УДК 595.341.1(262.5):574.625

SEASONAL AND INTERANNUAL DYNAMICS OF THE ABUNDANCE OF THE BLACK SEA ALIEN SPECIES *PSEUDODIAPTOMUS MARINUS* SATO, 1913 (COPEPODA, CALANOIDA, PSEUDODIAPTOMIDAE) IN THE CRIMEAN COASTAL WATERS: INFLUENCE OF THE TEMPERATURE FACTOR

© 2022 Seregin S., Popova E.

A. O. Kovalevsky Institute of Biology of the Southern Seas of RAS, Sevastopol 299011
e-mail: serg-seryogin@yandex.ru; el-popova@yandex.ru

Received November 22, 2021; revised September 4, 2022; accepted November 18, 2022

Observation on the occurrence of the Black Sea alien species *Pseudodiaptomus marinus* were initiated since this species was reported in the coastal waters of Crimea, in 2016. Current study is focused on the 170-500 µm microplankton fraction represented by nauplii and the first copepodite stages. These data were complemented by the mesoplankton fraction abundance contributed by copepodite stages II–V and adults. Samples were collected by plastic bottles at the sea surface and by Juday and Apstein plankton nets in the upper 10 m layer. Nauplial stages of *P. marinus* were observed during the first three years after species invasion, in September, at the sea surface temperature range from 21.1 to 25.5 °C. From 2019 to 2020, specimens appeared in July, at temperatures from 25.8 to 26.0 °C. The presence of specimens in samples has been observed by the end of November or December, at sea surface temperature of 13.1 or 8.6 °C, respectively. The maximal abundance was observed in the inner part of the Sevastopol Bay. The correlation value of 0.7-0.9 was estimated between the abundance and sea surface temperature throughout the year. Inter-annual variations of the abundance were associated with an integrative indicator of temperature (in particular, the sum of active temperatures).

Key words: alien species, *Pseudodiaptomus marinus*, abundance, seasonal and inter-annual dynamics, temperature, Black Sea.

DOI: 10.35885/1996-1499-15-4-106-107

Full text of the paper is published in Russian Journal of Biological Invasions. DOI: 10.31857/S207511172104XXXYYY

References

Altukhov, D.A., Gubanova, A.D., Mukhanov, V.S., 2014. New invasive copepod *Oithona davisae* Ferrari and Orsi, 1984: seasonal dynamics in Sevastopol Bay and expansion along the Black Sea coasts. Marine Ecology, 35(1), 28–34.

Budyko, M.I., 1978. Heat balance of the Earth. Hydrometeoizdat, Leningrad, 46 pp. [Budy`ko, M.I., 1978. Teplovoj balans Zemli. Gidrometeoizdat, Leningrad, 46 s.(In Rus.)].

Deschutter, Y., Vergara, G., Mortelmans, J., Deneudt, K., De Schamphelaere, K., De Troch, M., 2018. Distribution of the invasive calanoid copepod *Pseudodiaptomus marinus* (Sato, 1913) in the Belgian part of the North Sea. Bio Invasions Records, 7(1), 33–41.

Garbazey, O.A., Popova, E.V., Gubanova, A.D., Altukhov, D.A., 2016. First Record of the Occurence of *Pseudodiaptomus marinus* (Copepoda: Calanoida: Pseudodiaptomidae) in the Black Sea (Sevastopol Bay). Marine Biological Journal, 1(4), 78–80.

Gubanova, A., Drapun, I., Garbazey, O., Krivenko, O., Vodiasova, E., 2020. *Pseudodiaptomus marinus* Sato, 1913 in the Black Sea: morphology, genetic analysis, and variability in seasonal and interannual abundance. Peer Journal. Iss. 8. Article no. e10153, 26 pp. DOI: 10.7717/peerj.10153

Huang, Y., Zhu, L., Liu, G., 2006. The effects of bis(tributiltyn) oxide on the development, reproduction and sex ratio of calanoid copepod *Pseudodiaptomus marinus*. Estuarine,Coastal and Shelf Sci*ence*, 69, 147–152.

Ivanov, V.A., Ovsyany, E.I., Repetin, L.N., Romanov, A.S., Ignatyeva, O.G., 2006. Hydrological and hydrochemical regime of the Sebastopol Bay and its changing under influence of climatic and anthropogenic factors. MHI NAS of Ukraine, Sevastopol, 90 pp. [Ivanov, V.A., Ovsyany`j, E.I., Repetin, L.N., Romanov, A.S., Ignat`eva, O.G., 2006. Gidrologo-gidroximicheskij rezhim Sevastopol`skoj buxty` i ego izmeneniya pod vozdejstviem klimaticheskix i antropogenny`x faktorov. MGI NAN Ukrainy`, Sevastopol`, 90 s. (in Rus.)].

Jha, U., Jetter, A., Lindley, J.A., Postel, L., Wootton, M.,2013. Extension of distribution of *Pseudodiaptomus marinus*, an introduced copepod, in the North Sea. Marine Biodiversity Records, 6: e53. https://doi.org/10.1017/S1755267213000286.

Lee, D.B., Song, H.Y., Park, C., Choi, K.H., 2012. Copepod feeding in a coastal area of active tidal mixing: Diel and monthly variations of grazing impacts on phytoplankton biomass. Marine Ecology, 33(1), 88–105.

Liang, D., Uye, S.,1997. Population dynamics and production of the planktonic copepods in a eutrophic inlet of the Inland Sea of Japan. IV. *Pseudodiaptomus marinus*, the egg-carrying calanoid. Marine Biology,128, 415–421.

Lučić, D., Mozetič, P., Francé, J., Lučić, P., Lipej, L., 2015. Additional record of the non-indigenous copepod *Pseudodiaptomus marinus* (Sato, 1913) in the Adriatic Sea. Acta Adriatica, 56, 275–282.

Rajakaruna, H., Strasser, C., Lewis, M., 2012. Identifying non-invasible habitats for marine copepods using temperature-dependent R0. *Biological Invasions*, 14, 633–647.

Rajakaruna, H., Lewis, M., 2017. Temperature cycles affect colonization potential of calanoid copepods. Journal of Theoretical Biology, 419, 77–89.

Sabia, L., Zagami, G., Mazzocchi, M.G., Zambianchi, E., Uttieri, M., 2015. Spreading factors of a globally invading coastal copepod. Mediterranean Marine Science, 16, 460–471.

Salvacion, M., Golez, N., Takahashi, T., Ishimaru, T., Ohno, A., 2004. Post-embryonic development and reproduction of *Pseudodiaptomus annandalei* (Copepoda: Calanoida). Plankton Biology and Ecology, 51(1), 15–25.

Sazhina L.I., 1985.Nauplii of mass species of pelagic copepods of the world ocean. Kiev,Naukova dumka, 238 pp. [Sazhina L.I. Naupliusy` massovy`x vidov pelagicheskix copepod mirovogo okeana. Kiev: Naukova dumka, 1985. 238 p. (in Rus).].

Seregin, S.A., Popova, E.V., 2016. Long-term dynamics of abundance of the copepod-invader, *Oithona davisae*, in the coastal waters of the Black Sea. Russian Journal of Biological Invasions, 7(4), 374–382.

Seregin, S.A., Popova, E.V., 2019. Different-Scale Variations in the Abundance and Species Diversity of Metazoan Microzooplankton in the Coastal Zone of the Black Sea. Water Resources, 46(5), 769–779.

Seregin, S., Popova, E., 2020. *Pseudodiaptomus marinus* Sato, 1913 – a New Species of Invasive Copepod in the Black Sea: The First Results of Invasion. Russian Journal of Biological Invasions, 11(2), 143–147.

Seregin, S., Popova, E., in press. Abundance, species diversity and structure of the metazoan microzooplankton community in the bay - seaside gradient (on the example of the Sevastopol Bay). Marine Biology Journal. [Seregin, S.A., Popova, E.V., in press. Obilie, vidovoe raznoobrazie I struktura soobshhestva metazojnogo mikrozooplanktona v gradiente buxta – vzmor`e (na primere Sevastopol`skoj buxty`). Morskoj biologicheskij zhurnal. (in Rus.)].

Sorokin, Yu.I., Kopylov, A.I., Mamaeva, N.V., 1985. Abundance and dynamics of microplankton in the central tropical Indian Ocean. Marine Ecology Progress Series, 24, 27–41.

Sovga, E.E., Mezentseva, I.V., Slepchuk, K.A., 2020. Comparison of assimilative capacity and trophic index for various parts of the Sevastopol Bay water area. Ecological Safety of Coastal and Shelf Zones of Sea, 3, 63–76. [Sovga, E.E., Mezenceva, I.V., Slepchuk, K.A., 2020. Sravnenie assimilyacionnoj emkosti I indeksa trofnosti razlichny`x chastej akvatorii Sevastopol`skoj buxty`. E`kologicheskaya bezopasnost` pribrezhnoj i shel`fovoj zon morya, 3, 63–76. (in Rus.)]. https://doi.org/ 10.22449/2413-5577-2020-3-63-7.

Svetlichny, L., Hubareva, E., Khanaychenko,A., Uttieri, M., 2019. Response to salinity and temperature changes in the alien Asian copepod *Pseudodiaptomus marinus* introduced in the Black Sea. Journal of Experimental Zoology, 331,416-426.https://doi.org/10.1002/jez.2309.

Tachibana, A., Ishimaru, T., Itoh, H., Yoshida, Y.,2013. Seasonal and annual change in community structure of meso-sized copepods in Tokyo Bay, Japan. Journal of Oceanography, 69, 545-556.

Temnykh, A.V., Tokarev, Yu.N., Mel`nikov, V.V., Zagorodnyaya, Yu.A., 2012. Diurnal dynamics and vertical distribution of pelagic Copepoda in open waters of southwestern Crimea (Black Sea) in autumn 2010. Marine Ecology Journal, 11(2), 75-84. [Temny`x, A.V., Tokarev, Yu.N., Mel`nikov, V.V., Zagorodnyaya, Yu.A.,2012. Sutochnaya dinamika I vertikal`noe raspredelenie pelagicheskix Copepoda v otkry`ty`x vodax u yugo-zapadnogo Kry`ma (Chernoe more) osen`yu 2010 g. Morskoj e`kologicheski jzhurnal, 11(2), 75–84. (In Rus.)].

Tlili S., Ovaert J., Souissi A., Ouddane B., Souissi S., 2016. Acute toxicity, uptake and accumulation kinetics of nickel in an invasive copepod species: *Pseudodiaptomus marinus*. Chemosphere, 144, 1729–1737.

Uriarte, I., Villate, F., Iriarte, A., 2016. Zooplankton recolonization of the inner estuary of Bilbao: influence of pollution abatement, climate and non-indigenous species. Journal of Plankton Research, 38(3), 718–731. doi:10.1093plankt/fb060.

Uttieri, M., Aguzzi, L., Aiese Cigliano, R., Amato, A., Bojanić, N., Brunetta, M., Camatti, E., Carotenuto,Y., Damjanović, T., Delpy, F. +29 more., 2020. WGEUROBUS – Working Group "Towards a European Observatory of the non-indigenous calanoid copepod *Pseudodiaptomus marinus".* Biological Invasions, 22, 885–906.

Uye, S., Iway, Y., Kasahara, S., 1982. Reproductive biology of Pseudodiaptomus marinus (Copepoda: Calanoida) in the Inland Sea of Japan. Bulletin of the Plankton Society of Japan, 29(1), 25–35.

Uye, S., Iwai, Y., Kasahara, S.,1983. Growth and production of the inshore marine copepod *Pseudodiaptomus marinus* in the central part of the Inland Sea of Japan. Marine Biology, 73, 91–98.