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Krill monitoring in Admiralty Bay (King George Island, South Shetland Islands) is summer 1979/1980*)

ABSTRACT: The presence of *Euphausia superba*, *E. crystallorophias* and *Thysanoessa macrura* was observed in Admiralty Bay (King George Island, South Shetland Islands) and the size of individuals of particular species are diverse and varying during the summer season. *E. superba* population is older and specimens larger than in analogous season in 1979. The maximum number of females with eggs was noted in the first half of January 1980, i.e. earlier than in 1979. In *E. crystallorophias* population the presence of females with eggs was observed in the second half of December 1979.

Key words: Antarctic krill, structure of population

1. Introduction

The observation conducted during the summer season 1979/1980 were a continuation of the monitoring studies on the composition, biology and structure of krill population and Admiralty Bay (Kittel 1980, Rakusa-Suszczewski and Stępnik 1980). The hitherto observations have shown that in the summer three species dominate among macroplankton in the Bay: *Euphausia superba* Dana, *E. crystallorophias* Holt and Tattersall and *Thysanoessa macrura* G. O. Sars. *E. superba* occur in greatest numbers. This species shows considerable differences of the population, the degree of development and the size of the individuals from year to year. These changes occur as well in Admiralty Bay as in the waters of the open sea (Witek, personal communication). A thorough examination of all these variations and determination of the causes of this phenomena is the aim of biological monitoring of krill populations in Admiralty Bay.

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The results from the examinations of krill population presented in this study are a continuation of the investigations carried out in the summer seasons of the previous three years and include an analysis of postlarval stages of krill.

2. Material and methods

Material for analyses was caught in Admiralty Bay and Ezcurra Inlet, from 11 December 1979 to 15 March 1980. Over 50 effective catches were hauled, mainly at nighttime (at dusk), using a 6×6 mm mesh net stretched over a metal frame dragged along from the depth of 150 m up to the water surface by a fish cutter, during 20–60 min. From each haul from 150 to 250 specimens were examined at random. Some less numerous catches (containing a large number of *Salpae*) were examined as a whole. In total, 2849 specimens of *E. superba*, 1074 — *E. crystallorophias* and 140 — *Th. macrura* were examined.

There were great difficulties in getting the proper material for analyses due the very great quantities of *Salpae* preponderating in the subsequent hauls. The quantity of *Salpae* caught during the period of investigations made up a by-catch amounting to 50–70% of the total volume of the catches. The wet weight of the caught *Euphausiidae* ranged from 0.5 to 1.0 kg per one haul.

All the examined specimens were measured (from rostrum to the end of telson) with accuracy to 1 mm. The distribution of the size frequency in the population is presented in 2-millimetre-length classes. In *E. superba* the following groups were differentiated: juvenile forms, mature and immature males, mature and immature females, and females with eggs. In *E. crystallorophias* only males, females and females with eggs were differentiated and in *Th. macrura* merely males and females. The age-structure and size distribution of the *Crustacea* were calculated by summing up the results from all the hauls in two-week periods.

3. Results and discussion

The observations carried out in the regions of Admiralty Bay in the summer season showed the presence of three species of krill: *Euphausia superba*, *E. crystallorophias* and *Thysanoessa macrura* (Rakusa-Suszczewski, and Stępnik 1980).

The distribution of the maximum length of individuals of different species of krill varies considerably throughout the summer season (Fig. 1). *Th. macrura* occurs in maximal numbers at the body length of about 21 mm. *E. crystallorophias* shows two peaks in numbers at the body length of about 26 mm and 32 mm. *E. superba* is most numerous at the body length of 47 mm, 51 mm and 37 mm. These peaks of in numbers correspond to the various stages of development (Tables I and II).

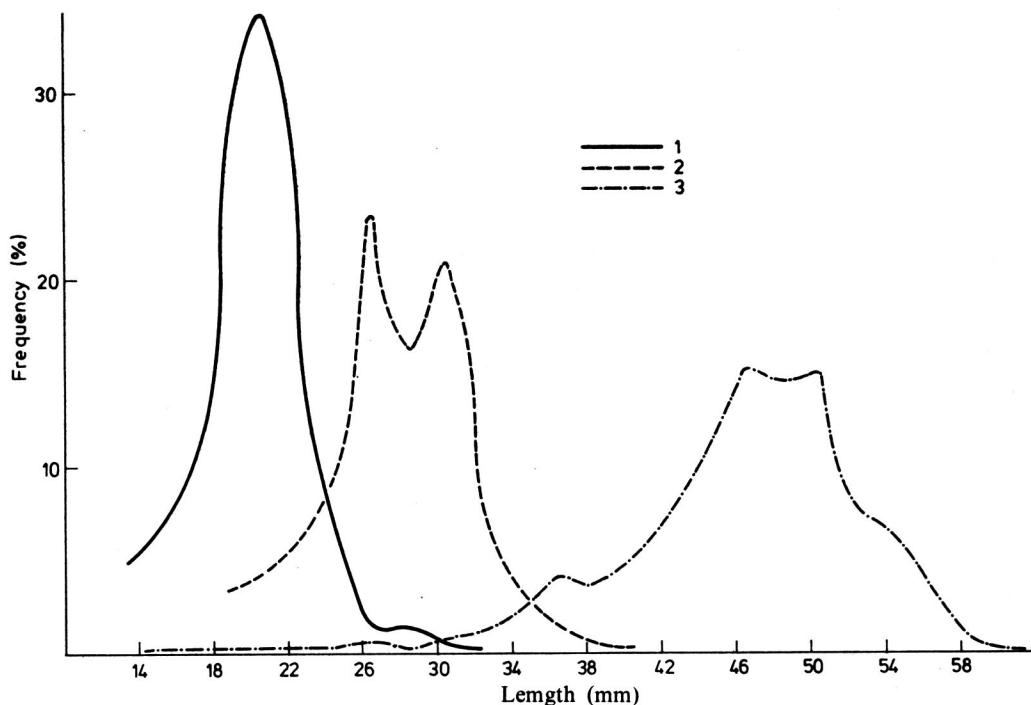


Fig. 1. Length distribution of individuals of *Euphausia superba*, *E. crystallophias* and *Thysanoessa macrura* throughout austral summer 1979/1980
1 — *Th. macrura*, 2 — *E. crystallophias*, 3 — *E. superba*

The population of *E. superba* shows greater variety and variability of age-structure than the population of *E. crystallophias* (Figs. 2 and 3). *E. superba* juvenile forms are relatively scarce and quite often their size groups overlap the groups of adult forms (Fig. 2). This is particularly conspicuous in the time from mid-December to mid-January and may be connected with maturing of the larger juvenile forms. Males are of a larger size (up to 62 mm long) than females (up to 57 mm long).

The age-structure of the population of *E. superba* undergoes very significant seasonal changes. The number of juvenile animals and especially their smallest forms decrease extensively. Mature females with eggs appear in the latter part of December and reach their maximum in the earlier part of January. Males occur in greatest numbers in the latter part of January and then their numbers decrease gradually (Fig. 2). The number of immature males remains vitly at a high level throughout the season, as compared with the numbers of mature males (Table II), the frequency of which does not exceed 20%, except in the latter part of January when they occur in great numbers. The number of mature females increases slowly while the number of females with eggs decreases (Table I).

In comparison with analogous season in 1979 (latter part of January and earlier part of February) the population of *E. superba* is older (Table III). It is also older than the populations occurring in this area in 1978 and 1979.

Table I

Age structure and size distribution of individuals in the population of *Euphausia superba*

Stages of development		Research period					
		11—31	1—15	16—31	1—15	16—29	1—15
		December 1979	January 1980	January 1980	February 1980	February 1980	March 1980
Juveniles	Number of individuals	79	50	53	24	31	14
	(%)	14.6	11.1	8.9	4.8	5.5	7.3
	Average length and S.D. (mm)	32±5	32±6	36±4	36±2	36±2	35±2
Males	Number of immature males	182	123	127	127	173	45
	(%)	33.6	27.3	21.2	25.5	30.5	23.4
	Number of mature males	6	67	215	81	69	12
	(%)	1.1	14.9	35.9	16.3	12.2	6.3
	Number of individuals	188	190	342	208	242	57
	(%)	34.7	42.2	57.1	41.8	42.7	29.7
Females	Average length and S.D. (mm)	34±4	47±5	50±4	52±3	52±5	49±4
	Number of immature females	83	38	50	19	42	11
	(%)	15.3	8.4	8.3	3.8	7.4	5.7
	Number of mature females	155	75	80	201	228	110
	(%)	28.6	16.6	13.4	40.4	40.2	57.3
	Number of individuals	238	113	130	220	270	121
	(%)	43.9	25.0	21.7	44.2	47.6	63.0
	Average length and S.D. (mm)	41±4	44±4	46±3	48±3	47±3	47±3
	Number of females with eggs	37	98	74	46	24	0
(%)	6.8	21.7	12.4	9.2	4.2	—	
Average length and S.D. (mm)	48±4	47±3	48±4	51±4	52±4	—	

Table II

Age structure and size distribution of individuals in the population of *Euphausia crystallorophias*

Stages of development		Research period					
		11—31	1—15	16—31	1—15	16—29	1—15
		December 1979	January 1980	January 1980	February 1980	February 1980	March 1980
Juveniles	Number of individuals	37	29	27	9	2	
	(%)	9.4	20.9	15.9	6.3	1.1	
	Average length and S.D. (mm)	20±2	22±1	21±2	20±2	21±1	
Males	Number of individuals	46	28	66	64	78	
	(%)	11.6	20.1	38.8	44.4	39.8	
	Average length and S.D. (mm)	24±2	26±2	26±3	28±2	28±2	
Females	Number of individuals (mature and immature females)	264	82	77	71	116	
	(%)	66.8	59.0	45.3	49.3	59.1	
	Average length and S.D. (mm)	28±3	30±3	29±2	31±3	31±2	
	Number of females with eggs	48	0	0	0	0	
	(%)	12.2	—	—	—	—	
Average length and S.D. (mm)	30±3	—	—	—	—		

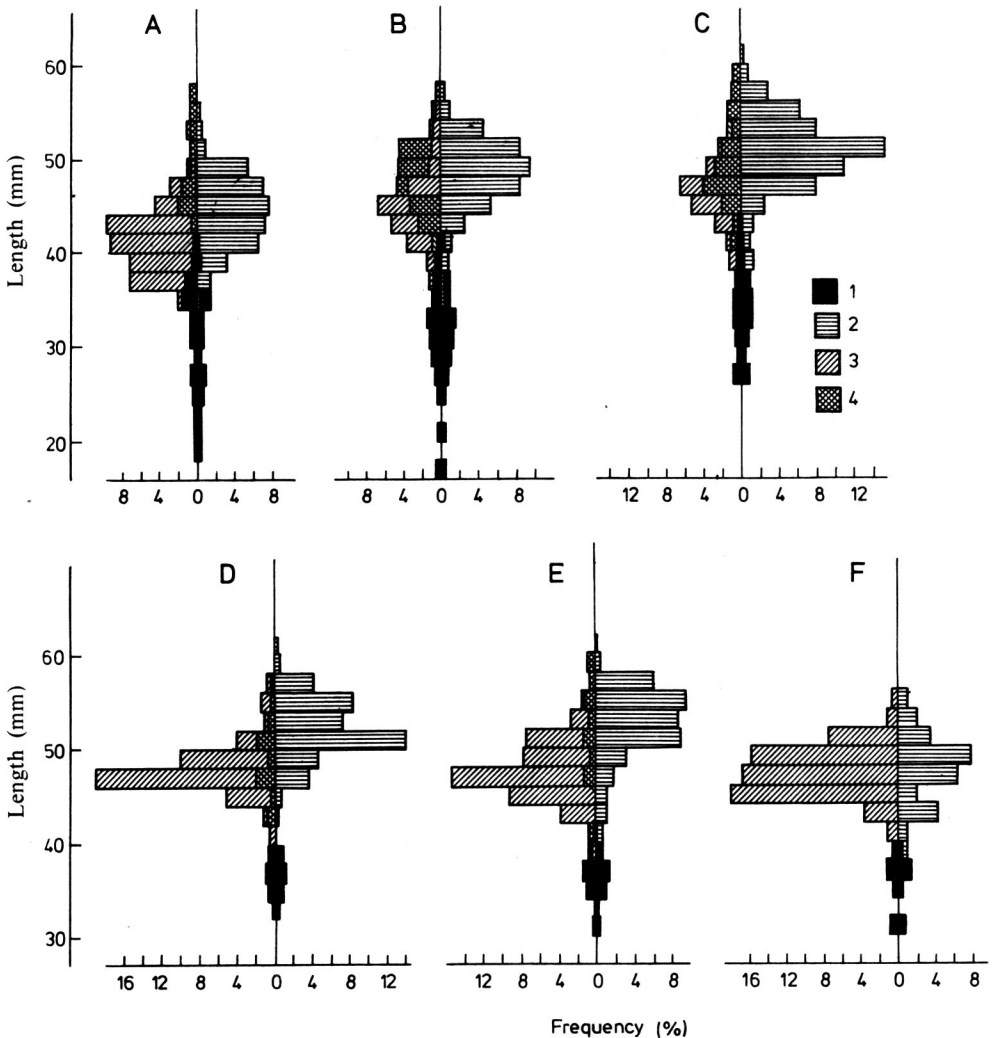


Fig. 2. Length distribution and population structure of *Euphausia superba* 1 — juveniles, 2 — males, 3 — females, 4 — females with eggs, A — latter part of December 1979, B — earlier part of January 1980, C — latter part of January 1980, D — earlier part of February 1980, E — latter part of February 1980, F — earlier part of March 1980.

On the whole, the crustaceans in all stages of development were in the summer 1980 of a larger size as compared with the analogous individuals of *E. superba* in 1978 and 1979. Maybe, this is connected with a mild winter in 1979 and the Bay not covered with ice and consequently an earlier start of the phytoplankton vegetative season. Thus, more favourable conditions for the growth and reproduction of the *Crustacea* could occur sooner. This is evidenced also by a much earlier appearance of the maximum numbers of females with eggs, i.e. already in the earlier part of January.

The population of *E. crystallorophias* consists of two size-age groups

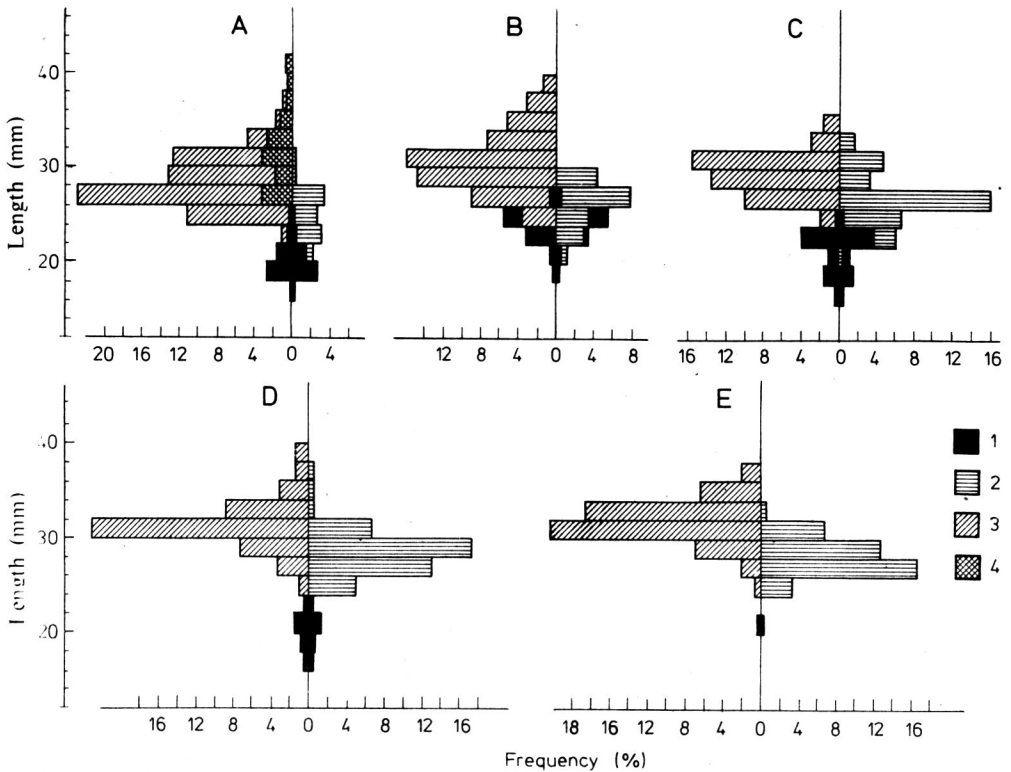


Fig. 3. Length distribution and population structure of *Euphausia crystallorophias*. Explanations see Fig. 2.

(Fig. 3). One group — juvenile forms with body length ranging from 16 to 24 mm, another — mature individuals with body length ranging from 24 to 42 mm. Females predominate in the population (Table II), they are of larger size (modal length — 30.5 mm) than males (modal length — 26.5 mm). The number of juvenile forms (modal length — 21 mm) decreases markedly during the summer season. In the latter part of December the presence of females with eggs was noted, they average 15.4% of the total number of *E. crystallorophias* females caught at that time. Females with eggs attained the maximum body length about 42 mm (modal length — 30.5 mm) (Table II). The number of males caught in December and the early part of January is much lower than that of females. The number of males increases gradually throughout the season while the number of females remains steadily at the same high level.

The comparison of the population of *E. crystallorophias* observed between mid-December and mid-February 1980 with analogous population of 1979 shows that individuals in the same stages of development were of much smaller size in 1979 (Table IV). It seems that *E. crystallorophias* population is older than that of 1979 due to the occurrence of females with eggs.

Throughout the season *Th. macrura* occurred in very small quantities a few or several specimens in successive hauls. The body length of the specimens ranges from 14 to 30 mm. The modal length of males and

Table III

Comparison of age structure and size distribution of individuals in the population of *Euphausia superba* caught in Admiralty Bay during 1978, 1979, 1980 austral summer season

Stages of development		1977/1978*)		1978/1979**)		1979/1980	
		Population structure (%)	Most frequent sizes (mm)	Population structure (%)	Most frequent sizes (mm)	Population structure (%)	Most frequent sizes (mm)
Latter part of January	Juveniles	48.7	28—30	13.6	26—28	8.9	36—39
	Males	35.1	36—40	43.5	42—48	57.1	48—51
	Females	14.9	34—40	43.5	42—48	57.1	48—51
	Females with eggs	2.3	44—46	13.2	46—48	12.2	46—51
Earlier part of February	Juveniles	18.2	30—34	8.3	24—28	4.8	34—37
	Males	48.8	46—48	39.9	46—48	41.8	50—55
	Females	24.5	36—40	20.6	40—42	44.2	48—51
	Females with eggs	2.0	50—52	31.2	46—48	9.2	46—51

*) after Kittel (1980)

**) after Rakusa-Suszczewski and Stępnik (1980)

Table IV

Comparison of age structure and size distribution of individuals in the population of *Euphausia crystallorophias* caught in Admiralty Bay during 1979 and 1980 austral summer season

Stages of development		1978/1979*)		1979/1980	
		Population structure (%)	Most frequent sizes (mm)	Population structure (%)	Most frequent sizes (mm)
Latter part of December	Juveniles	15.1	20—22	9.4	18—21
	Males	42.7	18—20	11.6	24—27
	Females	42.2	22—24	66.8	26—29
	Females with eggs	0	—	12.2	30—33
Earlier part of January	Juveniles	8.1	22—24	20.9	20—23
	Males	48.3	22—24	20.1	26—29
	Females	43.6	20—24	59.0	28—31
Latter part of January	Juveniles	2.2	18—20	15.9	21—23
	Males	51.1	22—24	38.8	26—30
	Females	46.7	22—24	45.3	28—31
Earlier part of February	Juveniles	1.0	18—20	6.3	20—21
	Males	50.6	22—25	44.4	27—29
	Females	48.4	22—26	49.3	30—32

*) after Rakusa-Suszczewski and Stępnik (1980)

females is the same — 20.5 mm. The presence of juvenile forms and females with eggs was not observed.

The analysis of species composition in subsequent hauls shows that in

general *E. superba* dominated the catch quantitatively, whereas *E. crystallorophias* were much less and *Th. macrura* the least numerous. Very likely, such structure of the catches evidences the formation of separate associations of the tested crustaceans, where individuals of similar size (this suggests also similar feeding needs and similar physiological conditions) occur together. On the other hand, no dependence of the composition of the haul on the level of the depth was found.

4. Summary

The summer studies on the population structure of three species of krill (*Euphausia superba*, *E. crystallorophias* and *Thysanoessa macrura*) found in Admiralty Bay (King George Island, South Shetland Islands) were continued from 11 December 1979 to 15 March 1980. Test material was collected at various depths (from 0 to 150 m deep). Altogether 4064 specimens were examined: *E. superba* — 2850, *E. crystallorophias* — 1074 and *Th. macrura* — 140. The observations show that *E. crystallorophias* population is much less diversified and variable as compared with the population of *E. superba* (Figs. 2 and 3). The population of *Th. macrura* shows least variability of all (Fig. 1).

Very substantial seasonal changes occur in the age structure of the analysed populations. The number of smallest forms decreases gradually during the season (Figs. 2 and 3). In the population of *E. superba* only one size-age group was present. The maximum number of females with eggs occurred in the earlier part of January whereas the maximum numbers of mature males were noted in the latter part of January. The ratio of males and females of *E. superba* remained at the same level throughout the season with but a slight preponderance of females (Table I). Males are of a slightly bigger size than females.

The population of *E. crystallorophias* consists of two size-age groups (juveniles and mature forms) (Fig. 3). Females prevail quantitatively and are larger than males. In the latter part of December the presence of *E. crystallorophias* females with eggs was observed for the first time in this region (Table II).

The population of *E. superba* is older and individuals are bigger as compared with the crustaceans caught in analogous periods in 1978 and 1979 (Table III). Similar changes were observed in the structure of *E. crystallorophias* populations (Table IV).

5. Резюме

В период от 11 ноября 1979 г. до 15 марта 1980 г. продолжались летние популяционные исследования трёх родов крылья (*Euphausia superba*, *E. crystallorophias* и *Thysanoessa macrura*) выступающих в Адмиральты Бей (Кинг Джордж Исланд, Южные Шетланды). Материал происходил из разных глубин (с 0 до 150 м). В целом исследовано 4064 особи с чего 2850 особей составляли *Euphausia superba*, 1074 *Euphausia crystallorophias* и 140 *Thysanoessa macrura*. Проведенные наблюдения доказали, что популяция *Euphausia crystallorophias* в отношении размеров значительно менее дифференцирована в сравнении с популяцией *Euphausia superba* (рис. 2 и 3). Самую меньшую дифференциацию представляет популяция *Thysanoessa macrura* (рис. 1).

В структуре анализированных популяции выступают существенные сезонные изменения. Уменьшается количество самых маленьких форм (рис. 2 и 3). В популяции *Euphausia superba* констатировано выступление одной изmero-возрастной группы. В первой половине января появляется максимальное количество самок с яйцами, зато зрелые самцы достигают свою максимальную численность во второй половине января. Взаимое

отношение самцов и самок *Euphausia superba* всё время исследований удерживалось на постоянном уровне, с невеликим преобладанием самок (таблица I). Самцы отличаются незначительно увеличенными размерами. Популяция *Euphausia superba* старше и особи больше в сравнении с ракообразными исследованными в аналогичном периоде года 1978/1979 (таблица III). В популяции *Euphausia crystallorophias* преобладают самки, которые достигают больших размеров. Во второй половине декабря впервые констатировано в исследованном районе присутствие самок с яйцами (таблица II). В популяции *Euphausia crystallorophias* размеры особей так как и *Euphausia superba* были больше чем в аналогичном летнем сезоне 1978/79 (таблица IV).

6. Streszczenie

W okresie od 11 grudnia 1979 do 15 marca 1980 kontynuowane były letnie badania populacyjne trzech gatunków kryla (*Euphausia superba*, *E. crystallorophias* i *Thysanoessa macrura*) występujących w Zatoce Admiralicji. Materiał pozyskiwano z różnych głębokości (od 0 do 150 m). Ogółem zbadano 4064 skorupiaki, z czego 2850 stanowiła *E. superba*, 1074 *E. crystallorophias* i 140 *Th. macrura*. Przeprowadzone obserwacje wykazały, że populacja *E. crystallorophias* jest znacznie mniej zróżnicowana i wykazuje mniejszą zmienność w porównaniu z populacją *E. superba* (rys. 2 i 3). Jeszcze mniejszą zmienność wykazuje populacja *Th. macrura* (rys. 1).

W strukturze analizowanych populacji następują istotne zmiany sezonowe. Zmniejsza się ilość form najmniejszych (rys. 2 i 3). W populacji *E. superba* stwierdzono występowanie jednej tylko grupy wymiarowo-wiekowej. W pierwszej połowie stycznia pojawia się maksymalna ilość samic z jajami, natomiast dojrzałe samice osiągają swą maksymalną liczebność w drugiej połowie stycznia. Wzajemny stosunek samców do samic u *E. superba* przez cały okres badań utrzymywał się na stałym poziomie, z niewielką przewagą samic (tabela I). Samce wykazują nieznacznie większe rozmiary niż samice. Populację *E. crystallorophias* stanowią dwie grupy wymiarowo-wiekowe (formy juwenilne i dojrzałe) (rys. 3). Ilościowo przeważają w niej samice, one również osiągają większe rozmiary. W drugiej połowie grudnia po raz pierwszy stwierdzono w badanym rejonie obecność samic z jajami *E. crystallorophias* (tabela II).

Populacja *E. superba* jest starsza, osobniki większe w porównaniu ze skorupiakami badanymi w analogicznym okresie roku 1978 i 1979 (tabela III). Podobne zmiany wystąpiły w strukturze populacji *E. crystallorophias* (tabela IV).

7. References

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