Trokhymets, V., Gorobchyshyn, V., & Kozeretska, I. (2021).
Population features of *Boeckella poppei* in Lake Wujka,
King George Island.
Ukrainian Antarctic Journal, 1, 117—122.
https://doi.org/10.33275/1727-7485.1.2021.670

Коротке повідомлення

Short note

V. Trokhymets [1], V. Gorobchyshyn [1, 2, *], I. Kozeretska [3]

[1] Taras Shevchenko National University of Kyiv, Kyiv, 01601,Ukraine
[2] State Institution Institute for Evolutionary Ecology of the National Academy of Sciences of Ukraine, Kyiv, 03143,Ukraine
[3] State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, 01601, Ukraine

*** Corresponding author:** medziboz@yahoo.com

Population features of *Boeckella poppei* in Lake Wujka, King George Island

Abstract. The maritime Antarctic is one of the most interesting regions on planet where climate change can be observed to impact all components of its poor flora. *Boeckella poppei* is common in the maritime and continental Antarctic species of the copepod. The aim of the study was to check the local trends in the copepod's population density over summer. The samples were collected 23.12.05, 03.01.06 and 10.01.06 at the King George Island from the lake near the Polish Antarctic Station. The population density varied with strongly fluctuating ratios of different juvenile and generative developmental stages. We also analyzed the regularities reported by other authors. The sex structure of the population did not change during the study period with females much more numerous than males. The article discusses possible causes of this phenomenon.

Keywords: population density, sex structure, Calanoida, crustacean, Antarctica

1 Introduction

The copepod genus *Boeckella* Guerne & Richard, 1889 consists of 42 species distributed throughout Australia, New Zealand, South America, Antarctica, and sub-Antarctic islands (Menu-Marque et al., 2000; Dartnall, 2017; Díaz et al., 2019; Maturana et al., 2019). Some species, including *Boeckella poppei* (Mrázek, 1901) (Centropagidae), were originally described in the genus *Pseudoboeckella* Mrázek, 1901, but were transferred to *Boeckella* (Bayly, 1992).

A limited number of recent studies have focused on the ultrastructure, ecological characteristics, dispersal, and origin of *B. poppei* in widely separated maritime and continental Antarctic locations (Reed et al., 2021; Bayly et al., 2003; Butler et al., 2005; Gibson & Zale, 2006; Janiec, 1988; 1996). Heywood (1970) and Weller (1977) reported the age and sex structure of *Boeckella silvestri* (Daday, 1901) and *B. poppei* populations at Signy Island, South Orkney Island. The embryos of *B. poppei* from sediments of the lake on Barton Peninsula, King George Island, Antarctica, will passively accumulate moderately lipophilic chemicals while lying dormant in anoxic sediments, which can decrease hatchings uccess (Reed et al., 2018). The current known distribution of *B. poppei* extends beyond the Antarctic to include Argentina and Chile. Additionally, other species of this genus have been described from Antarctic Peninsula: *Boeckella michaelseni* (Mrázek, 1901), *Boeckella brevicaudata* (Brady, 1875), *Boeckella vallentini* (Scott T., 1914) (Menu-Marque et al., 2000).

King George Island is the largest one of the South Shetland Islands, with an area of 1.312 km^2, about

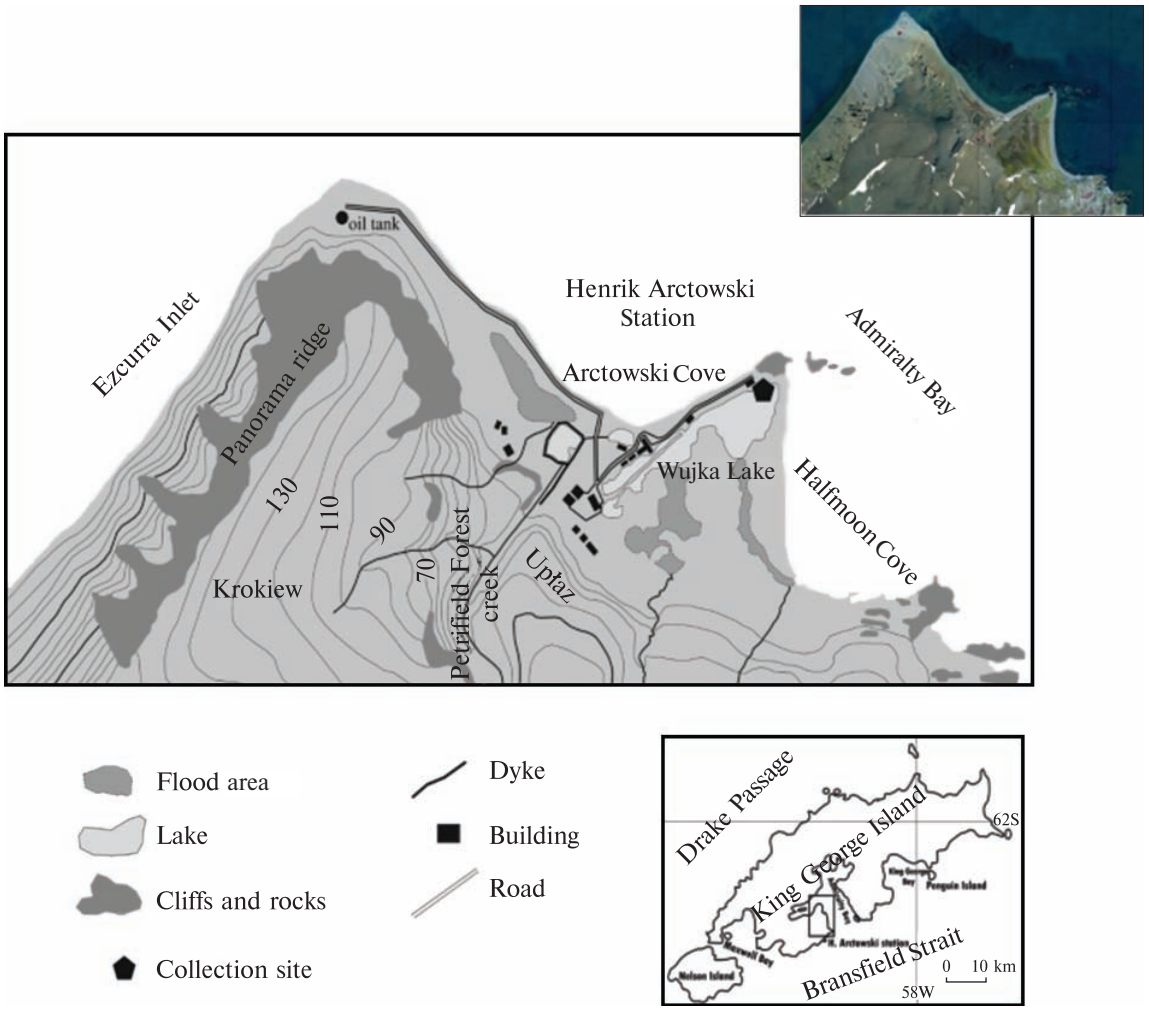

Figure. Surroundings of Polish Arctowski Station. The asterisk indicates Lake Wujka

90% of which is under permanent ice cover (Rakusa-Suszczewski, 2002). There are several permanent freshwater bodies on the island, with Lake Wujka near the Polish Arctowski Station being one of the largest (Figure). Previous studies of *B. poppei* on King George Island are limited. Janiec (1988; 1996) noted *B. poppei* in Lake Wujka and provided some data on population density. Pociecha and Dumont (2008) provide some information on life cycle features based on studies carried out in Lake Wujka.

The objectives of the current study were to document seasonal population density and population age and sex structure of *B. poppei* in Lake Wujka. As this location lies within a well-recognized region of rapid climate change off the Antarctic Peninsula, while maritime Antarctic lakes have been proposed to be particularly sensitive to and magnify the regional signature of macroclimatic change (Quayle et al., 2002), such data also provide a potentially important baseline against which future comparisons can be made.

2 Materials and methods

Lake Wujka has an approximate surface area of 200 m^2 (Heywood, 1970) and is situated close to the Polish Arctowski Station on King George Island (–62.158958°, –58.467157°; Figure). The lake surface is typically ice-free for ~7 months a year. The lake benthos forms

 ISSN 1727-7485. Ukrainian Antarctic Journal, 1, 2021, https://doi.org/10.33275/1727-7485.1.2021.670

a layer of silt (20–40 cm depth) containing 5–20% filamentous green algae (Janiec, 1993). During the summer months, the lake's pH is in the range of 6.0–8.0 (Pociecha & Dumont, 2008). The lake is fed by snowmelt in the Antarctic spring, thawing permafrost, and inflow from Moss Creek. Occasional sea water ingress into the lake has been noted during heavy gales (Pociecha, 2007), although this was not observed during the study season.

The maximum depth of the lake did not exceed 1 m during the study period. Samples were collected using a conical plankton net (№ 67) at a depth of 0.15 m on 23.12.2005, 3.01.2006, and 10.01.2006 (Figure), between 10.00 and 12.00 (local time). A total of 3 samples were taken. Samples consisted of the filtrate from 20 l of lake water and were fixed in 96% ethanol. Individual *B. poppei* were assigned to one of five copepodite stages (CI–CV). The sex of C VI individuals was determined using morphological characteristics. Water temperature was recorded at the sampling site using an alcohol thermometer.

Statistical evaluation was carried out employing Pearson correlation and χ^2 method.

3 Results

All samples collected in Lake Wujka contained only one Calanoida species. We confirmed the finding of *Boeckella (Pseudoboeckella) poppei* at King George Island, Lake Wujka in the surroundings of Polish Arctowski Station (Janiec,1996; Menu-Marque et al., 2000; Pociecha, 2007). Visually, in all the studied freshwater ponds except Lake Wujka, there were registered only single specimens at copepodid stages.

Sample analysis demonstrated a stable tendency towards increasing of population density of copepods during the month of investigations (Table).

The average density of the species was 1050 ind./m^3 at 4.5 °C (23.12.2005). In ten days (3.01.2006), the temperature increased up to 10 °C, and copepodid density rose nine-fold, to 9350 ind./m^3. At the last sampling (10.01.2006), the density of *B. poppei* was even higher — 15500 ind./m^3, when the temperature was 11.5 °C.

Population density varied with significant fluctuations in different juvenile and generative copepodite numbers (Table). In the first sample, copepodite stages (CI–CV) dominated (800 ind./m^3), with only 250 ind./m^3 of pubescent individuals: density of juveniles more than thrice exceeded that of pubescent individuals. However, this ratio changed drastically in 10 days. By that time, the most abundant group was adult individuals — 6550 ind./m^3, with juveniles lagging at 2800 ind./m^3, so pubescent individuals outnumbered larvae by 2.5 folds. In the third sample, we noted the tendency towards an increase of juvenile fraction: pubescent individuals — 9400 ind./m^3, juveniles — 6100 ind./m^3.

Interestingly, the sex structure of the population (Table) did not change during the whole period of study, with significantly more females than males. Thus, at the end of December, the ratio of females to males was 150 to 100 ind./m^3; at the beginning of January, the numbers were 4200 to 2350 ind./m^3, and mid-January, 5450 to 3960 ind./m^3, respectively.

4 Discussion

Our results demonstrated a stable tendency towards increasing population density of copepods during the month of investigations. Similar results were obtained for freshwater lakes of Signy Island (Heywood, 1970; Weller, 1977). However, year-long monitoring of Lake Wujka (2003–2004) showed that calanoid density

Table. Dynamics of population density of *Boeckella poppei* in Lake Wujka

Date	Water temperature, °C	Juveniles, ind./m^3	Adults, ind./m^3		
			females	males	F/M
23rd December	4. 5	800	150	100	1.5
3rd January	10	2800	4200	2350	1.8
10th January	11.5	6100	5450	3950	1.4

almost did not change during the period coinciding with our research time (Pociecha & Dumont, 2008). The intensification of crustacean development may explain our observations since the elevation of water temperature is most likely followed by increases in the copepods' food. Unfortunately, we cannot compare these temperature-dependent trends in population density with earlier studies (the temperature dynamics of the lake in 2003–2004 was discussed in Pociecha and Dumont (2008)), showing no such trends. Meanwhile, our data on the correlation between *B. poppei* development rates and water temperature correspond well with Heywood's (1970) and Weller's (1977) findings. As the density of *B. poppei* in the last sample only slightly exceeded that of the previous one, and the temperature approached its maximum, it may be assumed that soon afterwards, calanoid density in Lake Wujka stabilized.

Relative increase of juvenile density with respect to pubescent individuals may be explained by asynchronous recruitment of crustaceans. It was most unexpected that the total quantity of adult individuals in the second sample was several times the total number of juvenile individuals in the first one; we can only explain this now by extreme shortening of the development cycle and prolonged larvae emergence from the eggs. However, these suggestions require further investigations.

During our fieldwork, the sex structure of the population did not change over the whole period of study. We showed that females outnumbered males with statistical reliability. Contrary to our data, adult males significantly outnumbered females in Heywood's (1970) study. Heywood (1970) considers his results to confirm the suggestion that the sex ratio of the species is determined by the environment (ESD — environmental sex determination). It is known that there are also gene (GSD) and chromosome (CSD) sex determinants (Ryner & Swaint, 1995). However, to draw a conclusion about sex determination in a species, it is necessary to thoroughly study it genetically, as shown by our data not aligned with Heywood's. It is also possible that the species does not regularly reproduce sexually. Thus, parthenogenesis has been described for three Copepoda species (Dole-Olivier et al., 2000) but not for *Boeckella*. At the chromosomal level, sex is usually defined by sex chromosomes XY (XX) (Einsle, 1993). All this points at the theoretical sex ratio close to 1:1, which is not congruent either with our or with Heywood's experimental data. Investigations of the development cycle of *B. poppei* and also of the levels of its infestation by endosymbionts (Mioduchowska et al., 2018; Duron et al., 2008) will further help to answer problems formulated in this work and to establish a connection between population changes and dynamics of abiotic factors.

Author contributions. VG — conceptualization; IK — collecting samples; VT, VG — determination of samples; VT, VG, IK — writing original draft preparation, reviewing and editing. Each author contributed to the analysis and discussion of the results and edited the manuscript.

Acknowledgments. Authors express gratitude to State Institution National Antarctic Scientific Centre, Ministry of Education and Science and National University Taras Shevchenko of Kyiv for comprehensive support of the conducted research. We are deeply grateful to V. I. Monchenko (Schmalhausen Institute of Zoology, Kyiv, Ukraine) for kind help with interpretation of the results, to Peter Convey (British Antarctic Servey, UK) for critical discussion and to Antonio Batista Pereira, and to Edvaldo Simões da Fonseca Junior (Universidade Luterana do Brazil, Canoas, Brazil) for generously granted photo of the area of investigation.

Conflicts of Interest. The authors declare no conflict of interest.

References

Bayly, I. A. E. (1992). Fusion of the genera *Boeckella* and *Pseudoboeckella* (Copepoda) and revision of their species from South America and sub-Antarctic islands. *Revista Chilena de Historia Natural*, 65(1), 17–63.

Bayly, I. A. E., Gibson, J. A. E., Wagner, B., & Swadling, K. M. (2003). Taxonomy, ecology and zoogeography of two East Antarctic freshwater calanoid copepod species: *Boeckella poppei* and *Gladioferens antarcticus*. *Antarctic Science*, 15(4), 439–448. https://doi.org/10.1017/S0954102003001548

Butler, H., Atkinson, A., & Gordon, M. (2005). Omnivory and predation impact of the calanoid copepod *Boeckella pop-*

pei in a maritime Antarctic lake. *Polar Biology*, 28, 815–821. https://doi.org/10.1007/s00300-005-0014-4

Dartnall, H. J. G. (2017). The freshwater fauna of the South Polar region: A 140-year review. *Papers and Proceeding of the Royal Society of Tasmania*, 151, 19–57. https://doi.org/10.26749/rstpp.151.19

Díaz, A., Maturana, C. S., Boyero, L., Escalante, P. D. L. R., Tonin, A. M., & Correa-Araneda, F. (2019). Spatial distribution of freshwater crustaceans in Antarctic and Subantarctic lakes. *Scientific Reports*, 9, 7928. https://doi.org/10.1038/s41598-019-44290-4

Dole-Olivier, M.-J., Galassi, D. M. P., Marmonier, P., & Creuze des Chatelliers, M. (2000).The biology and ecology of lotic microcrustaceans. *Freshwater Biology*, 44(1), 63–91.

Duron, O., Bouchon, D., Boutin, S., Bellamy, L., Zhou, L., Engelstädter, J., & Hurst, G. D. (2008). The diversity of reproductive parasites among arthropods: *Wolbachia* do not walk alone. *BMC Biology*, 6, 27. https://doi.org/10.1186/1741-7007-6-27

Einsle, U. (1993). *Crustacea, Copepoda, Calanoida und Cyclopoida. Süsswasserfauna von Mitteleuropa,* 8/4, 1. Gustav Fisher Verlag.

Gibson, J. A. E., & Zale, R. (2006). Holocene development of the fauna of Lake *Boeckella*, northern Antarctic Peninsula. *The Holocene*, 16(5), 625–634. https://doi.org/10.1191/0959683606hl959rp

Heywood, R. B. (1970). Ecology of the fresh-water lakes of Signy Island, South Orkney Islands: III. Biology of the copepod *Pseudoboeckella silvestri* Daday (Calanoida, Centropagidae). *British Antarctic Survey Bulletin*, 23, 1–17.

Janiec, K. (1988). *Pseudoboeckella poppei* (Copepoda, Calanoida) from Petrel Lake in Antarctic Penguin Island. *Polish Archives of Hydrobiology*, 35(2), 181–184.

Janiec, K. (1993).The freshwater micro- and meiofauna of Admiralty Bay, King George Island, South Shetland Islands.*Proceedings of the NIPR Symposium on Polar Biology*, 6, 133–138.

Janiec, K. (1996). The comparison of freshwater invertebrates of Spitsbergen (Arctic) and King George Island (Antarctic). *Polish Polar Research*, 17(3–4), 173–202.

Maturana, C. S., Rosenfeld, S., Naretto, J., Convey, P., & Poulin, E. (2019). Distribution of the genus *Boeckella* (Crustacea, Copepoda, Calanoida, Centropagidae) at high latitudes in South America and the main Antarctic biogeographic regions. *Zoo Keys*, 854, 1–15. https://doi.org/10.3897/zookeys.854.29614

Menu-Marque, S., Morrone, J. J., & de Mitrovich, C. L. (2000). Distributional patterns of the South American species of Boeckella (Copepoda: Centropagidae): a track analysis. *Journal of Crustacean Biology*, 20(2), 262–272. https://doi.org/10.1651/0278-0372(2000)020[0262:DPOTSA]2.0.CO;2

Mioduchowska, M., Czyż, M. J., Gołdyn, B., Kilikowska, A., Namiotko, T., Pinceel, T., Łaciak, M., & Sell, J. (2018). Detection of bacterial endosymbionts in freshwater crustaceans: the applicability of non-degenerate primers to amplify the bacterial 16S rRNA gene. *PeerJ*, 6, e6039. https://doi.org/10.7717/peerj.6039

Pociecha, A. (2007). Effect of temperature on the respiration of an Antarctic freshwater anostracan, *Branchinecta gaini* Daday 1910, in field experiments. *Polar Biology*, 30, 731–734. https://doi.org/10.1007/s00300-006-0230-6

Pociecha, A., & Dumont, H. J. (2008): Life cycle of *Boeckella poppei* Mrazek and *Branchinecta gaini* Daday (King George Island, South Shetlands). *Polar Biology*, 31, 245–248. https://doi.org/10.1007/s00300-007-0360-5

Quayle, W. C., Peck, L. S., Peat, H. J., Ellis-Evans, J. C., & Harrigan, P. R. (2002). Extreme responses to climate change in Antarctic lakes. *Science*, 295(5555), 645. https://doi.org/10.1126/science.1064074

Rakusa-Suszczewski, S. (2002). King George Island — South Shetland Islands, Maritime Antarctic. In L. Beyer, & M. Bolter (Eds.), *Geoecology of Antarctic Ice-Free Coastal Landscapes* (pp.23–39). Springer-Verlag Berlin.

Reed, K. A., Park, H., Lee, S. G., Lee, W., Lee, S. H., Bleau, J. M., Munden, T. N. M., & Covi, J. A. (2018). Embryos of an Antarctic zooplankton require anoxia for dormancy, are permeable to lipophilic chemicals, and reside in sediments containing PCBs. *Scientific Reports*, 8(1), 16258. https://doi.org/ 10.1038/s41598-018-34689-w

Reed, K. A., Lee, S. G., Lee, J. H., Park, H., & Covi, J. A. (2021). The ultrastructure of resurrection: Post-diapause development in an Antarctic freshwater copepod. *Journal of Structural Biology*, 213(1), 107705. https://doi.org/10.1016/j.jsb.2021.107705

Ryner, L. C., & Swaint, F. (1995). Sex in the '90 s. *Cell*, 81(4), 483–493. https://doi.org/10.1016/0092-8674(95)90069-1

Weller, D. L. M. (1977). Observations on the diet and development of *Pseudoboeckella poppei* (Calanoida, Centropagidae) from an Antarctic lake. *British Antarctic Survey Bulletin*, 45, 77–92.

Received: 19 May 2021
Accepted: 9 July 2021

В. Трохимець[1], В. Горобчишин[1, 2, *], І. Козерецька[3]

[1] Київський національний університет імені Тараса Шевченка, м. Київ, 01601, Україна
[2] Державна установа Інститут еволюційної екології НАН України, м. Київ, 03143, Україна
[3] Державна установа Національний антарктичний науковий центр, Міністерство освіти і науки України, м. Київ, 01601, Україна

*** Автор для кореспонденції:** medziboz@yahoo.com

Особливості популяції *Boeckella poppei* озера Вуйка, острів Кінг Джордж

Реферат. Прибережна Антарктика — один із найцікавіших регіонів нашої планети, в якому спостерігаються швидкі кліматичні зміни, підвищуючи вразливість усіх компонентів її збідненої флори. *Boeckella poppei* широко розповсюджена у прибережній та континентальній Антарктиці. Метою даної роботи було дослідити, чи існують тенденції у зміні щільності популяцій ракоподібних у літній сезон в даному регіоні. Зразки відібрані 23.12.2005, 03.01.2006 та 10.01.2006 біля о. Кінг Джордж, з озера Вуйка поблизу Польської антарктичної станції. Варіювання щільності популяції супроводжувалося значними коливаннями у співвідношенні різних ювенільних та генеративних стадій копепод. Проаналізовано закономірності попередніх досліджень інших авторів. Статева структура популяції не змінилася протягом періоду вивчення, самиці значно переважали самців. В роботі обговорюються можливі причини даного явища.

Ключові слова: щільність популяції, статева структура, Calanoida, ракоподібні, Антарктика