

TWO LIFE STRATEGIES IN COPEPOD CRYPTIC SPECIES: COEXISTENCE AND DISPLACEMENT

Sukhikh N., Alekseev V.*

Zoological Institute of the RAS, 1 Universitetskaya Embankment, Saint-Petersburg, 199034, Russia
e-mail: *valekseev2@yahoo.com

Received 30 June 2022; revised June 17, 2023; accepted 31 August, 2023

Among invasive species there is a special group so named cryptic species for which morphological identification is very difficult. This review is devoted to analysis of the dispersal routes of two copepod cryptic species complexes into aquatic ecosystems. *Eurytemora carolleeae* introduction was revealed in 2007 with bar-code. The species was described as a new taxon; its distribution was also studied using morphology. Biological invasions of two other Copepod species *Acanthocyclops americanus* and *Eurytemora caspica* were mainly studied using morphological methods since the species have already been described. At the same time, to confirm their distinctions from local forms, molecular genetic tools were also used. Two scenarios resulting from cryptic species' invasions and their competitions with native species were the partly (*E. carolleeae*) or full displacement (*A. americanus*). Example: the invasion of *Eurytemora carolleeae* into the Baltic Sea and the Atlantic coast of Europe. When assessing the possible negative impact of invasive species on competitors, the most attention should be paid to predator species. Identification of cryptic species significantly complicates the situation with the assessment of bioinvasion and needs the use of molecular methods.

Key words: aquatic, invasion, biotic interaction, life cycle, ship transportation, aquatic birds dispersal, Copepoda, *Acanthocyclops*, *Eurytemora*
DOI: 10.35885/1996-1499-16-3-196-199

Full text of the paper is published in Russian Journal of Biological Invasions. DOI: 10.31857/S207511172104XXXXYY

References

- Abramova, E., Vishnyakova, I., Boike, J., Abramova, A., Solovyev, G., and Martynov, F., Structure of freshwater zooplankton communities from tundra waterbodies in the Lena River Delta, Russian Arctic, with a discussion on new records of glacial relict copepods, *Polar Biol.*, 2017, vol. 40, no.8, pp. 1629–1643. DOI: 10.1007/s00300-017-2087-2
- Ackerman, J.D., Sim, B., Nichols, S.J., and Claudi, R.M., A review of the early life history of zebra mussels (*Dreissena polymorpha*): comparisons with marine bivalves *Can. J. Zool.*, 1994, vol. 72, pp. 1169–1179
- Alekseev, V.R., Growth, development and production of mass species of cyclops in the hollow system of the Volga delta: dissertation, *Cand. Sci. Biol.*, Leningrad, 1981, 245 p.
- Alekseev, V.R., Key to freshwater invertebrates of Russia and adjacent lands. Vol. 2: Crustacea, Suborder Cyclopoida; Suborder Harpacticoida., St. Petersburg: Zoologicheskii Institut, Rossiiskoi Akademii Nauk, 1995, pp. 75-128. (in Russian.)
- Alekseev, V.R., Key to freshwater Cyclopidae of Russia and adjacent lands (Crustacea), *Zoosyst. Ross.*, 1998, vol. 7, pp. 25–43.
- Alekseev, V. R., Confusing Invader: *Acanthocyclops americanus* (Copepoda: Cyclopoida) and Its Biological, Anthropogenic and Climate-Dependent Mechanisms of Rapid Distribution in Eurasia, *Water*, 2021, vol. 13, no.10, pp. 1423. DOI: 10.3390/w13101423
- Alekseev, V.R., Abramson, N.I. and Sukhikh, N.M., Introduction of sibling species to the ecosystem of the Baltic Sea. *Dokl. Biol. Sci.* 2009, vol. 429, no. 5, pp. 694–697.
- Alekseev, V. R., and Kossova, A. A., Finding of *Acanthocyclops americanus* (Copepoda) in the delta of the Volga River, *J. Zool.*, 1976, vol. 5511, pp. 1726–1728.
- Alekseev, V., and Souissi, A., A new species within the *Eurytemora affinis* complex (Copepoda: Calanoida) from the Atlantic Coast of USA, with observations on eight morphologically different European populations, *Zootaxa*, 2011, vol. 2767, pp. 41–56.
- Alekseev, V., Makrushin, A., and Jiang-Shiou, H., Survivorship of activated resting stages in toxic environments: provide treatment cues for ballast water, *Mar. Pol. Bul.*, 2010, vol.61, pp.254–258.
- Alekseev, V.R., Miracle, M.R., Sahuquillo, M., and Vicente, E., Redescription of *Acanthocyclops vernalis* (Fischer, 1853) and *Acanthocyclops robustus* (Sars, 1863) from neotypes, with special reference to their distinction from *Acanthocyclops americanus* (Marsh, 1892) and its invasion of Eurasia, *Limnetica*, 2020, vol. 40, pp. 57–78.
- Alekseev, V.R., Fefilova, and E., Dumont, H.J., Some noteworthy free-living copepods from surface freshwater in Belgium. *Belg. J. Zool.* 2002, vol. 132, pp. 133–139.
- Alekseev V.R., and Pugachev V.A. 1978. Some peculiarities of food relationships between *Acanthocyclops americanus* (March.) and phyllopod nauplii, in: Study of aquatic invertebrates' behaviour in natural condi-

- tions, Abstracts of the III All-Union Symposium on the behaviour of aquatic invertebrates. Borok, pp. 3–4. (In Russian)
- Alekseev, V.R., and Sukhikh, N.M., Ust-Luga Seaport of Russia: Biological Invasions and Resting Stages Accumulation, *Life*, 2023, vol. 13, no.1, pp. 117. <https://doi.org/10.3390/life13010117>
- Anufriieva E., Hołyńska M., and Shadrin N., Current invasions of Asian Cyclopoid species (Copepoda: Cyclopidae) in Crimea, with taxonomical and zoogeographical remarks on the hypersaline and freshwater fauna, *An.Zool.*, 2014, vol. 64, no.1, pp. 109-130. DOI: 10.3161/000345414X680636
- Arnold, J.D., and Yue, H.S., Prevalence, relative abundance, and mean intensity of plerocercoids of *Proteocephalus* sp. in young striped bass in the Sacramento-San Joaquin estuary, *California Fish Game*, 1997, vol. 83, no.3, pp. 105–117.
- Beasley, D. E., Bonisoli-Alquati A., and Mousseau T. A., The use of fluctuating asymmetry as a measure of environmentally induced developmental instability: a meta-analysis, *Ecol. Ind.*, 2013, vol. 30, pp. 218–226. DOI: 10.1016/j.ecolind.2013.02.024
- Beyrend-Dur, D., Souissi, S., Devreker, D., Winkler, G., and Hwang, J.S. Life cycle traits of two transatlantic populations of *Eurytemora affinis* (Copepoda: Calanoida): salinity effects, *J. Plankton Res.*, 2009, vol. 31, no. 7, pp. 713–728. DOI: 10.1093/plankt/fbp020
- Carlton, J.T., Biological invasions and cryptogenic species, *Ecology*, 1996, vol. 77, pp. 1653–1655. DOI: 10.2307/2265767
- Chuykov, Y.S., Fauna Planktonnykh Bespozvonochnykh Vodoyemov Severnogo Prikaspiya i Kaspiya, in *Gidrobiologicheskkiye Issledovaniya Estuariyev*, St. Petersburg: Zoological Institute of Russian Academy of Sciences, 1986, pp. 58–74. (In Russian)
- Colwell, R.R., Infectious disease and environment: cholera as a paradigm for waterborne disease, *Int. Microbiol.*, 2004, vol. 7, pp. 285–289.
- Declerck, S.A., Malo, A.R., Diehl, S. et al. Rapid adaptation of herbivore consumers to nutrient limitation: eco-evolutionary feedbacks to population demography and resource control. *Ecology Letters*, 2015, vol. 18, pp. 553-562 DOI: 10.1111/ele.12436
- Devreker, D., Pierson, J., Souissi, S., Kimmel, D., and Roman, M., An experimental approach to estimate egg production and development rate of the Calanoid copepod *Eurytemora affinis* in Chesapeake Bay, USA, *J. Exp. Mar. Bio. Ecol.*, 2012, vol. 416–417, pp. 72–83. DOI: 10.1016/j.jembe.2012.02.010
- Devreker, D., Souissi, S., Molinero, J.C., Beyrend-Dur, D., Gomez, F., and Forget-Leray, J., Tidal and annual variability of the population structure of *Eurytemora affinis* in the middle part of the Seine estuary during 2005, *Estuar. Coast. Shelf. Sci.*, 2010, vol. 89, no.4, pp. 245–255. DOI: 10.1016/j.ecss.2010.07.010
- Devreker, D., Souissi, S., Molinero, J.C., and Nkubito, F., Trade-offs of the copepod *Eurytemora affinis* in mega-tidal estuaries. Insights of high frequency sampling in the Seine estuary, *J. Plankton Res.*, 2008, 30, pp. 1329–1342. DOI: 10.1093/plankt/fbn086
- Dodson S.I., Skelly D.A., and Lee C.E., Out of Alaska: Morphological evolution and diversity within the genus *Eurytemora* from its ancestral range (Crustacea, Copepoda), *Hydrobiologia*, 2010, vol. 653, pp. 131–148.
- Dur, G., Souissi, S., Devreker, D., Ginot, V., Schmitt, F.G., and Hwang, J.S., An individual based model to study the reproduction of egg bearing copepods: application to *Eurytemora affinis* (Copepoda; Calanoida) from the Seine estuary, *Ecol. Model.*, 2009, vol. 8, pp. 1073–1089. DOI: 10.1016/j.ecolmodel.2008.12.013
- Dussart, B.H., Contribution à l'étude des Copépodes d'Espagne. *Publicaciones del Instituto de Biología Aplicada*, Barcelona, 1967, vol. 42, pp. 87-105. (in French)
- Dussart, B.H. *Acanthocyclops americanus* en France. *Bulletin du Muséum National d'Histoire Naturelle*, 1971, vol. 42, pp. 725–729.
- Gelembiuk, G.W., May, G.E., and Lee, C.E., Phylogeography and systematics of zebra mussels and related species, *Mol. Ecol.*, 2006, vol. 15, pp. 1033–1050. DOI: 10.1111/j.1365-294X.2006.02816.x
- Geller, J.B., Darling, J.A., and Carlton, J.T., Genetic perspectives on marine biological invasions, *An. R. Mar. Sci.*, 2010, vol. 2, pp. 401–427. DOI: 10.1146/annurev.marine.010908.163745
- Goedknecht, M.A., Thielges, D.W., van der Meer, J., Wegner, K.M., and Luttikhuisen, P.C., Cryptic invasion of a parasitic copepod: Compromised identification when morphologically similar invaders co-occur in invaded ecosystems, *PLoS ONE*, 2018, vol. 13, no.3, e0193354. <https://doi.org/10.1371/journal.pone.0193354>
- Gollasch, S., MacDonald, E., Belson, S., Botnen, H., Christensen, J.T., Hamer, J.P., Houvenaghel, G., Jermert, A., Lucas, I., Masson, D., et al., Distribution, impacts and management. Life in ballast tanks, in *Invasive aquatic species of Europe*, Leppäkoski, E., Olenin, S., and Gollasch, S., Eds., Dordrecht: Springer, 2002. pp. 217–231.
- Grabowski M., Rewicz T., Bacela-Spychalska K. et al. 2012. Cryptic invasion of Baltic lowlands by freshwater amphipod of Pontic origin. *Aquatic Invas.*, vol. 7, no.3, pp. 337–346. DOI: 10.3391/ai.2012.7.3.005
- Gurney, R., *British fresh-water copepod*, London: Ray Society, 1931, vol. 1, pp. 238
- Hirche, H-J., Egg production of *Eurytemora affinis*-Effect of k-strategy, *Estuar. Coast. Shelf. Sc.*, 1992, vol. 35, pp. 395–407. DOI: 10.1016/S0272-7714(05)80035-6
- weatherarchive.ru/Sea/Ust-luga/July. (Electronic resource) // (<http://weatherarchive.ru>). Accessed 27.02.2023.
- [wiki/ 2010_Northern_Hemisphere_summer_heat_waves](https://en.wikipedia.org/wiki/2010_Northern_Hemisphere_summer_heat_waves). (Electronic resource) // (<https://en.wikipedia.org>). Accessed 27.02.2023.
- Hutchinson, G. E., The paradox of the plankton, *Amer. Nat.*, 1961, vol. 95, pp. 137–145.
- Ishida, S., and Taylor D.J., Quaternary diversification in a sexual Holarctic zooplankter, *Daphnia galeata*, *Mol. Ecol.*, 2007, vol. 16, pp. 569-582. DOI: 10.1111/j.1365-294X.2006.03160.x
- Jarić, I., Heger, T., Castro Monzon, F., Jeschke, J.M., Kowarik, I., McConkey, K.R., Pyšek, P., Sagouis, A., and

- Essl, F., Crypticity in Biological Invasions, Trends in Ecology & Evolution, 2019, vol. 34, no.4, pp.291–302. DOI: 10.1016/j.tree.2018.12.008
- Kamburska, L., Schrimpf, W., Djavidnia, S., Shiganova, T., and Stefanova, K., Special Focus on the Ctenophore *Mnemiopsis leidyi* (Agassiz, 1865) in the Black Sea. EC JRC Institute of Environment and Sustainability, EUR 22310 EN, 2006, p. 59.
- Kiefer, F., Freilebende, Copepoda, in Die Binnengewässer Einzeldarstellungen aus der Limnologie und ihren Nachbargebieten. Das Zooplankton der Binnengewässer, 2. Teil, Elster, H.J., and Ohle, W., Eds., Stuttgart: Schweizerbart'sche Verlagsbuchhandlung, 1978. (In German)
- Kimmel, D.G., Miller, W. D., and Roman, M.R. Regional scale climate forcing of mesozooplankton dynamics in Chesapeake Bay. Estuar. Coast. 2006, vol. 29, no. 3, pp. 375–387. DOI: 10.1007/BF02784987
- Knatz, G. Succession of copepod species in a middle Atlantic estuary, Estuaries, 1978, vol. 1, pp. 68–71.
- Knowlton, N., Sibling species in the sea, Annu Rev Ecol System., 1993, vol. 24, pp. 189–216. DOI: 10.1146/annurev.es.24.110193.001201
- Kotov, A.A, Garibian, P.G., Bekker, E.I., Taylor, D.J., and Karabanov, D.P., A new species group from the *Daphnia curvirostris* species complex (Cladocera: Anomopoda) from the eastern Palaearctic: taxonomy, phylogeny and phylogeography, Zool. J. Lin. Soc., 2020. <https://doi.org/10.1093/zoolinnean/zlaa046>
- Kruppa, E. G., The ecological preferences of *Eurytemora affinis* (Poppe, 1880) in the water bodies of Kazakhstan (Central Asia) and some notes about *Eurytemora caspica* Sukhikh & Alekseev, 2013, Crustaceana, 2020, vol. 93, nos.3-5, pp. 405-428. DOI: 10.1163/15685403-00003967
- Kruppa, E.G., On the Morphological Deviations of *Acanthocyclops americanus* Marsh and *Cyclops vicinus* Uljanin (Crustacea, Copepoda) from the Polluted Water Bodies of Almaty Region (Southeastern Kazakhstan), Russ. J. Aquat. Ecol., 1998, vol. 7, pp. 11–16.
- Lajus, D., Sukhikh, N., and Alekseev, V., Cryptic or pseudo-cryptic: can morphological methods inform copepod taxonomy? An analysis of publications and a case study of the *Eurytemora affinis* species complex, Ecol. Evol., 2015, vol. 5, no.12, pp. 2374-2385. DOI: 10.1002/ece3.1521
- Lajus, D., Sukhikh, N., and Alekseev, V., Stochastic phenotypic variation: empirical results and potential use in *Eurytemora* research (Copepoda, Calanoida). Crustaceana, 2020, vol. 93, pp.317–336, <https://doi.org/10.1163/15685403-00003983>
- Lazareva, V. I., Distribution of *Eurytemora caspica* Sukhikh & Alekseev, 2013 (Copepoda, Calanoida) in the water reservoirs of the Volga and Don River basins. Crustaceana, 2020, vol. 93(3-5), pp. 261–273. DOI: 10.1163/15685403-00003982
- Lazareva, V.I., Current State and Long-Term Dynamics of Zooplankton of the Tsimlyansk Reservoir (Don River, Russia). Arid Ecosystems, 2021, vol. 11, no.2, pp. 213–219. DOI: 10.1134/S2079096121020098
- Lazareva, V.I., Sabitova, R.Z., and Sokolova, E.A., Features of structure and distribution of late summer (August) zooplankton in the Volga reservoirs, Tr. Inst. Biol. Vnutr. Vod, Ross. Akad. Nauk, 2018, no. 82 (85), pp. 28–51. DOI: 10.24411/0320-3557-2018-1-0011
- Lee C.E., Rapid and repeated invasions of fresh water by the copepod *Eurytemora affinis*, Evolution, 1999, vol. 53, 1423–1434. DOI: 10.2307/2640889
- Lee, C.E., Global phylogeography of a cryptic copepod species complex and reproductive isolation between genetically proximate populations, Evolution, 2000, vol. 54, pp. 2014–2027. DOI: 10.1111/j.0014-3820.2000.tb01245.x
- Lee, C.E., and Frost, B.W., Morphological stasis in the *Eurytemora affinis* species complex (Copepoda: Temoridae). Hydrobiologia 2002, vol. 480, pp. 111–128.
- Lee, C.E., Remfert, J.L., and Chang, Y. Response to selection and evolvability of invasive species, Genetica, 2007, vol. 129, no.2, 179–192. DOI: 10.1007/s10709-006-9013-9
- Lloyd, S., Elliott, D., and Roman, M., Egg production by the copepod, *Eurytemora affinis*, in Chesapeake Bay turbidity maximum regions, J. Plankton. Res., 2013, vol. 35, no.2, pp. 299. DOI: 10.1093/plankt/fbt003
- Lowndes, A.G., On *Cyclops americanus*, Marsh, Ann. Mag. Nat. Hist., 1926, vol. 17, pp. 616-619. DOI: 10.1080/00222932608633452
- Lowndes, A.G. *Cyclops americanus* Marsh. A discussion and description of its specific characteristics and its occurrence in Europe, Int. Rev. Ges. Hydrobiol., 1928, vol. 19, pp. 12-20. DOI: 10.1002/iroh.19280190103
- Lowndes, A.G. *Eurytemora thompsoni*, A. Willey, a new European record, Ann.Mag.nat.Hist., 1931, vol. 8, pp. 501-507.
- Mergeay, J., Verschuren D., and de Meester L., Cryptic invasion and dispersal of an American *Daphnia* in East Africa, Limnol. Oceanogr., 2005, vol. 50, pp. 1278–1283. DOI: 10.4319/lo.2005.50.4.1278
- Mirabdullayev, I.M., and Defaye, D., On the taxonomy of the *Acanthocyclops robustus* species complex (Copepoda, Cyclopidae): *Acanthocyclops brevispinosus* and *A. einslei* sp. n., Vestnik Zoologii, 2004, pp. 38, 27–37.
- Mirabdullayev, I.M., and Defaye, D., On the taxonomy of the *Acanthocyclops robustus* species complex (Copepoda, Cyclopidae). *Acanthocyclops robustus* (G.O. Sars, 1863) and *Acanthocyclops trajani* n. sp., Selevinia, 2002, vol. 1–4, pp. 7–20.
- Miracle, M.R., Alekseev, V., Monchenko, V., Sentandreu, V., and Vicente, E., Molecular-genetic based contribution to the taxonomy of the *Acanthocyclops robustus* group, J. Nat. Hist., 2013, vol. 47, 863–888. DOI: 10.1080/00222933.2012.744432
- Miura, O., Molecular genetic approaches to elucidate the ecological and evolutionary issues associated with biological invasions, Ecol. Res., 2007, vol. 22, pp. 876–83. DOI: 10.1007/s11284-007-0389-5
- Monakov, A.V., Feeding of Freshwater Invertebrates, Ghent: Kenobi Publications, 2003. 373 pp.
- Monchenko, V.I. Shchepnoroti tsyklopodibni, tsyklopy (Cyclopidae) [Gnathostome cyclopoids (Cyclopidae)]. Kiev, Ukraine: Naukova Dumka. 1974. (in Ukrainian)

- Monchenko, V. I., On species independence of *Acanthocyclops americanus* (Marsh) and on its finding in the Soviet Union, Zool. zhurnal, 1961, vol. 40, pp. 13–19. (In Russian)
- Morais, P., and Reichard, M., Cryptic invasions: a review, Sci. Total Environ., 2017, vol. 613, pp. 1438–1448. DOI: 10.1016/j.scitotenv.2017.06.133
- Novak, S.J. Geographic origins and introduction dynamics. In Encyclopedia of Biological Invasions, Simberloff, D, Rejmánek, M., Eds., University of California Press: Berkeley and Los Angeles, USA, 2011, pp. 273–280.
- Panov, V., and Caceres, C., Role of Diapause in Dispersal of Aquatic Invertebrates. Diapause in Aquatic Invertebrates Theory and Human Use. Springer: Springer: Dordrecht, Netherlands, 2007, pp. 187–195. DOI: 10.1007/978-1-4020-5680-2_12
- Papakostas, S., Michaloudi, E., Proios, K. et al., Integrative taxonomy recognises evolutionary units despite widespread mitonuclear discordance: Evidence from a rotifer cryptic species complex, Syst. Biol., 2016, vol. 65, pp. 508–524. DOI: 10.1093/sysbio/syw016
- Piasecki, W., Goodwin, A.E., Eiras, J.C., and Nowak, B.F., Importance of copepod in freshwater aquaculture, Zool. Stud. 2004, vol. 43, no.2, pp. 193–205.
- Pierson, J.J., Kimmel, D.G., and Roman, M.R., Temperature impacts on *Eurytemora carolleeae* size and vital rates in the upper Chesapeake Bay in winter, Estuar. Coast. 2016, vol. 39, no. 4, 1122–1132. DOI: 10.1007/s12237-015-0063-z
- Roman, J., Diluting the founder effect: cryptic invasions expand a marine invader's range, Proc. R. Soc. B, 2006, vol. 273, pp. 2453–2459 doi:10.1098/rspb.2006.3597
- Samchishina, L.V., Ecological–faunistic and morphological aspects of the study of freshwater and brackish-water Calanoida (Crustacea, Copepoda) of Ukraine, Cand Sci. (Biol.) Dissert., Kiev. Inst. Zool. im. I.I. Shmal'gauzena, Natl. Acad. Sci. Ukraine, 2005.
- Sharma, P. and Kotov, A.A., Establishment of *Chydorus sphaericus* (O.F. Muller, 1785) (Crustacea: Cladocera) in Australia: consequences of mass fish stocking from Northern Europe? J. Limnol., 2015, vol. 74, pp. 225–233. DOI: 10.4081/jlimnol.2014.1037
- Śługocki, Ł., Rymaszewska, A., and Kirczuk, L., To fit or to belong: Characterization of the non-native invader *Eurytemora carolleeae* (Copepoda: Calanoida) in the Oder River system (Central Europe), Aquat. Invasions, 2021, vol. 16, no.3, pp. 443–460. DOI: 10.3391/ai.2021.16.3.04
- Sukhikh, N., Abramova, E., Holl, A.C., Souissi, S., and Alekseev, V., A comparative analysis of genetic differentiation of the *E. affinis* species complex and some other *Eurytemora* species, using CO1, ITSn and 18SrRNA genes (Copepoda, Calanoida), Crustaceana, 2020a, vol. 93, pp. 931–955. DOI: 10.1163/15685403-bja10074
- Sukhikh, N.M., and Alekseev, V.R., *Eurytemora caspica* sp.nov. from the Caspian Sea — one more new species within the *E. affinis* complex (Copepoda: Calanoida), Proc. Zool. Inst. RAS, 2013, vol. 317, no.1, pp. 85–100. DOI: 10.31610/trudyzin/2013.317.1.85
- Sukhikh, N.M., Lazareva, V.I., and Alekseev, V.R., Copepod *Eurytemora caspica* Sukhikh et Alekseev, 2013 (Crustacea, Calanoida) in Volga and Kama River Reservoirs, In. Water Biol., 2020b, vol. 13, pp. 198–205, <https://doi.org/10.1134/S1995082920020145>
- Sukhikh, N.M., Souissi, A., Souissi, S., and Alekseev, V.R., Invasion of *Eurytemora* sibling species (Copepoda: Temoridae) from North America into the Baltic Sea and European Atlantic coast estuaries, J. Nat. Hist., 2013, vol. 47, nos. 5–12, pp.753–767. DOI: 10.1080/00222933.2012.716865
- Sukhikh, N.M., Souissi, A., Souissi, S., Holl, A. C., Schizas, N.V., and Alekseev V., Life in sympatry: coexistence of native *Eurytemora affinis* and invasive *Eurytemora carolleeae* in the Gulf of Finland (Baltic Sea), Oceanologia, 2019, vol. 61, pp. 227–238. DOI:10.1016/j.oceano.2018.11.002.
- Sukhikh, N.M., Souissi, A., Souissi, S., Winkler, G., Castric, V., Holl, A. C., and Alekseev, V.R., Genetic and morphological heterogeneity among populations of *Eurytemora affinis* (Crustacea: Copepoda: Temoridae) in European waters, C.R. Biol., 2016, vol. 339, pp. 197–206. DOI: 10.1016/j.crv.2016.03.004
- Taylor, D.J., Connelly, S.J., and Kotov, A.A., The Intercontinental phylogeography of neustonic daphniids, Sc. Rep., 2020, vol. 10, pp. 1818. DOI: 10.1038/s41598-020-58743-8
- Uitto, A., Gorokhova, E., and Valipakka, P., Distribution of the nonindigenous *Cercopagis pengoi* in the coastal waters of the eastern Gulf of Finland, ICES J. Mar. Sci., 1999, vol. 56 (Suppl.), pp. 49–57, <http://dx.doi.org/10.1006/jmsc.1999.0613>.
- Vasquez, A.A., Hudson, P.L., Fujimoto, M., Keeler, K., Armenio, P.M., and Ram, J.L., *Eurytemora carolleeae* in the Laurentian Great Lakes revealed by phylogenetic and morphological analysis. J. Great. Lakes. Res., 2016, vol. 42, no.4, pp. 802–811. doi: 10.1016/j.jglr.2016.04.001.
- Vijushkova, V.P., and Kuznetsova, V.P. Distribution of *Acanthocyclops americanus* (Marsh.) Copepoda in USSR, Zool. Zh., 1974, vol. 53, pp. 1873–1875. (In Russian)
- Wasmund, N., Augustin, C., Pollehne, F., Siegel, H., and Zettler, M., Biologische standseinschätzung der Ostsee im Jahre, 2012, Meereswiss Ber: Warnemünde, Germany, 2013, 92. (in German)
- Winkler, G., Dodson, J.J., and Lee, C.E., Heterogeneity within the native range: population genetic analyses of sympatric invasive and noninvasive clades of the freshwater invading copepod *Eurytemora affinis*, Mol. Ecol., 2008, vol. 17, pp. 415–430. DOI: 10.1111/j.1365-294X.2007.03480.x
- Winkler, G., Souissi, S., Poux, C., and Castric, V. Genetic heterogeneity among *Eurytemora affinis* populations in Western Europe. Mar. Biol. 2011., vol. 158, pp. 1841–1856. DOI: 10.1007/s00227-011-1696-5
- Zakharov, V. M., Future prospects for population phenogenetics, Sov. Sci. Rev. Sect. F. Physiol. Gen. Biol. Rev., 1989, vol. 4, pp. 1–79 (In Russian).