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Artemia in the Salt Lakes of Russia: the Productivity of Populations, the Reserves of the Cysts and the Fisheries

Lyudmila LITVINENKO[1,2], Aleksandr LITVINENKO[1,2], Elena BOYKO[2,1] and Kirill KUZANOV[1,2]

1 Federal State Unitary Enterprise «State research and production centre of fishery» Gosrybcenter, Tyumen, Russia
2 State Agrarian University of Northern Urals, Tyumen, Russia

Artemia cysts are an extremely important component of aquaculture diets. It is well established that the cultivation of fish and shellfish derive substantial health and growth advantages when *Artemia* are included in the diets of the first stages of larval growth. *Artemia* cysts are an important contributor to the continued expansion of the aquaculture industry. According to FAO, the products of world aquaculture in 2000 amounted to 35.6 million tons and in 2010 the estimate was 59.9 million tons. Thus, a rough estimate of growth rate of aquaculture is about 2.4% per year. Due to the demise of many wild sources of fish and crustaceans there has been a distinct shift toward aquaculture production. Thus, in 2010 the share of cultivation of fed species in Asia amounted to 67% (about 38 million tons) compared to 50% in 1980.

World consumption of *Artemia* cysts is about 2000 tons (dry weight) in the year (according to: NATO Science for Peace: project: CP EAP SFP 980859), which corresponds to about 7000-8000 tons. However, given the advances in the aquaculture industry this estimate is likely to be below the actual amount of *Artemia* cysts used.

According to the literary data (Van Stappen, 2002) and own research in Russia (Litvinenko et al.,2009; Van Stappen et al., 2009) in the world there are about 700 *Artemia* habitats located in 66 countries. But the commercial catch of *Artemia* cysts is performed only in a small part of these reservoirs. The main reasons are either their low productivity, or prohibition of fishing, or weak organization of fishing.

The largest single location for the production of *Artemia* cysts is the Great Salt Lake (Utah, USA). The annual harvest of cysts in the period 1985 to 2000 (Isaacson et al, 2002) was from 1 to 10 thousand tons of wet biomass (about 4 thousand tons in average), that is almost half of the world's demand for *Artemia* cysts. Limited production of *Artemia* cysts occurs in other water bodies of USA: San Francisco Bay, Mono Lake in California, Abert Lake in Oregon, and also in other Western hemisphere countries: Argentina, Brazil, Mexico.

Large reserves of *Artemia* are also available in the reservoirs of Turkmenistan, Kazakhstan, Iran, China and other countries. It is difficult to obtain accurate estimates of *Artemia* production in Kazakhstan, and estimates range from 500-5000 tons. The reserves of *Artemia* cysts in Uzbekistan and Turkmenistan are substantially less, though Turkmenistan did have substantial production in 1998-2000. Cyst harvesting in these countries is not well organized. In 2013 in Kazakhstan for the first time officially were harvested about 1000 tons, of which 200 tons - on the Aral Sea. In Russia saline lakes situated in the South of Western Siberia annually produce an average of about 1100 tons. *Artemia* cysts are also produced in salt evaporation ponds of Vietnam, Thailand, China and other countries). However, this type of *Artemia* cyst production is generally intended for domestic consumption within the country and is not a significant influence on the world market.

Thus, at present, the deficit in the *Artemia* cysts appears to be primarily associated with the occasional instance of low production from the Great Salt Lake. Due to improved methods of resource management and cooperation between resource managers (Utah Division of Wildlife Resources) and the brine shrimp industry stocks of Great Salt Lake *Artemia* cysts have been much more reliable over the past decade. In spite of improved reliability there remains a need for alternative sources of *Artemia*.

Artemia stocks in Western Siberia have been thoroughly document by Gosrybcentr scientists for almost 20 years. During this period 65 lakes located on the territory from

* Corresponding author. E-mail: litvinenko_li@mail.ru

the Urals to the West Sayan Mountains were studied (Van Stappen et al., 2009; Litvinenko and others, 2009, 2013). Each year, we comprehensively investigated about 40 lakes, located in five administrative regions (Chelyabinsk, Kurgan, Tyumen, Omsk, Novosibirsk). On five model lakes we conducted multiple years of intensive monthly or bimonthly monitoring. These studies allow us to draw some conclusions concerning productivity of Artemia lakes and to identify the areas of encouraging improvement the reserves of cysts and an increase the prudent harvesting of cysts.

Productivity of Artemia lakes in West Siberia. The mean annual abundance and biomass of *Artemia* shrimps in different lakes amounted 0-4909 ind/l (on the average across all data 59.4±17.9; Cv=513%; n=327) and 0-211 mg/l biomass (26.4±2.0; Cv=134%). The maximum recorded biomass of 401 mg/l was observed in Salt Kulat Lake (Kurgan region, July 2001) when the salinity was 85 g/L. The mean annual densities of planktonic and benthic cysts were respectively 0-1102 cysts/l (on the average across all data 96.1±7.8; Cv=146%) and 0-7165 thousands cysts/m^2 (396±45; Cv=189%). Annual productivity of lakes was 0-49 g/m^2 of *Artemia* cysts in wet weight (on average across all of the data 7.45±0.61; Cv=129%; n=247). In the seasonal dynamics of *Artemia* population traced a clear pattern: the maximum population during hatching from overwintered cysts in the spring and a gradual decline to the end of the season. This is due to low fecundity in most Siberian *Artemia* populations.

Stocks of *Artemia* cysts. Stocks of cysts in 18 saline lakes in different years fluctuated from 0-1284 tons. Lakes of the first category had reserves of cysts of more than 100 tons: Bolshoye Medvezhye (in different years of reserves 97-1284 tons), Maloye Medvezhye (40-428 tons), Ebeyty (24-478 tons), Siverga (0-297 tons). There are significant fluctuations in productivity in different years in separate lakes, which is associated with hydrological changes. Of 18 saline lakes, with a total area of 256 km^2, cysts stocks varied according to hydrological changes: high water - 1403 tons, medium water - 1337 tons, low water - 1126 tons. This is explained to a large extent by the salinity of the lakes and the close relationship between productivity *Artemia* and salinity of water. It is established that the salinity within 140-180 g/l is the most favorable for the production of cysts in Siberian lakes. While there can be annual variation in a particular lake there is relative constancy of stocks of cysts within a given region.

Harvesting of *Artemia* cysts and future prospects. *Artemia* producing lakes are found most commonly in Western Siberia. In the territory from the Urals to the Altai Mountains there are about 100 saline lakes with a total area of about 1600 km^2. There are also *Artemia* lakes in other regions, for example, in Stavropol (Tambukan) and Krasnodar (Khanskoe) regions and in Kalmykia (Manych-Gudilo and Bolshoye Yashaltinskoe), Astrakhan (Tinaki), Orenburg regions (Dunno), Tuva (Dus-Khol and Cheder), Khakassia (Tus, Pervomayskoe), and in Transbaikalia. However, the commercial value of many of these lakes is not very promising due to the transient nature of the *Artemia* population. In Russia the primary *Artemia* production is concentrated in 5 regions: Kurgan, Omsk, Novosibirsk, Tyumen regions and the Altai territory, where annually on average, respectively, 170, 120, 40, 40 and 670 tons of Artemia cysts in raw mass.

The prospects of increasing fishing of Artemia cysts are associated with the following:

Improvements in the management of fisheries. In the last 10 years fishing was mastered only about 50% of the permitted amount of catch

Exploitation of cysts from new sources (i.e., alternative lakes, such as those in Crimea)

Create a regulated water supply and water drainage of fresh water in the salt lakes

Introduce local strains of cysts or nauplii into suitable water bodies

Introduce nauplii in August - in the period of natural decrease of the density in the lakes.

Key words: *Artemia*, salt lakes, Russia, productivity, cysts

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