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# Review of the biogeography of *Artemia* Leach, 1819 (Crustacea: Anostraca) in Russia

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## Abstract

*Artemia* has been studied for a long time in Russia; the present work consists of a short review on this topic. The genus *Artemia* has a wide distribution in Russia; it ranges from the Black and Azov coasts to the Far East where it has been found in more than 120 bodies of water. At least three bisexual species (*A. salina*, *A. urmiana*, and *A. sinica*), as well as a large number of parthenogenetic populations, have been reported from this country. Some of the factors limiting brine shrimp distribution in Russia are also discussed in the paper. Some workers suggest that the origin of all *Artemia* species in Eurasia resulted from the division of the ancient Tethys Ocean into the Mediterranean Sea and the Paratethys, and of the Paratethys splitting into a system of separate reservoirs. The changing physical and chemical conditions of these basins, as a result of other climatic and geological processes, also probably led to changes in the spatial distribution of suitable environments for *Artemia*. The wind roses as well as the migratory patterns of birds that can carry the cysts on their bodies were also changed. Additional studies are clearly needed in order to understand the distribution and biology of *Artemia* in Russia.

Key Words: *Artemia*, Branchiopoda, biogeography, Russia

## Introduction

Members of the genus *Artemia* (Crustacea, Anostraca), also known as brine shrimp, are typical inhabitants of hypersaline environments with low species diversity and simple trophic structures (Lenz, 1987; Vanhaecke *et al*., 1987). Today we know that populations of this organism are widely distributed around the World and are found on the five continents in salt lakes, lagoons, and solar saltworks. Interest in the distribution of this genus has increased steadily, in recent years, as a result of a growing number of biotechnological and commercial applications involving it. In view of the great importance of *Artemia* as live food for the culture of fish and shellfish larvae, and the present cyst shortage in the market, the need for commercial exploitation and development of new *Artemia* sources is now, more than ever, a priority. This is why it is very important to understand the biogeography and worldwide distribution of this genus.

The study of *Artemia* in Russia has a long history. Sokolov, a member of the P.S. Pallas expedition that took place in 1770, in the province of Iset, discovered multiple large populations of *Artemia* (then known as *Cancer salinus*) in Western Siberian lakes (Big and Small Shimelya) (Pallas, 1786). A few years after that G. Falk (1786) wrote: "*Cancer salinus* is a very common animal in the Caspian, Kirghiz and Siberian salt-lakes." In the 18th - 19th centuries, Russian researchers described many of the bodies of water inhabited by *Artemia,* in different parts of the Russian Empire (the Crimea, Volga, Urals, Western Siberia, the North-West coast of the Black Sea, etc.) (Fedchenko, 1870; Kulagin, 1888). In subsequent years, several other studies described a large number of additional *Artemia* habitats in that country.

We are aware of the existence of a relatively large number of articles on different aspects of brine shrimp habitats in Russia but they are not readily available except for a limited number of particular surveys that we have been able to identify (Mura & Nagorskaya, 2005; Litvinenko *et al.,* 2009; Van Stappen *et al*., 2009). The purpose of this review is to fill this gap, in the literature, by formally compiling all the available data we have been able to identify that mentions the occurrence of this genus in Russia.

Russia has several thousand saline/hypersaline water bodies that provide adequate conditions for *Artemia*. These sites are generally understudied. For example there are more than 500 salt lakes in the Baikal region and Transbaikalia regions (Dzuba, Kulagina, 2005) of which biologists have formally studied only 30. We found information, in the Internet and in the primary literature, which suggests that there are more than 120 water bodies in Russia, where adult brine shrimp are continuously or periodically present.

Table 1 provides a list of these sites. The available information suggests that *Artemia* is distributed from the Black and Azov coasts to the Far East. The distribution of *Artemia* in Russia is patchy and depends on the distribution of hypersaline habitats. The current distribution of these organisms, in Russia, probably depends on the transport of cysts by birds, wind or by anthropogenic means. Potentially, any new suitable salt pond/lake can be quickly inhabited by brine shrimp. Interestingly, *Artemia* populations have even been reported from fish-salting pools in Russia, very far from any natural population (e.g. the Far East) (Lozovskii, 1977).

## Factors determining *Artemia* distribution in Russia

Hypersaline water bodies are widely distributed in every climatic zone but the majority have originated as a result of dry (arid) climate and are situated in arid and semi-arid climatic zones that occupy about one-third of the surface of the earth (Zheng, 2001). The climatic prerequisite of water body salinization and hypersalinity requires several geophysical factors. A body of water needs to have several key geophysical characteristics in order for it to be a suitable environment for *Artemia*. We will briefly discuss the conditions required for this. The hydrophysical and hydrochemical structure of saline lake forms under region-specific climatic conditions and directly depends upon the interaction between the water surface and the air (i.e. the fluxes of warm air and moisture) and also upon the water exchange with the sea or a river. The water fluxes and exchange are influenced by regional hydro-meteorological conditions. Important factors affecting these environments are storm winds that can suddenly raise the sea level, strong waves rolling up onto the shore, water overflow that drastically increases the filtration rate of the lake/lagoon and the received seawater influx. It is worth mentioning that if under the hypersaline lake-air exchange, evaporation exceeds precipitation; then the received water influx (underground drainage or terrestrial run-off) compensates for the water lost to evaporation. The salts that enter the system with the inflow of water accumulate over time and increase the salinity of the lake. To attain a quasi-stationary state (i.e. to cease further salinization), the total water balance (i.e. precipitation, evaporation and drainage balance) should be equal to zero (Winkler, 1977). Steady temperature balance requires zero thermal balance, i.e. the balanced solar irradiation, direct and hidden (the heat used for evaporation) heat exchange between the lake and the air; the heat exchange between the lake and the shore land may be ignored.

In assessing the humidity, not only the level of precipitation, but also evaporation from the surface of the body of water, should be taken into consideration. The ratio between annual, monthly or seasonal total precipitation, $P$, and evaporation, $E_e$, (the local-specific evaporation possible under an unlimited ground water reserve) determines the humidity coefficient. Under increasing salinity, humidity equilibrium (the relative pressure of saturated water vapour) decreases (Vasiliev *et al.*, 2007). Evaporation from the surface of saline lakes is a variable factor that depends upon weather conditions and of the salinity of the water.

Assuming that the total annual land-air heat exchange, resulting from heat-conductivity, is negligible and can be ignored, we can assume that the annual locality-specific evaporation would consume the amount of heat equal to the annual irradiation balance. Thereby the irradiation index of dryness for a year can be described (Khromov & Petrosyan, 2001) by the following formula: $K_\delta = B/LP$

Where $B$ is annual irradiation balance, $P$ is total annual precipitation, and $L$ is heat of evaporation. The irradiation index of dryness indicates the portion of irradiation balance contributing to rainfall evaporation. It is often assumed that values greater than the conventional limit of climate dryness, $K_\delta = 3$ result in the climate in the locality being dry and favours salt accumulation and hypersaline lake formation (Efimov & Timofeyev, 1990). Global climatic changes lead to changes in the boundaries of arid areas. This fact must be considered when analyzing the habitat distribution of *Artemia* in a particular area. More details on the geographical distribution of *Artemia* in relation to climate were discussed earlier by Vanhaecke *et al*. (1987).

Some hypersaline water bodies in Russia did not originate as a result of arid climate, but as a result of local and geological characteristics such as the erosion of fossil salt deposits or salty springs. Several hypersaline reservoirs in Russia (i.e. Sol-Iletsk lakes) were formed as a result of the extraction of various salts (Abdrakhmanov *et al*., 2008). It should be noted that *Artemia* populations rapidly appeared in these ponds (most likely transported by birds or winds) without inoculation by man.

The primary literature, as well as personal observations and communications, suggest that *Artemia* can exist in water bodies with very different salinities. Adult brine shrimp can generally be found in large populations in predator or competitor-free bodies of water with salinity ranging from 4 (soda lake) to 370 ppt (Vanhaecke *et al*., 1987; Makarkina, 2009). Predatory invertebrates and fish usually feed readily on brine shrimp nauplii and adults \ resulting in their complete disappearance from a water body (Ivanova, 1990: Sultana *et al*., 2011). When salinity increases to a range of 250-300 ppt, the limiting factor for *Artemia* is usually not high salinity itself, but the associated low concentrations of dissolved oxygen in the waters (the solubility of oxygen in water is inversely proportional to salinity). *Artemia* populations can usually strive very well in thalassohaline as well as in athalassohaline (sulphate, soda) water bodies of a lower salinity.

## Biogeography and phylogeny

*Artemia* has been attracting the interest of many zoologists ever since Schmankewitsch (1876) made a series of classic observations and experiments that demonstrated variation in form of body of *Artemia* as a result of changes in the salinity of the external medium. Schmankewitsch's observations were re-examined and confirmed by many researches (Baid, 1963), including several Russian workers such as Anikin (1898) and Gajewski (1916, 1922).

The results of early observations and experiments on the taxonomy of *Artemia* suggest that all the populations in the world belonged to *Artemia salina* (Linnaeus, 1758). With the advent of molecular and modern microscopy techniques coupled to an increase in communication between researchers, we now know that the genus *Artemia* consists of a large group of geographically isolated species that have accumulated enough genetic differences to be (in many cases) reproductively isolated. These populations can also have very different physiological requirements (i.e. water chemistry - *Artemia tibetiana*), morphology, reproduction and even ploidy levels.

The genus *Artemia* consists of several sexual and parthenogenetic populations and species and is found in every continent, except Antarctica, from 0 to 4500 m above sea level (Triantaphyllidis *et al.,* 1998; Xin *et al.,* 1994). Both sexual and parthenogenetic populations have been reported for the Old World. Crossbreeding experiments and molecular studies have revealed reproductive isolation of several groups of populations and have resulted in the recognition of several sibling species and superspecies.

All the populations of *Artemia* from the New World are thought to be sexual (zygogenetic) and their systematic is still relatively understudied. In the New World either parthenogenesis never arose in *Artemia*, asexual lineages never became successfully established or there are parthenogenetic populations that have just not been described. Some investigators claim to have detected parthenogenetic animals in Great Salt Lake (Utah - USA) cyst material (Browne, 1993). Campos-Ramos *et al*. (2003) suggest that the *Artemia* population from the Great Salt Lake, a population that for decades has been thought to be composed of strictly bisexual animals, could be coexisting with a parthenogenetic population.

All of the New World sexual populations are currently grouped in the *A. franciscana* superspecies (except *A. persimilis* which is a species that can only be found in Argentina) even though recent morphological studies suggest that there may be more than one species in the Caribbean area. Some populations of *Artemia* from the Caribbean have been demonstrated to be morphologically different from each other and from *A. franciscana* collected from the San Francisco Bay, California area (this is the type location for this superspecies), thus suggesting that speciation may have occurred in these areas (Torrentera and Dodson, 1995; Mayer, 2002).

The currently recognized bisexual species from the Old World are: *Artemia sinica*, *Artemia urmiana*, *Artemia tibetiana*, *Artemia salina* and parthenogenetic populations.

Parthenogenetic populations of *Artemia* are distributed from Southern Africa throughout Southern Europe and across the mid-latitudes of Asia to Japan and vary considerably in life history strategies, physiological responses and genetic makeup (Browne, 1993). About 50 % of the parthenogenetic populations of *Artemia* are polyploid (i.e. have three or four sets of chromosomes) while the rest of the populations have two sets of chromosomes (diploid) and can produce offspring that are genetically different from the parents and from each other. Polyploid *Artemia* usually have larger cells, produce a higher number of offspring and have longer reproductive periods than their diploid counterparts (Browne, 1993).

*A. salina* and several parthenogenetic populations have been reported for the European part of Russia. Molecular genetic studies suggest that bisexual populations from the Altai lakes are in the same cluster with *A. urmiana* Gunther, 1900 and *A. tibetiana* Zhang et Sorgeloos, 1998 (Boyko & Muge, 2009). It seems likely that bisexual populations of the Altai belong to *A. urmiana*. Because Altai, Urmia, and the Crimea, where there are also populations of *A. urmiana* (Abatzopoulos *et al*., 2009; Shadrin & Batagova, 2009), are probably connected by migrating birds, which probably carry cysts from one location to another thus connecting the gene pools of those populations. The most likely candidates for the transfer of cysts between these three locations are birds like the Shelduck (*Tadorna tadorna*), Redshank (*Tringa totanus*) and Pied Avocet (*Recurvirostra avosetta*) (Khomenko, Shadrin, 2009). We suggest the Crimea (and some adjacent ancient territory, which is now part of the Black sea and The Sea of

Tab. 1: *Artemia* sites in Russia

| Region | Locality | Geographical coordinates | Reproductive mode | Species | Ref. |
|---|---|---|---|---|---|
| | | European part of Russia | | | |
| Astrakchan oblast | Tinaki | 46°24'N-47°56'E | ? | ? | 19 |
| Volgograd region | Baskuntchack | 48°20'N-46°55'E | ? | ? | 15 |
| | Elton | 49°08'N-46°40'E | ? | ? | 15 |
| Kalmykia | Bolshoe Yashaltinskoye | 46°16'N-42°27'E | P | Parthenogenetic population | 5 |
| Stavropolsky Krai | Solionoye | 45°15'N- 42°51'E | ? | ? | 3 |
| Kabardino-Balkaria | Tambukan | 43°96'N-43°16'E | ? | ? | 2, 17 |
| Krasnodarsky Krai | Khanskoye | 46°15'N-38°22'E | ? | ? | 4 |
| | Solionoye (Veselovka) | 44°80'N-36°96'E | ? | ? | 4 |
| Rostov region | Manych-Gudilo | 44°36'N-42°50'E | ? | ? | 6 |
| | | Southern Urals | | | |
| Chelyabinsk region | Berrsenevskoye | 55°05'N-62°07'E | ? | ? | 11 |
| | Kommunarskoye | 54°21'N-62°53'E | ? | ? | 11 |
| | Okunevo | 54°38'N-63°06'E | ? | ? | 11 |
| | pools near Troitsk | 54°05'N-61°34'E | ? | ? | 15 |
| | Solenoye (Oktyabrskoye) | 54°27'N-62°42'E | - | - | 11 |
| | Soleniy Kulat | 55°00'N-61°57'E | P | Parthenogenetic population | 11 |
| | Sosnovskoye | 54°29'N-62°42'E | ? | ? | 11 |
| | Tauzatkul | 54°25'N-61°53'E | P | Parthenogenetic population | 11 |
| Kurgan region | Aktoban | 55°18'N-66°19'E | P | Parthenogenetic population | 11 |
| | Aslykul | 54°58'N-62°07'E | P | Parthenogenetic population | 11 |
| | Bolshoye (B.) Medvezhye | 55°15'N-67°50'E | P | Parthenogenetic population | 11 |
| | Borki | 54°25'N-64°13'E | P | Parthenogenetic population | 11 |
| | Chastoozerskoe | 55°23'N-68°15'E | ? | ? | 11 |
| | Filatovo | 54°45'N-66°58'E | P | Parthenogenetic population | 11 |
| | Gashkovo | 54°42'N-64°31'E | P | Parthenogenetic population | 11 |
| | Gorkoye (Bolshoye Kureynoye) | 54°56'N-66°56'E | P | Parthenogenetic population | 11 |
| | Kurtamyshskoye | 54°38'N-64°32'E | ? | ? | 11 |
| | Lavrushino | 55°03'N-61°59'E | P | Parthenogenetic population | 11 |
| | Maloye (M.) Medvezhye | 55°15'N-68°05'E | P | Parthenogenetic population | 11 |
| | Nevidim | 55°08'N-66°55'E | P | Parthenogenetic population | 11 |
| | Novo-Georgievskoye | 55°19'N-67°52'E | P | Parthenogenetic population | 11 |
| | Parshkovo | 54°42'N-64°32'E | P | Parthenogenetic population | 11 |

Tab. 1: Continued

| Region | Locality | Geographical coordinates | Reproductive mode | Species | Ref. |
|---|---|---|---|---|---|
| Kurgan region | Shashmura (Petan) | 54°57'N-67°05'E | P | Parthenogenetic population | 11 |
| | Sobachye | 54°57'N-66°58'E | P | Parthenogenetic population | 11 |
| | Solenoye (Setovo) | 54°32'N-64°04'E | P | Parthenogenetic population | 11 |
| | Sulfatnoye (Shamelya) | 54°51'N-62°29'E | P | Parthenogenetic population | 11 |
| | Svetlenkoye | 55°16'N-66°15'E | P | Parthenogenetic population | 11 |
| | Tibizkol | 54°46'N-63°41'E | P | Parthenogenetic population | 11 |
| | Trebushinoe | 55°02'N-66°56'E | P | Parthenogenetic population | 11 |
| | Umreshevo | 55°02'N-67°00'E | P | Parthenogenetic population | 11 |
| | Vishnyakovskoye (Sorochye) | 54°44'N-63°48'E | P | Parthenogenetic population | 11 |
| | Voskresenskoye | 55°33'N-67°24'E | P | Parthenogenetic population | 11 |
| Orenburg region | Dunino | 51°09'N-55°00'E | ? | ? | 1 |
| | Rarzval | 51°09'N-55°00'E | ? | ? | 1 |
| | Tuzluchnoe | 51°08'N-55°00'E | ? | ? | 1 |
| | | Western Siberia | | | |
| Tyumen region | Seledniyovo | 55°40'N-69°05'E | P | Parthenogenetic population | 15 |
| | Siverga | 55°23'N-68°45'E | ? | ? | 11 |
| | Solionoye 18 (Okunevskoye) | 55°43'N-68°37'E | P | Parthenogenetic population | 11 |
| Omsk region | Ebeyty | 54°40'N-71°45'E | P | Parthenogenetic population | 11 |
| | Kamyshlovsky Log | 55°00'N-70°27'E | - | - | 10 |
| | Ostrovnoye | 54°20'N-75°40'E | - | - | 15 |
| | Ulzhai | 54°14'N-75°10'E | P | Parthenogenetic population | 11 |
| Novosibirsk region | Chebakly | 54°38'N-76°55'E | ? | ? | 11 |
| | Gorkoye (Barabashi) | 54°12'N-77°22'E | ? | ? | 11 |
| | Gorkoye (Konevo) | 54°15'N-78°50'E | ? | ? | 11 |
| | Gorkoye (Novoklyuchi) | 54°10'N-78°00'E | ? | ? | 11 |
| | Gorkoye (Olkhovka) | 54°45'N-76°35'E | ? | ? | 11 |
| | Gorkoye (Tsaritsino) | 55°00'N-76°22'E | ? | ? | 11 |
| | Karachi | 55°20'N-77°00'E | ? | ? | 11, 7 |
| | Krutoberegovoye | 54°35'N-75°40'E | ? | ? | 15 |
| | Lechebnoye | 54°45'N-76°30'E | ? | ? | 11 |
| | Mikhaylovskoye | 54°27'N-77°15'E | ? | ? | 11 |
| | Ostrovnoye | 54°50'N-78°55'E | ? | ? | 11 |
| | Solionoye | 53°28'N-78°05'E | ? | ? | 11 |
| | Solionoye (near Kupinsk) | 54°20'N-76°45'E | ? | ? | 15 |
| | Solionoye (near Tatarsk) | 54°25'N-75°50'E | ? | ? | 15 |
| | Solionoye (near Tchistozerny) | 54°32'N-75°58'E | ? | ? | 15 |
| | Tchani, (Udinski Ples) | 54°30'N-76°48'E | ? | ? | 15 |

Tab. 1: Continued

| Region | Locality | Geographical coordinates | Reproductive mode | Species | Ref. |
|---|---|---|---|---|---|
| Novosibirsk region | Tuchloye | 54°34'N-75°12'E | ? | ? | 15 |
| | Voniyucheye | 54°15'N-78°58'E | ? | ? | 15 |
| Altay region | Bauzhansor | 52°44'N-79°27'E | ? | ? | 11 |
| | Belenkoye | 52°59'N-78°57'E | ? | ? | 11 |
| | Bolshaya Gorchina | 51°56'N-79°11'E | ? | ? | 11 |
| | Bolshoye Shklo | 52°35'N-79°15'E | P | Parthenogenetic population | 15 |
| | Bolshoye Yarovoye | 52°50'N-78°41'E | P | Parthenogenetic population | 11 |
| | Bura | 52°40'N-78°28'E | ? | ? | 11 |
| | Burlinskoye | 53°08'N-79°25'E | ? | ? | 11 |
| | Chekurtuz | 52°24'N-79°19'E | ? | ? | 11 |
| | Dunay | 52°03'N-79°30'E | ? | ? | 11 |
| | Dushnoye | 52°53'N-81°01'E | ? | ? | 11 |
| | Dzhomansor | 52°48'N-79°25'E | ? | ? | 11 |
| | Dzhul-Suldy | 53°21'N-78°15'E | ? | ? | 11 |
| | Gornostalevo | 51°56'N-79°42'E | ? | ? | 11 |
| | Karatal | 51°51'N-79°11'E | ? | ? | 11 |
| | Krivaya Puchina | 52°26'N-79°21'E | ? | ? | 11 |
| | Kuchukskoye | 52°42'N-79°46'E | ? | ? | 11 |
| | Kulak-Sor | 53°15'N-78°15'E | ? | ? | 11 |
| | Kulundinskoye | 53°10'N-79°30'E | ? | ? | 11 |
| | Kurichye | 52°42'N-79°29'E | ? | ? | 11 |
| | Leviy Bliznets | 51°44'N-79°49'E | ? | ? | 11 |
| | Lomovoye | 51°43'N-79°42'E | ? | ? | 11 |
| | Malinovoye | 51°44'N-79°44'E | ? | ? | 11 |
| | Maloye Yarovoye | 53°14'N-79°10'E | P | Parthenogenetic population | 11 |
| | Ministral | 51°45'N-79°47'E | ? | ? | 11 |
| | Mirabilit | 52°30'N-79°05'E | B | *A. urmiana (?)* | 15 |
| | Mormyshanskoye 1 | 52°25'N-81°28'E | P | Parthenogenetic population | 11 |
| | Mormyshanskoye 2 | 52°25'N-81°15'E | P | Parthenogenetic population | 15 |
| | Nikolayev Bereg | 51°43'N-79°51'E | ? | ? | 11 |
| | Petukhovo | 52°06'N-79°09'E | ? | ? | 11 |
| | Petukhovskoye | 52°16'N-79°21'E | ? | ? | 11 |
| | Praviy Bliznets | 51°43'N-79°49'E | ? | ? | 11 |
| | Schekulduk | 52°27'N-79°00'E | P | Parthenogenetic population | 15 |
| | Severniy Zaliv | 51°43'N-79°47'E | ? | ? | 11 |
| | Solionoye (Bolshoye Gorkoye) | 52°30'N-81°15'E | ? | ? | 11 |
| | Solionoye (near Khabary) | 53°38'N-79°32'E | ? | ? | 9 |
| | Tanatar 1 | 51°37'N-79°53'E | B | *A. urmiana* | 11 |
| | Tanatar 2 | 52°17'N-80°59'E | B | *A. urmiana* | 11 |
| | Vshivka | 51°46'N-79°39'E | ? | ? | 11 |
| | Yodnoe | 51°42'N-79°48'E | ? | ? | 11 |
| | | Earsten Siberia | | | |
| Khakasia republic | Pervomayskoye | 54°33'N-90°55'E | ? | ? | 11 |
| | Tus | 54°37'N-90°00'E | B | ? | 11 |

Tab. 1: Continued

| Region | Locality | Geographical coordinates | Reproductive mode | Species | Ref. |
|---|---|---|---|---|---|
| Tuva republic | Cheder | 51°15'N-94°40'E | B | *A. sinica* (?) | 11, 16 |
| | Svatikovo (Dus-Khol) | 51°32'N-94°25'E | B | *A. sinica* | 11 |
| Irkutsk region | Solionoye (Ust-Kut) | 56°48'N-105°50'E | B | ? | 18 |
| Buryatia | Belyey Kluchi | 50°38'N-105°40'E | ? | ? | 14 |
| (Selenginskaya Dauria) | Verkhneye Beloye | 50°38'N-105°43'E | ? | ? | 14 |
| Zabaykalsky Krai | Bain-Tsahan | 50°15'N-115°02'E | ? | ? | 12 |
| | Barun-Shivertuj | 49°56'N-116°51'E | ? | ? | 12 |
| | Barun-Torey | 50°02'N-115°32'E | ? | ? | 12 |
| | Zun-Torey | 50°03'N-115°45'E | ? | ? | 12 |
| Sakha (Yakutia) republic | Salt lakes in central Yakutia | 62°N-123°E | ? | ? | 8 |
| | | Far East | | | |
| Primorsky Krai | Tanks for salt fish in Kievka bucht | 43°50'N-133°40'E | ? | ? | 13, 15 |

B: bisexual; P: parthenogenetic

Ref.: 1. Abdrakhmanov *et al*., 2008; 2. Andreeva, 1934; 3. Anonymous (Unofficial Report); 4. Anonymous (Unofficial Report); 5. Bambeeva, 2009; 6. Belik, 2006; 7. Decksbach & Anferova, 1971; 8. Desyatkin, personal communication; 9. Egorkina *et al*., 2006; 10. Korsun (Unofficial Report) ; 11. Litvinenko at al., 2009; 12. Lokot *et al*., 1991; 13. Lozovski, 1977; 14. Makarkina, 2009; 15. Mura & Nagorskaya, 2005; 16. Naumenko & Zaika, 2002; 17. Rogozhin & Lantsov, 2002; 18. Tahteev & Galimzyanova, 2009; 19. Vanhaecke *et al*., 1987.

Azov) as the site of origin of *A. urmiana*. This species has probably been transported by birds in Lake Urmia and from there to the Altai lakes.

Some bisexual populations of Eastern Siberia (Tuva) are genetically identical to *A. sinica* (Yaneng, 1989) (Boyko & Muge, 2009). The taxonomic status of bisexual *Artemia* populations from the Baikal region is not clear (Tahteev & Galimzyanova, 2009; Tahteev *et al*., 2010). The authors, who described them, considered them to be *Artemia sibirica* (Anikin, 1898). No conclusion can be safely drawn on Anikin's diagnosis of *Artemia sibirica*. At present, it probably represents a *nomen nudum*. It is clear that further work on the molecular genetics of these populations needs to be performed in order to clarify the taxonomic status of Siberian populations *Artemia* (Boyko & Muge, 2009). This would shed light on the phylogeny and dispersal paths of *Artemia* in that part of the world.

We can make the preliminary assumption that the origin of all *Artemia* species in Eurasia is due to the division of the ancient Tethys Ocean into the Mediterranean and Paratethys, and then the splitting of the Paratethys into separate reservoirs. The changes of these basins, in addition to other climatic and geological processes, probably led to changes in the spatial distribution of habitats that are suitable for the existence of brine shrimp. Additional biogeographic studies of these populations will also help us understand the distribution of these organisms in Russia.

## Conclusion

There are a large number of *Artemia* habitats in Russia, but only a limited area of Western Siberia has been used for the commercial harvesting of *Artemia* cysts (Litvinenko *et al*., 2009; Van Stappen *et al*., 2009). *Artemia* populations in Russian small natural and artificial water bodies are not expected to contribute significantly to world cysts supplies but studying their biology and biogeography will greatly contribute to the scientific understanding of this genus and may also even serve as a supply of *Artemia* biomass for local aquaculturists and aquarists. These populations also have a very important environmental role since they contribute to the formation of therapeutic mud (Ivanova, 1994), and provide opportunities for local commercial developments (i.e. aquaculture and aquarism), birdwatching, tourism, etc.

We need more detailed studies on the *Artemia* populations of Russia. Studies using a molecular genetic approach, as well as a clear knowledge of bird migratory flight routes, are necessary to understand the biology of *Artemia* and its geographical distribution in Eurasia.

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