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Algae found in the food of *Euphausia crystallorophias (Crustacea)* *)

ABSTRACT: This study contributes to the knowledge of morphology, biology and ecology of *Euphausia crystallorophias*. The structure of the filtratory apparatus and analysis of the stomach contents are described. Among 41 identified algae taxa 40 were diatoms. Benthic algae, numbering as many as 12 taxa constituted a high percentage in the total of food content, which may indicate that this species feeds near the bottom in the relatively shallow shelf-waters.

Key words: Antarctic, *Euphausia crystallorophias (Crustacea)*, food

1. Introduction

Euphausia crystallorophias Holt et Tattersall is the most neritic species among all other Antarctic *Euphasiidae* (Lomakina 1978). It lives in the area of pack ice and floating ice zones not extending northwards beyond the Antarctic Divergence (John 1936, Antezana, Aguire and Bustamante 1976, Percova 1976, Tomo and Marshoff 1976, Lomakina 1978). The localities were *E. crystallorophias* was collected by Bottino (1974, 1975) are also situated south of the Divergence line. In some places it forms heavy swarms (Knox 1970) often substituting *E. superba*, especially in shelf waters (Mackintosh 1970). Large concentrations of *E. crystallorophias* were observed in the Ross Sea and Whalers Bay and at the coasts of Victoria Land. *Euphausia crystallorophias* occurs also in great numbers in the Bellinghausen Sea and Bransfield Strait. In the regions between the Ross and Bellinghausen Seas and along the whole Atlantic sector of Antarctica this species was not found.

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The majority of the above-mentioned authors treated in their studies also the anatomy and taxonomy of *E. crystallorophias* (John 1936, Antezana, Aguire and Bustamante 1976, Tomo and Marshoff 1976, Lomakina 1978). Besides, some larval stages of this species were described (Percova 1976) and a subdivision into the developmental postlarval stages of *Euphausia crystallorophias* was suggested (Kittel and Presler, in press).

Nothing is known, however, about the feeding habits of *E. crystallorophias*. Therefore the exact place of this species in the trophic network of the ecosystem of the coastal Antarctic waters is not known. *Euphausia crystallorophias* is undoubtedly an important link in the food chain for the animals feeding on krill. Marr (1962) reports that this species was found in the stomachs of some species of whales. According to the recent investigations (Volkman, Presler and Trivelpiece, in press) in some samples taken from the stomachs of penguins *Euphausia crystallorophias* constituted qualitatively about 50% of the eaten food.

2. Material and methods

Material for studies was caught in the shelf waters of the Ezcurra Inlet — west arm of Admiralty Bay, King George Island, South Shetland Islands. For this purpose krill-net (mesh 6 × 6 mm) stretched on a metal frame (150 × 70 cm) trawled from the tugboat.

E. crystallorophias specimens used for the analyses were taken from the samples collected on 20 and 21 February 1978. The drawings were made using the microscopic slides in which the dissected appendages were mounted in the glycerolgel after treating with 10% KOH.

For examination of the food composition the stomachs of *E. crystallorphias* were removed and their contents were spread carefully on the covering glass. After drying up the residuum was moistened with ethyl alcohol and permanent microscopical slides were made pleurax.

All algal cells found in the slides made of the food contents from 40 specimens of *Euphausia crystallorophias* were identified. The percentage of *E. crystallorophias* stomachs in which particular algal taxon was observed is shown in Table I. The percentage was calculated with confidence limit to 5% (Kadłubowska 1975). Identified algae were classified into classes accroding to Tischler's scale (Tischler 1976), as absolutely stable, stable, accessory and occasional algae in the examined food. To determine the size of the identified algal cells the following parameters were measured: the length and width of the cells of the diatoms of the class *Pennatae* and diameter and thickness of the cells of *Baccillariophyceae* of the class *Centricae* and algae belonging to *Silicoflagellatae*. The fragments of cells were also measured when they could be identified on a genus level, at least. In the histograph (Fig. 1) the results of these measurements are given. The identified taxa were classified into planktonic and benthic algae (Table I). Among planktonic algae oceanic, neritic and eurychoric-neritic organisms were distinguished (Kozlova 1964, Abbot 1974).

Table I.

Algae in the stomachs of *Euphausia crystallorophias*

	Percentage of specimens in which algal taxa were found
I. Planktonic algae	
A. Oceanic	
1. *Chaetoceros criophilus* Castr.	100.0 ± 3.1
2. *Thalassiothrix antarctica* Cl. et Grun.	7.5 ± 4.8
3. *Nitzschia (Fragilariopsis) kerguelensis* (O'Meara) Hust.	65.0 ± 14.8
4. *Nitzschia barkleyi* Hust.	27.5 ± 13.8
5. *Rhizosolenia alata* Bright.	20.0 ± 12.4
6. *Dictyocha speculum* Ehr.	15.0 ± 11.1
7. *Navicula criophila* De Toni	7.5 ± 8.2
8. *Coscinodiscus lentiginosus* Janisch	5.0 ± 6.8
B. Eurychoric — neritic	
1. *Nitzschia (Fragilariopsis) rhombica* Hust.	37.5 ± 15.0
2. *Thalassiosira gracilis* Hust.	27.5 ± 13.8
3. *Corethron criophilum* Castr.	12.5 ± 10.2
4. *Tropidonëis belgicae* Heiden	7.5 ± 8.2
5. *Schimperiella antarctica* Karst.	5.0 ± 6.8
C. Neritic	
1. *Nitzschia (Fragilariopsis) curta* Hust.	100.0 ± 3.1
2. *Navicula jejinoides* V. Heurck	60.0 ± 15.2
3. *Charcotia actinochilus* Hust.	47.5 ± 15.5
4. *Thalassionema nitzschioides* Grunow	32.5 ± 14.5
5. *Nitzschia (Fragilariopsis) sublinearis* Hust.	25.0 ± 13.4
6. *Coscinodiscus inflatus* Karst.	22.5 ± 12.9
7. *Chaetoceros atlanticus* var. *skeleton* (Schütt) Hust.	5.0 ± 6.8
8. *Coscinodiscus symbolophorus* Grun.	5.0 ± 6.8
9. *Nitzschia (Fragilariopsis) cylindrus* Helmcke et Krieger	5.0 ± 6.8
10. *Porosira pseudodenticulata* (Hust.) Jouse	2.5 ± 4.8
II. Benthic alge	
1. *Achnanthes* sp.	85.0 ± 11.1
2. *Cocconeis costata* Greg.	80.0 ± 12.4
3. *Licmophora* sp.	72.5 ± 13.8
4. *Gomphonema* sp.	67.5 ± 14.5
5. *Melosira sol* (Ehr.) Kütz.	67.5 ± 14.5
6. *Cocconeis* sp.	60.0 ± 15.2
7. *Cocconeis imperathrix* Schmidt	47.5 ± 15.5
8. *Cocconeis californica* var. *kerguelensis* Heid. et Kolbe	42.5 ± 15.3
9. *Rhoicosphenia* sp.	22.5 ± 12.9
10. *Amphora* sp.	17.5 ± 11.8
11. *Grammatophora angulosa* Ehr.	12.5 ± 10.2
12. *Trachyneis aspera* (Ehr.) Cleve	5.0 ± 6.8
III. Non-classified into other groups	
1. *Navicula* sp.	67.5 ± 14.5
2. *Thalassiosira* sp.	42.5 ± 15.3
3. *Nitzschia* sp.	17.5 ± 11.8
4. *Triceratium permagnum* Jan.	15.0 ± 11.1
. *Pleurosigma* sp.	7.5 ± 8.2
6. *Biddulphia* sp.	2.5 ± 4.5

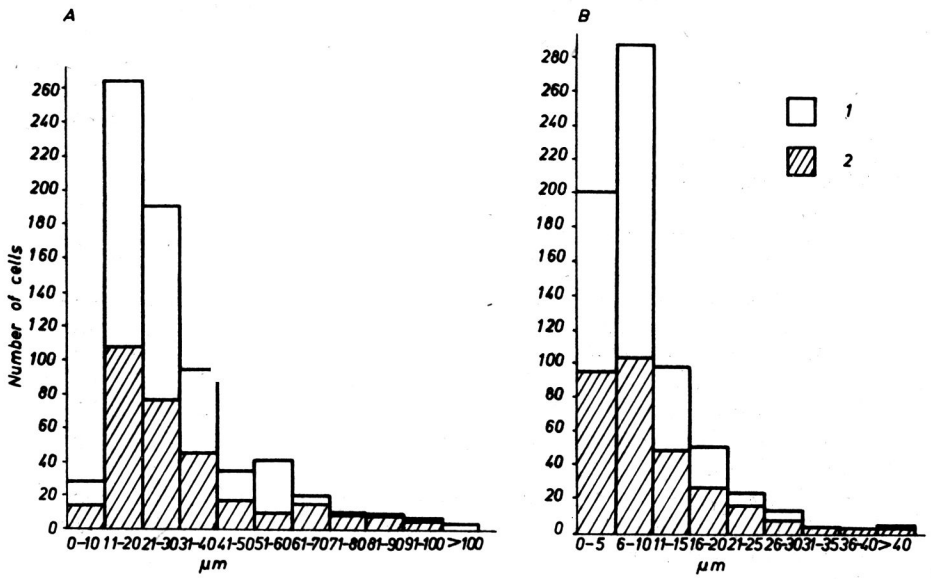

Fig. 1. Size-groups of the cells of algae found in the stomachs of *Euphausia crystallorophias* *A* — length or width, *B* — diameter or thickness, *1* — intact cells, *2* — damaged cells.

3. Results and discussion

Euphausia crystallorophias is a filter feeder. A filtratory basket formed by the endopodites of six pairs of thoracopoda densely fringed by long feathered seate plays a substantial role in feeding processes. The mean distance between the setae is 110 µm (100—120 µm) and the distance between bristles on the setae 3.5—6.9 µm. These values do not diverge in principle from the measurements made during investigations of the biology and morphology of *E. superba* (Dzik and Jażdżewski 1978). Since *E. crystallorophias* is a smaller species than *E. superba* (the maximal body length of the former is about 32—34 mm and of the latter even more than 60 mm) the setation of its thoracal appendages is comparatively less dense (Table II), which may be regarded as supplementary diagnostic features in distinguishing the two species.

The filtratory basket structure and feeding habits of *Euphausiacea* are described in detail by Kaestner (1959).

The mandible and the first and second pair of maxillae play a substantial role in the initial crushing of food (Fig. 2). A comparative analysis of the structure of mouth appendages of *E. crystallorophias* and *E. superba* did not show, except for their size, any striking differences in their shape and their setation. Only, the mandibular palpus in *E. crystallorophias* is considerably shorter than in *E. superba*, which is a convenient diagnostic feature (Lomakina 1978, Kittel and Presler, in press).

A similar structure of the filtratory apparatus in these two species and on the other hand the presumable formation of independent aggrega-

Table II.

Number of filtratory setae on various segments (1—4) of thoracopoda in *Euphausia crystallorophias* and *E. superba*

Thoracopoda	Segments	*E. crystallorophias*	*E. superba*
1st pair	1	5— 6	8—12
	2	7— 9	11—13
	3	7— 9	10—11
	4	20—21	22—26
2nd pair	1	5— 7	6— 9
	2	8—10	13—16
	3	6— 8	11—13
	4	20	22—25
3rd pair	1	4— 7	5— 9
	2	9—10	14—17
	3	8— 9	12—13
	4	20	24
4th pair	1	4— 7	5— 6
	2	9—10	12—15
	3	8— 9	13—14
	4	20—22	26—30
5th pair	1	4— 7	5
	2	8— 9	12—17
	3	8— 9	11—13
	4	21—24	29—34
6th pair	1	7— 8	3— 4
	2	7	6— 8
	3	6— 7	5— 7
	4	10—19	26—30

tions in the waters of Admiralty Bay (Kittel, in press, Kittel and Presler, in press) suggest a somewhat different ecology of *E. crystallorophias*. For this reason the authors tried to determine the ecological niche of this species, carrying out the taxonomic analysis of its food.

In the food contents from the removed stomachs 41 alga taxa were found, including 11 identified only on genus level (Table I). All of them, except one, were diatoms belonging to *Centricae* — 15 taxa and to *Pennatae* — 25 taxa.

According to the Tischler's scale (Tischler 1976) 5 species of diatoms: *Chaetoceros criophilus, Nitzschia (Fragilariopsis) curta, Thalassiothrix antarctica, Achnanthes* sp. and *Cocconeis costata* were classified as absolutely stable taxa. Among the stable taxa were 7 species of diatoms: *Licmophora* sp., *Gomphonema* sp., *Melosira sol, Navicula* sp., *Nitzschia (Fragilariopsis) kerguelensis, Cocconeis* sp. and *Navicula jejinoides*. Moreover, 8 accessory and 21 occasional taxa were distinguished in *E. crystallorophias* food, using the same scale.

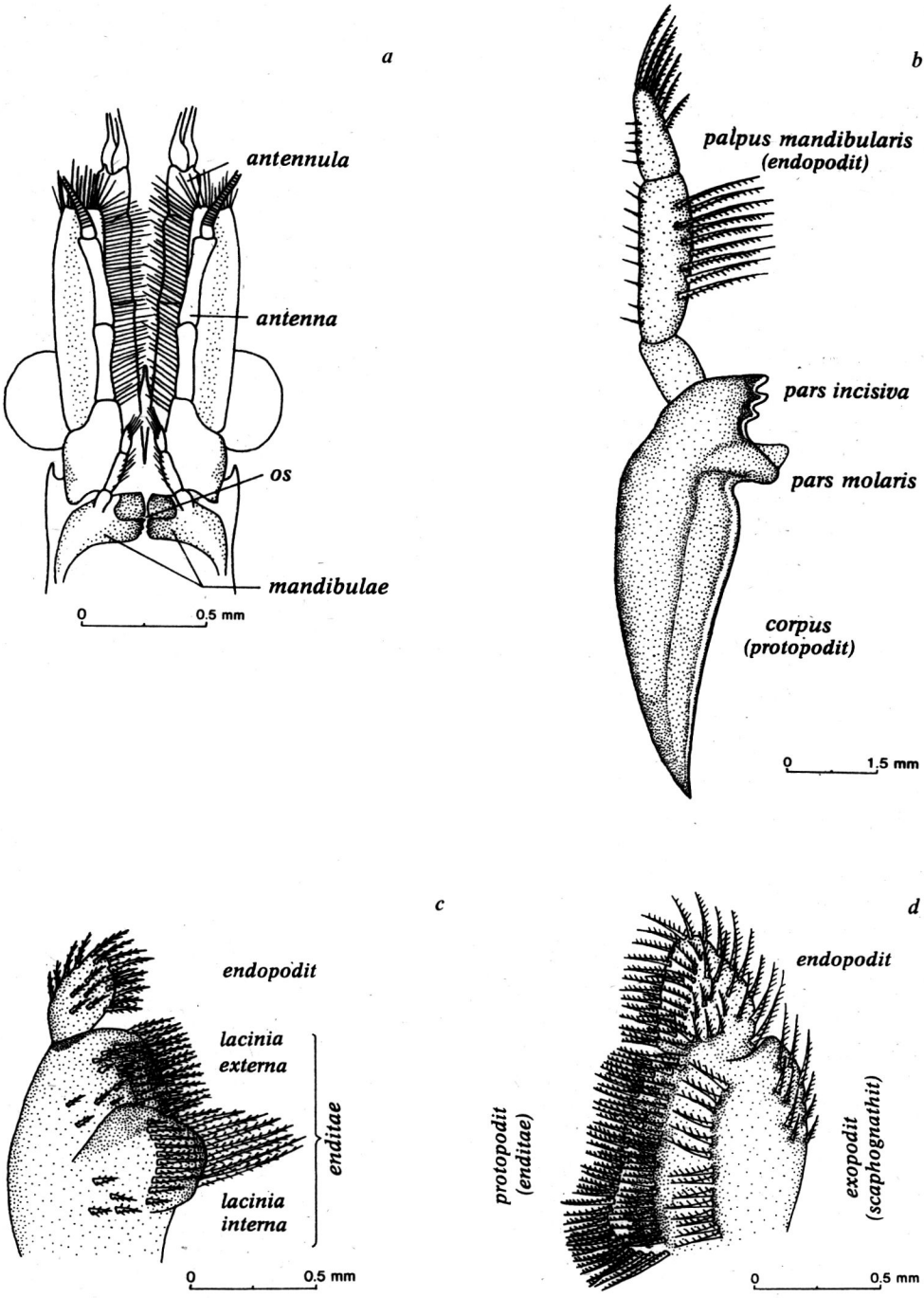

Fig. 2. Structure of the filtratory appendage thoracal and mouth of *Euphausia crystallorophias* *a* — position of the mandibles (mandibulae) and the mouth (os), *b* — mandible (mandibulae), *c* — the first pair of maxilla (maxillula), *d* — the second pair of maxilla.

Some of the identified algae were observed in fragments. This applies mainly to algae with large and long cells, e.g. *Cocconeis imperatrix, Licmorpha* sp., *Melosira sol, Navicula jejinoides, Triceratium permagnum, Thalassiotrix antarctica, Rhizosolenia alata* and a species having long processes: *Chaetoceros criophilus*. Due to the crushing into fragments some specimens were not identified even to genus. Crushed cells of the species *Nitzschia (Fragilariopsis) curta* were not observed. The cells of *Cocconeis californica* var. *kerguelensis* and *Nitzschia (Fragilariopsis) rhombica* were rarely crushed.

In almost all the diatoms observed in the stomachs of *E. crystallorophias* only siliceous shells remained. Organic content was found only in some large cells of the genus *Licmphora*.

Histogram (Fig. 1) shows that in the range of the length or diameter over 60 μm and the width or thickness over 30 μm more fragments of algae occur in the total number of the cells observed in the examined food.

Among the identified taxa 25 belong to planktonic algae (including oceanic algae — 8, neritic-eurychoric — 5 and neritic — 10) and 12 to benthic algae (Table I).

Using Tischler Scale, out of 12 identified benthic diatoms six belong to absolutely stable or stable taxa in *E. crystallorophias* food, i.e. occurring in the majority of the examined stomachs. These taxa were: *Achnanthes* sp., *Cocconeis costata, Licmophora* sp., *Gomphonema* sp., *Melosira sol, Cocconeis* sp. Benthic algae may occur in neretic plankton, however, the presence of a great quantity of benthic algae found in food contents may indicate also that *Euphausia crystallorophias* feeds near the bottom of the relatively shallow shelf waters.

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4. Summary

Morphological analysis of the structure of the filtratory apparatus in *Euphausia crystallorophias* was made (Fig. 2). To establish ecological niche of this species living in the Admiralty Bay (King George Island, South Shetland Islands) in common with *Euphausia superba* qualitative composition of algae was examined in the stomachs of *E. crystallorophias*.

Altogether 41 taxa of algae were found in the food: 40 taxa of *Bacillariophyceae* and one species of *Silicoflagellatae*. In the stomachs of the examined specimens the following groups of taxa were distinguished: 5 absolutely stable species, 7 stable species, 8 accessory and 21 occasional species (Table I). On the basis of the measurements of the cells or their fragments identified in the food the percentage of algae in the different size-groups was calculated (Fig. 1).

Among the identified taxa: 8 were planktonic oceanic algae, 5 — eurychoric algae, 10 — neritic algae and 12 — benthic algae.

5. Резюме

Проведено анализ морфологического строя фильтрационного аппарата *Euphausia crystallorophias* (рис. 2). Предполагая, что экологическая ниша этого вида похожа на найболее известную и проживающую также в водах Адмиральты Бей (Остров Кинг Джорж, Южные Шетланды) *Euphausia superba.*

Исследовано качественный состав водорослей в желудках *Euphausia crystallorophias* выловленных в водах Залива. В корме обнаружено 41 таксон водорослей: 40 таксонов *Bacillariophyceae* и 1 вид *Silicoflagellatae.* В желудках исследованных особей выделено 5 видов абсолютно постоянных, 7 видов постоянных, 8 аксессуарных и 21 случайных (таблица I). На основании идентифицированных обмеров в корме клеток или их фрагментах представлено участие водорослей в выделенных классах величины (рис. 1).

Среди идентифицированных таксонов к океаническим планктонным принадлежит 8 таксонов, к планктонным водорослям эврихоригным — 5, к планктонным неритическим водорослям — 10, а к бентосовым водорослям 12 таксонов.

6. Streszczenie

Dokonano analizy morfologicznej budowy aparatu filtracyjnego u *Euphausia crystallorophias* (rys. 2). Zakładając, że nisza ekologiczna tego gatunku jest podobna do najbardziej znanego i żyjącego również w wodach Zatoki Admiralicji (Wyspa Króla Jerzego, Południowe Szetlandy) *Euphausia superba,* zbadano skład jakościowy glonów w żołądkach *E. crystallorophias* złowionych w wodach Zatoki.

W pokarmie stwierdzono 41 taksonów glonów: 40 taksonów *Bacillariophyceae* i 1 gatunek *Silicoflagellatae.* W żołądkach badanych osobników wyróżniono 5 gatunków absolutnie stałych, 7 gatunków stałych, 8 akcesorycznych i 21 przypadkowych (tabela I). Na podstawie wymiarów zidentyfikowanych w pokarmie komórek lub ich fragmentów przedstawiono udział glonów w wyróżnionych klasach wielkości (rys. 1).

Spośród zidentyfikowanych taksonów, do glonów oceanicznych planktonowych należy 8 taksonów, do glonów planktonowych eurychorycznych — 5, do glonów planktonowych nerytycznych — 10 oraz do glonów bentosowych 12 taksonów.

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