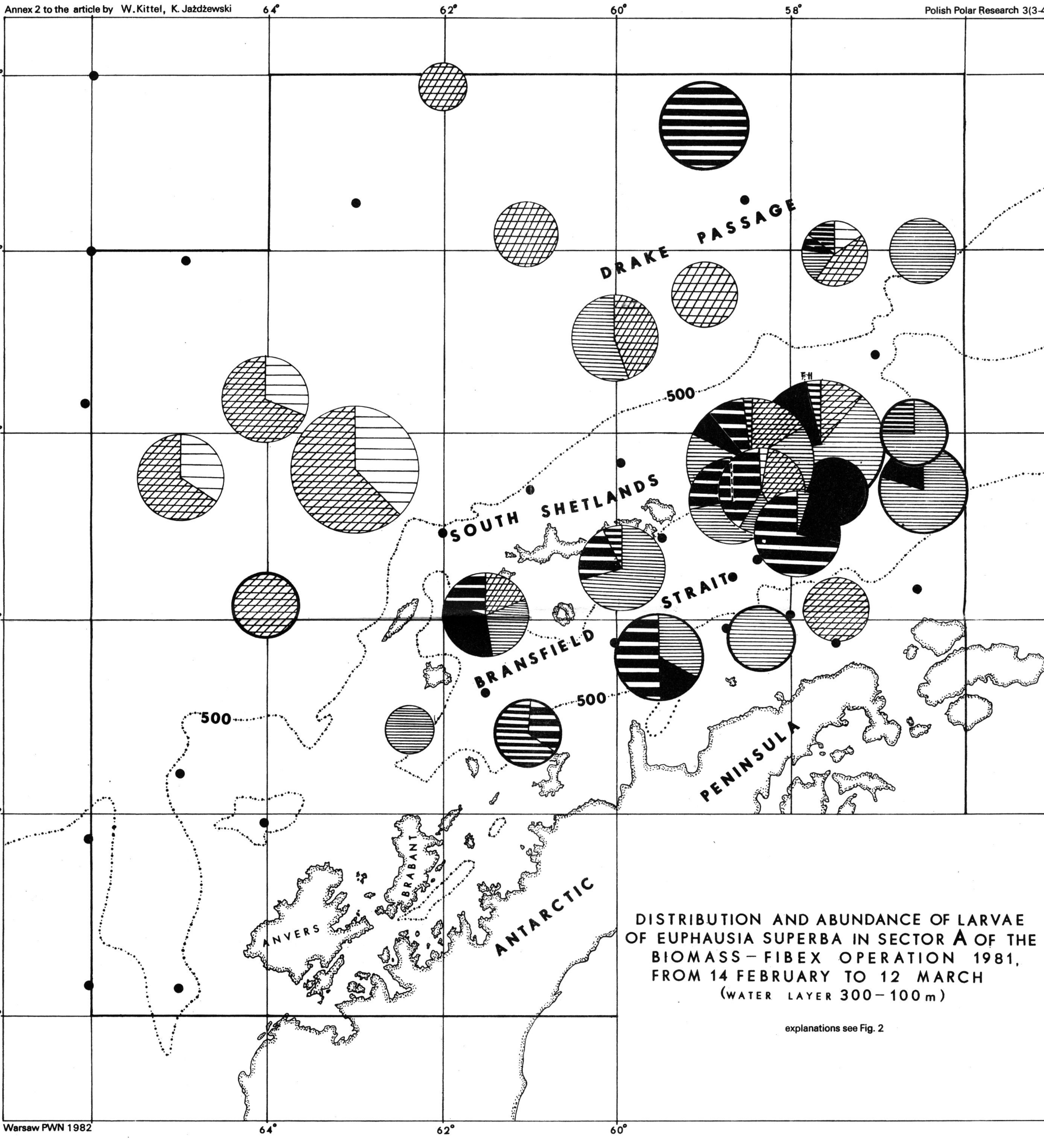

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Fig. 3. Distribution and abundance of various larval stages of *Euphausia superba* in the water layer 300–100 m in the sector "A" of the BIOMASS-FIBEX expedition
Designations as in fig. 2