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Life cycle of *Branchinecta gaini* Daday, 1910, (*Branchiopoda, Anostraca*) from King George Island, South Shetland Islands*)

ABSTRACT: The occurence of the crustacean *Branchinecta gaini* was observed in the fresh-water ponds on King George Island. Morphological structure of the following developmental stages was described: *nauplius, metanauplius,* adult males, adult females, and gravid females with egg-sacs filled with eggs. The active phase of the life cycle of this species lasts 6 months (November-May). During that time one generation of *Branchinecta* develops. The reproductive season lasts from January until the freezing of the ponds.

Key words: Antarctic, *Branchinecta gaini* Daday, *Branchiopoda, Anostraca,* morphology, life cycle

1. Introduction

Fresh-water fauna of the Antarctic is relatively poor, as compared with marine fauna. This results mainly from the extreme conditions of the environment — long lasting ice cover at the surface and often freezing of the water bodies down to the bottom. Only few species are able to adapt to such hard conditions of life. One of them is a crustacean *Branchinecta gaini* Daday, 1910 (*Branchiopoda, Anostraca*). The occurence of this species was observed for the first time on Petermann Island off the west shores of Antarctic Peninsula (Daday 1910) and later on South Georgia (Linder 1941) and on Signy Island, South Orkneys (Heywood 1970).

Branchinecta gaini was also found in small fresh water ponds on King George Island (South Shetland Islands) during the investigations carried out

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by the participants of the First and Second Antarctic Expeditions of the Polish Academy of Sciences in 1977 and 1978. The occurence of *Branchiopoda* of the genus *Branchinecta* in the fresh water bodies on Fildes Peninsula (King George Island) was reported earlier by Campos, Arenas and Steffen (1978), but this material was identified only to the generic level.

2. Materials and methods

Nine fresh water bodies situated in the neighbourhood of the Arctowski Antarctic Station were searchrd for *Branchinecta* (Fig. 1).

From hydrographical viewpoint the investigated fresh water bodies may be divided into three groups:

1. Large ponds formed at the base of the storm ridge (I, II, VIII). They are situated close to the shores of Admiralty Bay and are supplied with water by run-offs from the glacier (Figs. 2 and 3).
2. Small ponds (V, VII, IX) situated at the lateral moraine of the Ecology Glacier. They are supplied with water by run-offs from the glacier, or (possibly) by thawing ice lenticles enclosed in the moraine (Fig. 4).
3. Other bodies of water (III, IV, VI) not connected with the glacier. They lie about 50 m above sea level and are filled with water from precipitations. They dry up periodiccally during Antarctic summer.

Morphological studies and other investigations concerning *Branchinecta gaini* are based on the typical form of this species collected in the pond No. I, where the most complete materials of this species were collected. It is a large pond of the area of about 9500 m^2 and is about 1.5 m deep. At the time of investigation it was covered with ice for about 6 months — from May till November. The water temperature ranged from 0 C to 10.6 C (Presler 1980). The fauna of this pond consisted of the following animal groups: *Protozoa, Nematoda, Tardigrada, Copepoda* and *Anostraca.*

Materials of *Branchinecta gaini* were collected with a hand-net from February 1977 till July 1977 and from November 1977 till March 1978. In August 1977 a sample was collected by cutting out blocks of ice together with pieces of frozen bottom. In September and October samples were not taken.

In total 32 samples of *Branchinecta gaini* inhabiting the pond No I were collected. In austral autumn and spring the time span in collecting was about 1 month, whereas in summer this span was shortened to several days; however for population study richer samples collected in the 10—14 days intervals were chosen (Table I).

When less than 100 specimens were in the sample all animals were mesured with an accuracy of 0.1 mm and their developmental stage was determined; adult animals were sexed. In the case of richer samples about 100 specimens were taken at random for such analysis. To arrange the diagrams of the population structure length classes evry 1 mm were adopted.

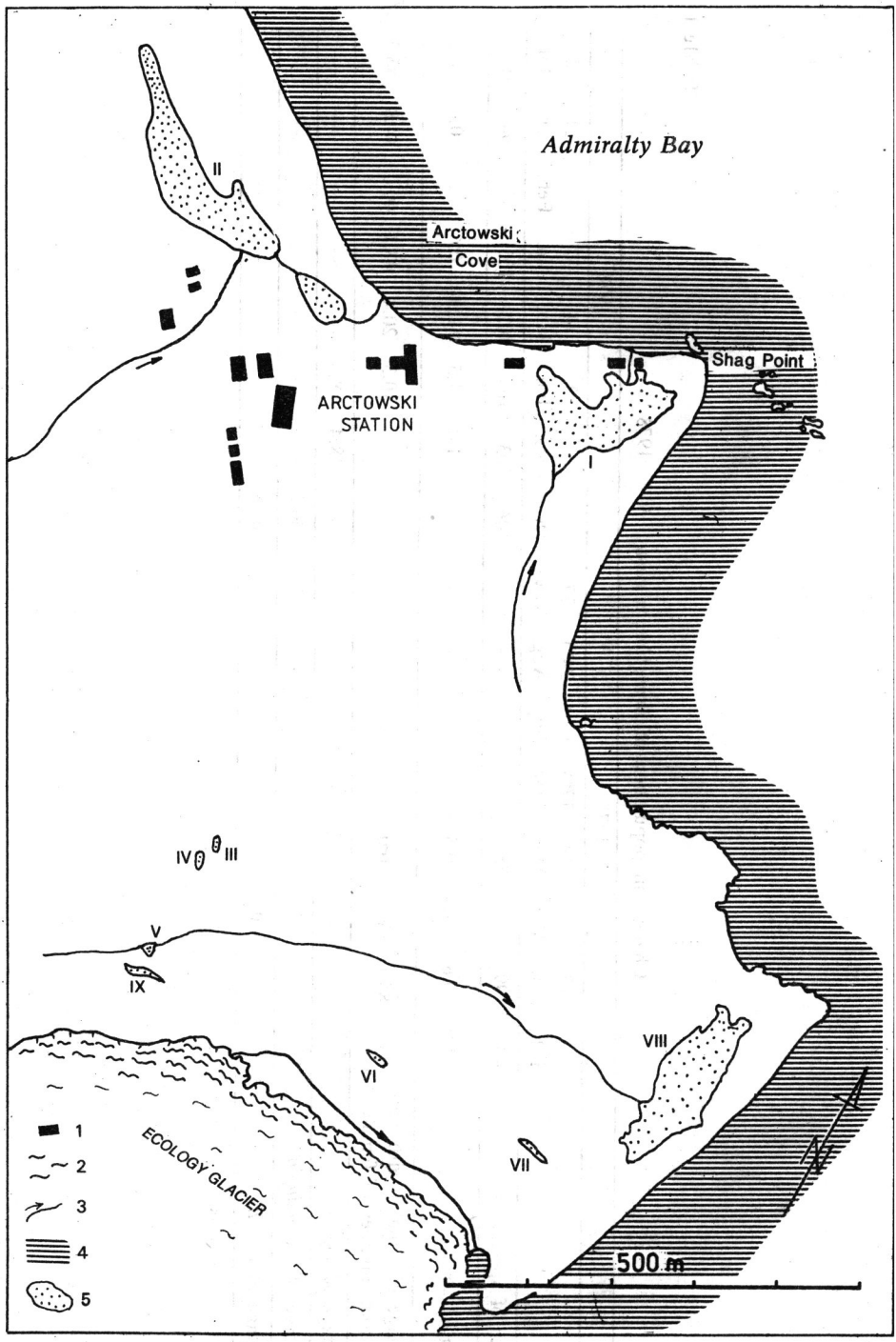

Fig. 1. Investigated area
I—VIII — fresh water ponds under investigation, 1 — station buildings, 2 — glacier, 3 — streams, 4 — sea, 5 — freshwater bodies

Table I

Changes in population of *Branchinecta gaini* 1977—1978

	1977										1978					
	13 Feb.	13 Mar.	23 Mar.	19 May	17*) June	15*) July	24*) Aug.	27 Nov.	2 Dec.	25 Dec.	2 Jan.	14 Jan.	27 Jan.	11 Feb.	21 Feb.	2 Mar.
Number of specimens	43	99	113	38	—	—	—	102	106	103	105	102	105	45	94	105
Sex ratio — $\frac{♂}{♀}$	1.9	0.6	1.4	0.5	—	—	—	—	—	1.0	1.5	1.1	0.6	1.3	0.6	0.5
Percentage of females with eggs in the total number of females	73.3	84.1	60.2	50.0	—	—	—	—	—	—	10.3	20.4	43.1	40.0	44.8	46.3
Percentage of *juvenes*	—	—	—	—	—	—	—	—	—	18.4	8.6	—	—	—	—	—
Percentage of *metanauplii*	—	—	5.3	—	—	—	—	32.4	36.2	13.6	—	—	—	—	—	—
Percentage of *nauplii*	—	—	0.9	—	—	—	—	67.6	63.8	—	—	—	—	—	—	—

) only eggs were found

Fig. 2. Pond No. I — sampling station

Photo W. Kittel

Fig. 3. Pond No. II situated at the foot of a massif of rock. Habitat of the typical form of *Branchinecta gaini*

Photo W. Kittel

Fig. 4. Pond No. VII situated at the lateral moraine of the Ecology Glacier. Habitat of the large form of *Branchinecta gaini*

Photo W. Kittel

For drawings of the population structure of *Branchinecta gaini* microscopic slides were made of various appendages of the animals macerated in 10% KOH and embedded in glycerogel.

4. Results

4.1. Morphology of developmental stages of *Branchinecta gaini*

Branchinecta gaini was found in three (I, II, VII) of the nine investigated water bodies. The typical form described by Daday (1910) was collected in ponds I and II (Figs. 2 and 3), the large form described by Linder (1941) in the pond VII (Fig. 4).

The following postembryonic developmental stages were found in the

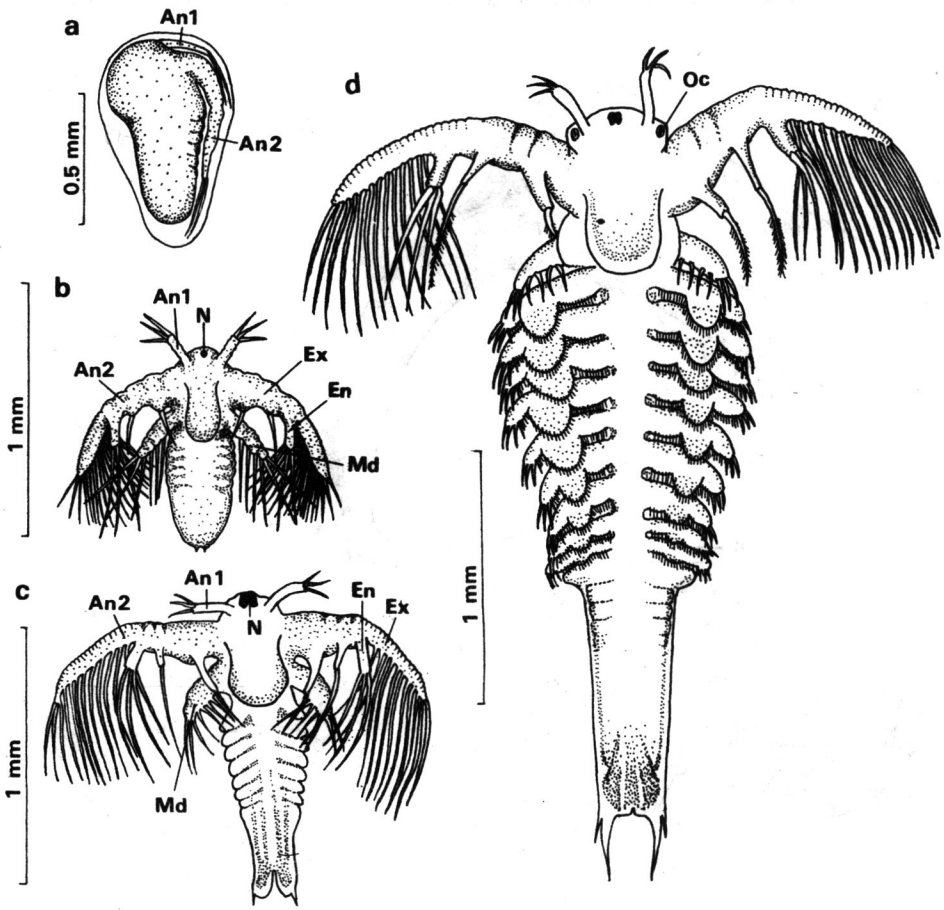

Fig. 5. Larval stages of *Branchinecta gaini*
a — embryo within the inner egg-membrane, b, c — *nauplii* (ventral view), d — *metanauplius* (ventral view), An 1 — 1st antenna, An 2 — 2nd antenna, N — *nauplius* eye, En — endopodite, Ex — exopodite, Md — mandible, Oc — stalked composed eye.

material collected in pond No. I: 1. *nauplius*, 2. *metanauplius*, 3. *juvenes*, 4. males with clearly marked features of sexual dimorphism, 5. females with clearly marked features of sexual dimorphism, 6. females with egg-sacs filled with eggs.

Embryos of *Branchinecta gaini* develop in eggs with two membranes. After breaking the outer membrane they hatch enveloped in a thin inner membrane (Fig. 5a) with the 1st and 2nd pair of the antennae already visible. The body length of an embryo is about 0.5 mm.

Nauplii have, at first, a "spidery" shape with a distinctly marked *nauplius* eye and three pairs of appendages. These are the 1st and 2nd pair of the antennae and mandibulae (Figs. 5b and 5c). The body length of the *nauplii* ranges from 0.9 to 1.8 mm.

Metanauplii (Fig. 5d) besides the three pairs of appendages characteristic for *nauplii* have maxillae and stalked compound eyes. Thorax is

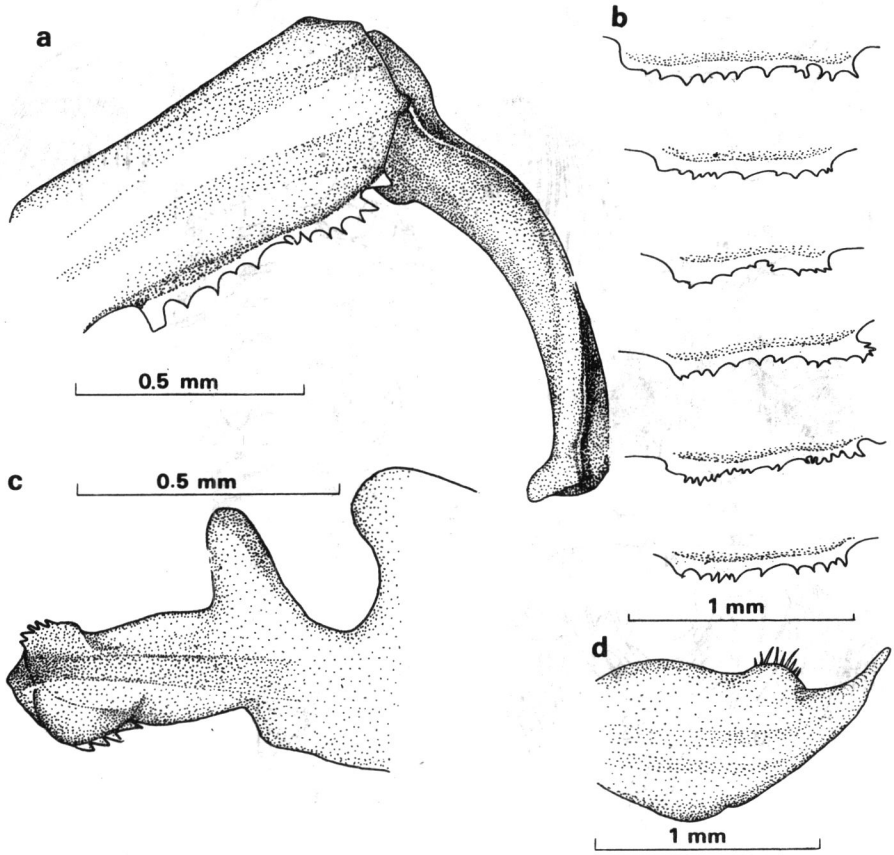

Fig. 6. Features of sexual dimorphism of *Branchinecta gaini*
a — 2nd antenna of male, b — changes in serration of the proximal segment of the 2nd antenna of a male, c — penis, d — 2nd antenna of a female.

segmented with distinctly visible, gradually developing, foliaceous appendages. On the end of non-segmented abdomen four spines are strongly marked. Body length of *metanauplii* ranges from 1.6 to 4.7 mm.

Forms classified by the authors as *juvenes* include specimens in with reduction of *nauplius* eye is observed as well as gradual reduction of endopodites and setae on the 2nd pair of antennae. They are unsexable without either initial egg-sacs or penes. Animals belonging to this developmental stage differ morphologically from *metanauplii* and from specimens with apparent features of sexual dimorphism. The body length of *juvenes* ranges from 5 to 7 mm.

The group of adult forms includes specimens with distinct features of sexual dimorphism. Males have a well-developed 2nd pair of antennae with very characteristic serration of the proximal segment (Figs. 6a and 6b). Fused ventral surface of the two first abdominal segments of male specimens is produced in a paired penis. An egg-sac gradually filling with eggs is observed in females. Female 2nd antennae are not segmented and on their inner side thre is a very characteristic tuft of setae (Fig. 6d). Abdominal appendages (Figs. 7a, 7b and 7c) and furca (Fig. 8) do not differ in both sexes. The maximum length of males is 19.6 mm, females — 19.2.mm.

The above-mentioned features enabled proper identification of the species.

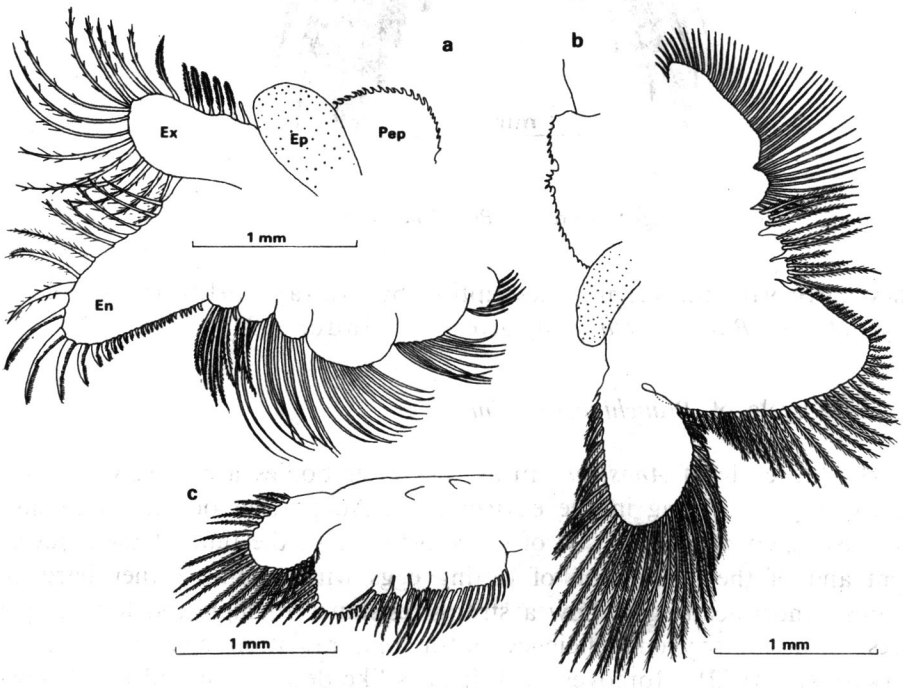

Fig. 7. Thoracal appendages of *Branchinecta gaini*
a — 1st thoracal appendage, b — 6th thoracal appendage, c — 11th thoracal appendage, Ex — exopodite, En — endopodite, Ep — epipodite, Pep — praeepipodite, End — endites.

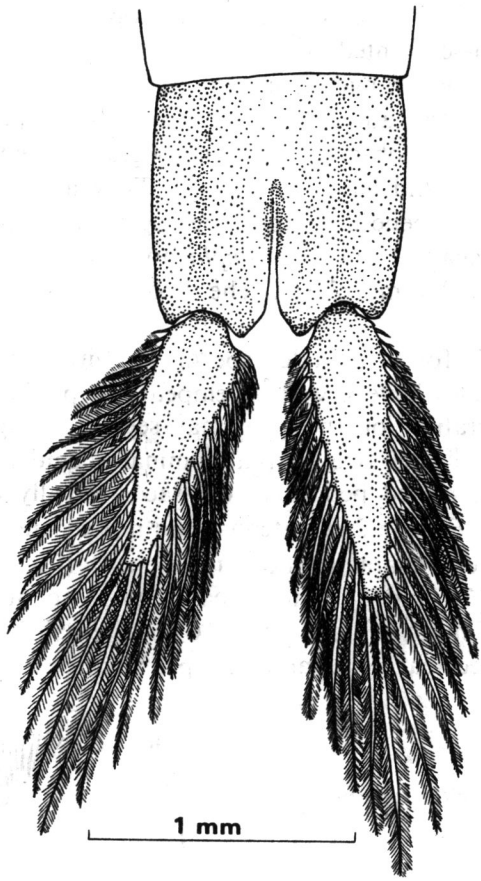

Fig. 8. Furca of *Branchinecta gaini*

They agree with the original description by Daday (1910) and supplementary data on *Branchinecta gaini* given by Linder (1941).

4.2. Life cycle of *Branchinecta gaini*

The life cycle of *Anostraca* in astatic water bodies are closely associated with changes occuring in the environment. Adaptation of these animals to the existing conditions consist of the shortening of the time of their development and of the production of resting eggs withstanding rather hard conditions. Anostracan eggs show a strong resistance to high and low temperatures, drought, oxygen deficiency, ultraviolet radiation etc. (Hempel-Zawitkowska 1972). Moreover, such factors like desiccation and low temperatures seem to be prerequisites for a normal development of eggs (Srámek-Hušek, Straškraba and Brtek 1962).

The life cycle of *Branchinecta gaini* in the pond No. I was determined

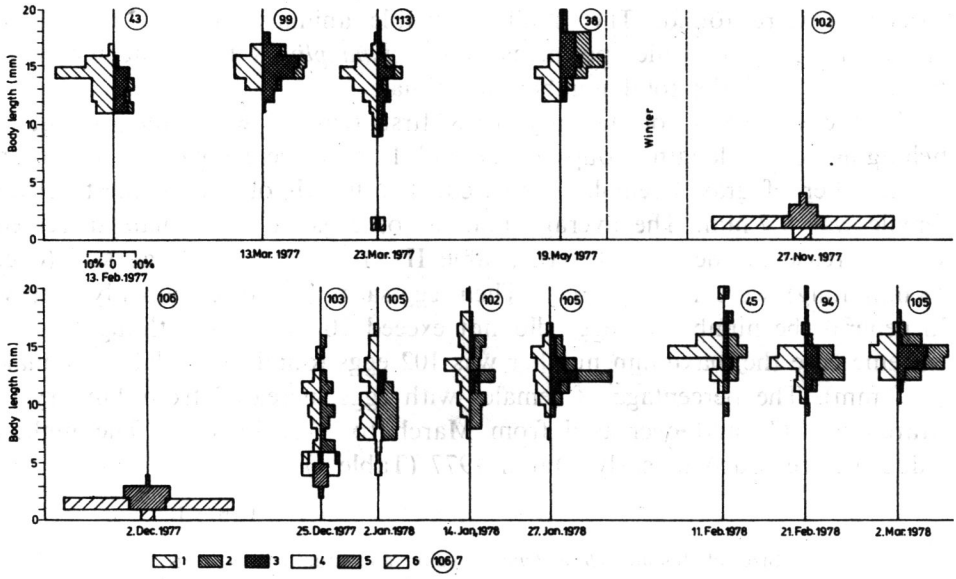

Fig. 9. Population structure of *Branchinecta gaini* in the period of 1977—1978
1 — adult males, b — adult females, 3 — females with egg-sacs filled with eggs, 4 — *juvenes*, 5 — *metanauplii*, 6 — *nauplii*, 7 — numbers of tested specimens.

on the basis of the observations carried out from February 1977 till March 1978 (Table I, Fig. 9).

During the Antarctic summer and autumn 1977 it was found that numerous sexually mature *Branchiopoda* were present in the investigated pond. They were alive until mid May when the pond was already covered with ice. The animals died after resting eggs were laid. Not all the females laid eggs simultaneously. This fact can explain the phenomenon observed in the late March 1977. At that time the presence of a small number of larval stages was observed. It seems unlikely that this could be a second generation produced in the course of the one-year cycle. It is more likely to suppose the premature hatching of certain number of eggs deposited in the shallower part of the pond and subjected to accidental freezing.

The resting phase of the life cycle of *Branchinecta gaini* occurs in the winter months (June-October). In the samples collected in that period no living animals were found; eggs only were lying in the mud of the frozen bottom of the pond.

Larval forms hatched from resting eggs appeared in November 1977 after melting of the ice cover. In *Branchinecta gaini*, as in other *Anostraca*, two larval forms are observed: *nauplii* and *metanauplii*. At that time *nauplii* made up about 65% and *metanauplii* about 35% of the analysed population. A similar quantitative relations was noted in the sample collected a few days later.

At the end of December, along with *metanauplii* and *juvenes*, first adult

specimens were found. The smallest sexable animals were in the length group of 6 mm. Juvenile specimens and *metanauplii* at that time made up together 36% of the total number of animals.

In the beginning of January 1978 first females with filled egg-sacs, belonging to the length groups of 11 and 12 mm, were collected. Later on the number of gravid females increased. The length of the smallest gravid female was 9.7 mm. The average number of eggs in one female increased with increase of the body length (Table II). Females of a large size (over 18 mm long) were found rarely. Their egg-sacs were often already empty. In general the number of eggs did not exceed 20 (Table II), though in the extreme case the maximum number was 102 eggs found in the largest female (19.2 mm). The percentage of females with eggs increased from January to March in 1978 and decreased from March to May in 1977. The highest value was recorded in early March 1977 (Table I).

Table II

Size of females *Branchinecta gaini* and number of eggs in egg-sac

Body length size class (mm)	Number of eggs			Number of specimens
	maximal	minimal	average	
9	6	1	3.0	4
10	10	1	4.6	10
11	13	1	4.6	14
12	12	1	4.5	38
13	12	1	5.5	36
14	18	1	6.0	47
15	15	1	7.5	33
16	19	4	9.8	16
17	16	2	7.5	8

Sex ratio is subject to some changes during the life cycle, in general oscillating around one. The maximum percentage of males in the single samples selected at random was 65% and for females — 69%.

The active phase of life cycle of *Branchinecta gaini* lasted about 6 months (November — May). During that time one generation was produced. Fertilized eggs developed after the resting stage lasting also 6 months. Probably the freezing of eggs during the wintertime is indispensable for their development. The animals reached sexual maturity in about one month after hatching and their reproductive season began in January.

A large form of *Branchinecta gaini*, described by Linder (1941), was found in the pond No. VII. These specimens differed from the typical form in their size and the number of eggs in their egg-sacs. The maximum body length of males was 29.8 mm, females — 28.1 mm. The number of eggs in these large females ranged up to 200. These differences may be caused by different trophic conditions in the investigated ponds. Pond No. VII lies in

the neighbourhood of a large penguin rookery and is supplied abundantly with excrements causing eutrophisation of the pond and abundance of food (algae, detritus), which is reflected consequently in the appearance of larger forms and in higher fecundity of the animals living in this water body.

5. Резюме

В пресноводных водоемах расположенных вблизи польской антарктической станции на острове Кинг Джордж (рис. 1) было установлено присутствие ракообразного вида *Branchinecta gaini* Daday, 1910 (*Branchiopoda, Anostraca*). Водоем, из которого происходили материалы, подлежавшие подробным морфологическим и популяционным анализам, характеризовался площадью ок. 9500 м^2 и глубиной ок. 1.5 м (рис. 2). Кроме *Anostraca* в этом материале были определены также представители *Protozoa, Nematoda, Copepoda, Tardigrada.*

В собранном материале были установлены следующие постэмброинальные стадии развития *Branchinecta gaini*: науплиус, метанауплиус, молодь, самцы с четко выделяющимися признаками полового диморфизма, самки с четко обозначенными признаками полового диморфизма, а также самки с яйцевыми мешками наполненными в разной степени яйцами.

Активная фаза жизненного цикла исследуемого вида началась в конце ноября, с момента выклева науплиусов из перезимовавших яиц, отложенных предыдущим поколением самок. Через месяц появились первые половозрелые особи. В начале января появились первые самки с наполненными яйцевыми мешками (длина тела 9,7 мм) (рис. 9). Максимальное участие в популяции самок с яйцами приходилось в марте (свыше 80% общего числа самок) (таблица I). Половозрелые животные достигали максимальную длину тела 19,6 мм — самцы и 19,2 мм — самки. Следующая фаза жизненного цикла *Branchinecta gaini* начиналась в мае откладкой зимующих яиц. Необходимым условием развития яиц кажется воздействие на них минусовой температуры.

6. Streszczenie

W zbiornikach słodkowodnych położonych w pobliżu Polskiej Stacji Antarktycznej na Wyspie Króla Jerzego (rys. 1) stwierdzono występowanie skorupiaka z gatunku *Branchinecta gaini* Daday 1910 (*Branchiopoda, Anostraca*). Zbiornik, z którego pochodziły materiały poddane szczegółowej analizie morfologicznej i populacyjnej miał powierzchnię około 9500 m^2 i głębokość około 1.5 m (rys. 2). Oprócz *Anostraca* znaleziono w nim przedstawicieli *Protozoa, Nematoda, Copepoda, Tardigrada.*

W zebranych materiałach stwierdzono następujące postembrionalne stadia rozwojowe *Branchinecta gaini: nauplius, metanauplius, juvenes,* samce i samice z wyraźnie zaznaczonymi cechami dymorfizmu płciowego oraz samice z workami jajowymi wypełnionymi w różnym stopniu jajami.

Faza aktywna cyklu życiowego badanego gatunku rozpoczęła się pod koniec listopada z chwilą wylęgnięcia się naupliusów z jaj zimujących, złożonych przez poprzednie pokolenie. W miesiąc później pojawiły się pierwsze osobniki dojrzałe. Na początku stycznia zaobserwowano pierwsze samice, z wypełnionymi workami jajowymi (długość ciała 9,7 mm) (rys. 9). Maksymalny udział w populacji samic z jajami przypadał na marzec (ponad 80% ogólnej liczby samic) (Tabela I). Zwierzęta dojrzałe osiągały największą długość: 19,6 mm — samce; 19,2 mm — samice. Faza spoczynkowa cyklu życiowego *Branchinecta gaini* rozpoczynała się w maju złożeniem jaj zimujących. Warunkiem niezbędnym dla rozwoju jaj wydaje się być ich przemarznięcie.

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