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ECOLOGICAL CHARACTERISTIC OF CALANOIDS (COPEPODA, CALANOIDA) OF THE INLAND WATERS OF UKRAINE

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Ecological Characteristic of Calanoids (Copepoda, Calanoida) of the Inland Waters of Ukraine. Samchyshyna L. V. – The article presents analyze of known published data and own observations on ecology of freshwater and brackish calanoid copepods of fauna of Ukraine. The briefly characteristic of main types of waterbodies inhabited by calanoids is given. The relation of species to the important ecological factors of water environment like temperature, habitat permanence, salinity, pH, current, suspended matters, and interaction with other hydrobionts is analyzed.

Key words: ecology, freshwater and brackish Calanoida, Ukraine.

Екологическая характеристика каланоид (Copepoda, Calanoida) внутренних вод Украины. Самчишина Л. В. – Статья представляет собой анализ и обобщение всех известных литературных и собственных данных по экологии пресноводных и солоноватоводных каланоид фауны Украины. Дана краткая гидрохимическая характеристика основных типов водоемов, населяемых каланоидами, и проанализировано отношение видов к основным экологическим факторам водной среды: температуре, типу биотопа, солености, активной реакции воды, течению, взвешенным веществам, взаимодействию с другими гидробионтами.

Ключевые слова: экология, пресноводные и солоноватоводные Calanoida, Украина.

The fauna of freshwater and brackish Calanoida of Ukraine consists of 39 species and 1 subspecies belonging to 12 genera and 3 families. The known published and own data on relations of these species to the basic ecological factors of water environment are analyzed in this paper.

Different species of calanoid copepods inhabit in certain ecological conditions consisted of a number of factors of the water environment as mineralization, temperature, gas regime, current, depth, pollution, concentration of suspended matter, pH, as well as from a number of biotic factors those are interactions with other aquatic organisms as predator-prey, parasite-host relations, symbiosis, etc. The peculiarities of the water environment depend on the geographical position of the waterbody, landscape, bottom type, past geological events, affected by climate, etc. Ukraine, except the southern Crimea, lies in temperate zone which affects the regime of waterbodies. Complete ice cover occurs in the north and north-east of Ukraine while in south-west ice cover is not stable, with many breaks or sometimes even absence during the whole winter. Inland waters of Ukraine include rivers and lakes, water reservoirs and ponds, bogs and underground waters. Ecological factors differ greatly among waterbodies, and even within them.

Between different types of ukrainian inland waters calanoid copepods have more favorable conditions in lakes, ponds, and artificial water-reservoirs (which from time of flooding have passed succession from lotic to lentic ecosystem), so mostly in waters without swift current. There are around 20,000 lakes in Ukraine and over 1,000 of

water-reservoirs (Marinich et al., 1985). Salty lakes and marshes in Ukraine are situated on the Black and Azov Seas coast, in the Danube Delta. Oligohaline and marine species of the Calanoida inhabit those waters and form substantial biomass that is a favourable for the commercial fish farming. Lowland of the Crimea has some hyperhaline lakes where salinity could reach 270‰ (Perekopski, Chongaro-Arabatski lakes). Slovyansk Salty Lakes (Ripne, Slipne, Vejsove, etc.) are only ones situated so far (~ 300 km) from the sea, have a salinity up to 20‰. *Arctodiaptomus salinus* (Daday, 1885), a halophyle, which is the only species of calanoids found there. It is an important prey for fish; biomass of *A. salinus* accounted for 60—70% of zooplankton one all around the year and can reach up to 12 g/m^3 (Semik, 1991). This species is gathered in a great quantity in Slovyansk Salty Lakes, freezed in briquette and used in aquaculture.

Bogs and wetlands are an important part of inland waters in Ukraine too. Calanoids as planktonic species can exist in bogs with an open water surface. Peat bottom creates strong acidification of the water. In Ukrainian Polissya, bogs have pH of 2.8—5.4. By our observation, low pH is a limiting factor for colonization by calanoid copepods, however the impact of this factor needs future studies. Nevertheless, *Eudiaptomus vulgaris* (Schmeil, 1898) has been found in some bogs of Ukrainian Polissya; this species can inhabit dystrophic waters with high concentration of humus substances (Rylov, 1930).

Temperature is traditionally recognized as one of key environmental factors in continental aquatic ecosystems, having profound effect on water dwellers. Calanoid copepods of inland waters of Ukraine are divided in three groups by the relation to temperature factor.

1. Thermophile (heat-preferring) stenothermic species. They are in the active state only during the warm season of the year. It is a major part of species − 65% of fauna of Ukraine. E. g. hutching of eggs in *E. vulgaris*, one of the common species in Ukraine, occurs at spring then the water heats up to 2.5°C; the induction in diapause takes place in the autumn, then the water temperature decrease down to 2—4°C (Samchyshyna, 2005 a). So, such species forms diapausing eggs to survive cold season.

2. Psychrophile (cold-preferring) stenothermic species. They consist 20% of the calanoid fauna of Ukraine. Such species are active during the winter time in permanent water bodies. In temporary melting snow pools, they hutch from diapausing eggs early at spring. E. g. offsprings of typical for Ukraine astatic species *Hemidiaptomus amblyodon* (Marenzeller, 1873) appear late in February, when the water temperature is 0—3°C. Species lays diapausing eggs after the first generation in the end of May, and disappear together with drying up of pool (Samchyshyna, 2005 a). Later on when the pool will be flooded by raining waters the population has remained in diapause. So, species completes the life cycle in 2.5—3 months and then it stays in the state of diapausing eggs most part of the year. *Diaptomus castor* (Jurine, 1820), *D. charini* Siewerth, 1927, *D. falsomirus* Kiefer, 1972, *Hemidiaptomus rylowi* (Charin, 1928), *H. hungaricus* Kiefer, 1933, *H. amblyodon*, *Eudiaptomus arnoldi* Siewerth, 1928, *Mixodiaptomus kupelwieseri* (Brehm, 1907) are spring hydrobionts in Ukraine belonging to this group. *M. kupelwieseri* actually is a winter species (Champeau, 1970) in southern countries where the climate is warmer (Spain, France), whereas in Ukraine it occurs only in spring pools of the Danube Delta (Samchyshyna, 2005 b).

3. Eurythermic species. Such species occur in the plankton all around the year. Only some species (15%) of the fauna of Ukraine belong to this group. These are *Calanipeda aquaedulcis* Kristchagin 1873, *Eurytemora lacustris* (Poppe, 1887), *Eudiaptomus gracilis* (Sars, 1863), *Arctodiaptomus byzantinus* Mann, 1940, *A. salinus*, and *Mixodiaptomus incrassatus* (Sars, 1903). Thus, *A. salinus* was found in the twelve-month plankton study with water temperature varied from 0° to 30°C (Semik, 1991).

Therefore, the majority of calanoid copepods of the fauna of Ukraine is in active state only during the warm season of the year when the trophic factor is the most favourable for growing and reproduction.

Habitat type and permanence are the other important factors for aquatic organisms. Calanoid copepods are divided in two big categories by relation to the type of biotope.

1. Eurytopic species (*E. gracilis*, *E. transylvanicus*, *Eurytemora velox* (Lilljeborg, 1853), *A. salinus*). These are species with the life cycle adapted to inhabiting in a variety of ecological conditions like permanent and temporary waters, ditch-water and water with current, of different range of salinity (fresh and salty), etc. Such species are generalists and have wide ecological plasticity.

2. Stenotopic species are highly specialized and occur only in certain types of waterbodies. These calanoids could be divided in some groups:

2.1. Limnobionts. These are species lived in big deep lakes (*Heterocope appendiculata* Sars, 1863, *E. graciloides*, *Acanthodiaptomus denticornis* (Wierzejski, 1887), *Arctodiaptomus bacillifer* (Koelbel, 1885), *Mixodiaptomus incrassatus* (Sars, 1903), *M. tatricus* (Wierzejski, 1883). In Ukraine, they are mostly representatives of the boreal fauna, cold-preferring.

2.2. Telmathobionts and heleobionts. These are species, which occur in small, pond-like and bog-like ecotopes (*E. vulgaris*, *E. arnoldi*, *E. zachariasi*, *Arctodiaptomus acutilobatus* (Sars, 1903), *A. mucronatus* (Rylov, 1927), *A. dentifer* (Smirnov, 1928), *A. similis* (Baird, 1859), *A. spinosus* (Daday, 1890), *M. kupelwieseri*). They are usually summer species, which could lay diapausing eggs for the passing environmental stresses like desiccation. Temporary ponds may dry out in the summer for a few weeks or may have longer dry period for several years. 12 species (8 genera and 4 families) of the known from Ukraine 39 species and 1 subspecies have ability to enter diapause (= produce resting eggs). Some diaptomids were found to lay subitaneous eggs together with diapausing ones in the same egg sac (Watras, 1980). That is an important adaptation for living in unpredictable conditions of the temporary shallow waterbody (sudden drought, freezing, etc.).

2.3. Astatobionts are typical spring calanoids of temporary waters (*D. castor*, *D. charini*, *D. falsomirus*, *H. amblyodon*, *H. rylowi*, *H. hungaricus*). They are pure monocyclic species, cold-preferring, with a short period of development. Such species often occur in small shallow waterbodies remaining from high water of rivers and melted snow. Females lye only the diapausing eggs characterized by thick and hard chorion. The last protects embryos from drought and physical damage. The thickness of chorion in diapausing eggs of *Hemidiaptomus* varied from 2.8 to 9.4 μm (Petkovski, 1983). The thickness of the egg chorion of *H. amblyodon* is 3.2—4.8 μm in the Ukrainian Polissya population. It keeps viability of embryo during long periods in the dry soil. The diapausing eggs of diaptomids as old as 332 years are shown to be successfully hatched in the lab and viable nauplii emerged (Hairston et al., 1995). So, eggs of astatobionts should be strong and hard enough to survive long periods of desiccation.

2.4. Stygobionts- cavernicoles that live in the karstic or alluvial groundwaters. To date, *Speodiaptomus birsteini* Borutzky, 1962 is the only species in the calanoid fauna of Ukraine found in the underground lake in Skelskaya Cave of Crimea (Borutzky, 1962). Data of this species are so little; biology is not investigated.

Strong affiliation of separate species of the Calanoida either with flowing or ditch waters is not revealed, nevertheless, should be noted that calanoid copepods prefer non-flowing waters and so, they are reaphobs.

Based on Ponto-Azov brackish waters graduation elaborated by F. D. Mordukhaj-Boltovskoj (1960), the following groups can be recognized among calanoid copepods by the association of species with salinity: 1) stenohaline-freshwater species (these could

exist only in pure fresh water 0—0.5‰; mostly representatives of the *Diaptomus* genus), 2) oligohaline of freshwater origin (species which could develop in waters with 0.5—3‰): *E. transylvanicus*, *E. vulgaris*, *E. gracilis*, *E. graciloides* et al.), 3) mesohaline species of freshwater origin (could inhabit waters with salinity 3—15‰: mostly the genera *Arctodiaptomus, Metadiaptomus,* and *Lovenula*), 4) euryhaline-marine of mediterranean origin (species of marine origin, which colonize both polyhaline and fresh waters − *E. velox*, *C. aquaedulcis*), 5) ponto-caspian (the optimal development is in brackish waters, however at the last time some of them successfully migrate into fresh waters: *Heterocope caspia* Sars, 1897, *Eurytemora affinis* (Poppe, 1880), *Eurytemora grimmi* (Sars, 1897). *A. salinus* is of freshwater origin, but could be characterized as euryhaline with inclination to the hyperhalinity. It is halophil, which inhabited waters of wide salinity diapason 5—89‰.

Calanoids along with others crustaceans belong to active osmoregulators. They have pair of coelomic maxillary glands able to pump out osmotic water powerfully (Lee, 1999). So, the dominant group of calanoids of inland waters in Ukraine are freshwater (s. lato) species (80%). Brackish waters of the southern Ukraine are rich of mediterranean mesohaline, ponto-caspian and marine euryhaline forms.

Evidences of calanoid relation to different pH of water are limited. *E. vulgaris* was met in the acidic water with pH = 5.5—6.5; *H. appendiculata*, *Eudiaptomus zahariae* (Poppe, 1886), *A. spinosus*, *M. kupelwieseri* were found in neutral-alkaline one (pH = 6.8—8.0) (Kiefer, 1974). *E. gracilis*, *E. graciloides*, and *E. transylvanicus* were met in waters with wide range from acidic to alkaline (pH = 4.6—9.6). *M. tatricus* occurs in lakes with high concentrations of solved organic matter and in strongly acidified waters (Hořická et al., 2006). Impact of pH on aquatic dwellers are still little studied and mostly specified for waters outside Ukraine.

Regarding to quantity of suspended matter in water most of species of calanoids are hyalidrophilus. They prefer clear and transparent waters with small quantity of suspended matter. The first reason could be in the feeding type and structure of filtering apparatus. Big particles (>30 μ) may block up the mouth of the animal, filamentous ones could tie around the mouth appendages and lead to the death of animal. The second reason is of mechanical damaging of animals by big and hard suspended particles especially when the speed currency occurs (e. g. in mountain rivers). As folerophylous species, in our opinion, may be considered a few species inhabited muddy bog waters.

Inland waters of Ukraine are not deep. The calanoids of Ukrainian fauna were found on different depths and may be considered eurybathic. Some species were found in deep waters as well as high in mountains. For instance, *E. vulgaris* is known from the depth of 300 m (Smyly, 1964) and from mountain lakes at 1300—1900 m a. s. l. (Petkovski, 1983). Next species were found both in lowland and mountain lakes: *A. bacillifer* (1500—4000 m a. s. l.), *A. acutilobatus* (1800—3200 m) (Rylov, 1930), *A. mucronatus* (2500 m) (Ali-Zade, 1939), *A. denticornis* (2500 m) (Petkovski, 1983), *E. gracilis* (2400 m), and *D. castor* (1000 m) (Kiefer, 1974). Montane species *M. tatricus** was found at 1600—2350 m a. s. l. (Petkovski, 1983).

Interaction of calanoid copepods with biotic factors of aquatic environment is traced on topic, trophic, behavioral and parasite-host relations with other organisms. The Calanoida plays an important ecological role in the transmission of parasites found in vertebrates as final hosts (Piasecki et al., 2004). At least 12 species of calanoids are recorded in the fauna of Ukraine as intermediate hosts for helminths and microsporidians of the fishes, birds and human. V. I. Monchenko (1964) was the first who pointed out on importance for studying of calanoid copepods (*E. gracilis*, *E. graciloides*, *E. vulgaris*) as intermediate hosts for helminth worms in Ukraine. He noted tapeworms,

* In Ukrainian Carpathian Mountains had been found in lake at Hoverla at 1660 m a. s. l. (Terek, 1998).

trematodes, and nematodes inflict health problems in farming fishes cultured in southern Ukraine. These data are summarized by V. I. Monchenko (2003).

Another significant ecological role of calanoids reveals in serving as basibionts for different species of suctorians, chonotrich and peritrich ciliates, fungi, and bacteria. In that case epibionts got benefits in feeding, disperse, etc. Thus, *Heterocope appendiculata* was found to be infested on the thorax surface and legs by the suctorian species *Acineta euhaetae* Sewell, 1951 (Dovgal, 2002); *Diaptomus castor* and *Eudiaptomus vulgaris* by *Epistylis diaptomi* Faure-Fremiet, 1905 and *Trichodina latispina* Dogiel, 1940 (Morado, Small, 1995), etc. A saprolegnid fungus, *Leptolegnia baltica* Höhnk et Vallin, 1953, is responsible for *Eurytemora hirundoides* mortality (Vallin, 1951) and may kill *Eurytemora velox* (Fize et al., 1970). Negative effects of epibionts have been described on host reproduction, survival, swimming abilities, feeding (Weissman et al., 1993). Bacteria are known from the body surface and gut (Ho, 1985); vibrio cholerae is able to colonize *Eurytemora affinis* (Borotto, 1997). Although the occurrence of ecto- and endocommensals (parasites?) on calanoids has been documented repeatedly, the functionality of this relationship is not well understood and requires further deep analysis (Carman, Dobbs, 1997).

Most of calanoids are filter-feeders and are herbivores. However, in changeable trophic conditions their diet may vary and include bacteria and detritus. Some species (few representatives of *Heterocope*, *Eurytemora*) are carnivorous. They may attack the cladoceran neonats, nauplius, copepodites, protozoans, and rotifers.

The most part of calanoid copepods of the inland waters of Ukraine by their ecological characteristic are considered as thermophile stenothermic oligohaline species of freshwater origin. Inland waterbodies of Azov and Black Sea coastline are inhabited both by meso- and euryhaline species of ponto-caspian and mediterranean origin, and by freshwater ones. Hyperhaline (s. str.) calanoids in fauna of Ukraine at the present time are unknown probably because of the lack of investigations of hyperhaline lakes. In generaly, calanoids of inland waters of Ukraine have wide ecological plasticity. This reflects in their wide geographical distribution – around 40% of calanoid copepods of fauna of Ukraine has a palaearctic area (Samchyshyna, 2005 a). Conversely, the ecological specialization is expressed in narrow distribution of species. A typical representative in the last case is an endemic aquatic troglobiont *Speodiaptomus birshteini*, inhabiting one of the caves in Crimean Peninsula. Undoubtedly, the calanoids play a great ecological role in food webs of waterbodies in Ukraine. Filter-feeding species control the algae growth and contribute to the native restoration of lakes. Carnivorous species regulate the number of protozoans, rotifers, nauplius and copepodits in the plankton. At the same time calanoid copepods by themselves serve as food for age-1 freshwater, marine and semi-anadromous fishes in the nursery ponds of fishing farms in Ukraine. Juveniles and eggs of calanoids are also an important component of diet for carnivorous cladocerans (Polyphemoidea), cyclopoids (Cyclopidae), mosquito larvae (Chironomidae), sea walnuts (Ctenophorae), etc.

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