Development of artemia resources in the western basin of the Aral sea

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Abstract. Researchers from the Republic of Karakalpakstan are conducting continuous monitoring on the Aral Sea, studying artemia from various perspectives, as it is an interesting object from both a biological and applied perspective. This work is also being carried out jointly with the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences. This paper presents the results of long-term comprehensive scientific research conducted on the Aral Sea. The main material for the study was our own collection of hydrobiological samples collected from the Western basin of the Aral Sea. As a result of the research, the dynamics of artemia resource development has been determined.

1 Introduction

The largest hypersaline water body, the Aral Sea, is located in the territory of the Republic of Uzbekistan and is represented by a monoculture of the branchiopod crustacean *Artemia parthenogenetica.* They appeared in the plankton of the Aral Sea from the late 1990s. Scientific interest in these organisms is due to their osmoregulatory ability, diversity of physiological, biochemical, and morphological properties. The biological significance of this phenomenon lies in the preservation of the species during sudden ecological catastrophes and the mass mortality of animals, and under favorable conditions - in the rapid colonization of the biotope. Additionally, this is one of the potential promising species of biological (fish) resources of Uzbekistan.

The purpose of the study is to trace the dynamics of the development of brine shrimp resources in the Western Aral Sea basin in the period from 2000 to 2018 during the transition of the reservoir from brackish water to hyperhaline state.

Changes occurring in the composition of the biota of the Aral Sea have been most studied by the following scientists - Zholdasova I.M. and others “Dramatic changes in the composition of the biota of the Aral Sea” [16], Zholdasova I.M., Kazakhbaev S. and others “Detection of Artemia in the open part of the Aral Sea” [17]; Mirabdullaev I.M. and others “The current state of the ecosystem of the western part of the Aral Sea” [7], as well as “Development of Artemia population in the Aral Sea”[8]; Zavyalov P.O., Arashkevich

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A.G. and others “Quasi-synoptic expeditionary research in the western and eastern basins of the Aral Sea (October 2005)” [18], “The Great Aral Sea at the beginning of the XXI century: physics, biology, chemistry” [19]; Mustafayeva Z.A. etc. “Change in the Aral Sea plankton under conditions of salinity” [9]; B. Marden, G. Van Stappen, A. Musaev, I. Mirabdullaev, I. Zholdasova, P. Sorgelos “Assessment of the productive potential of the emerging Artemia population in the Aral Sea” [10], Musaev A., Abdurakhimova A.R., Mirabdullaev I.M. “The quality of Aral Artemia cysts” [11] and others.

2 Object and methods of research on the Aral Sea

Scientific research was carried out in the Western basin of the Aral Sea (Fig. 1). Material and samples were collected from the Western basin (at Aktumsuk, Asfaltkulau, and Zhideli sites).

Fig. 1. Sampling sites of zooplankton on the Aral Sea.

The sampling coordinates were determined using a Garmin Etrex Vista GPS. Water samples for hydrochemical analysis were collected from the surface and bottom of each site with a volume of 1 liter in the central part of the water area simultaneously with the collection of zooplankton samples. [6].

The collection and processing of zooplankton were carried out using commonly accepted hydrobiological methods. The quantitative sampling of zooplankton was carried out by vertical trawling using an Apstein conical plankton net made of capron gas with a ring diameter of 25 cm. Samples were collected at depths of 1, 3, 6, and 12 meters and fixed in a 4% formalin solution until the final concentration of 2-4%.

ATAGO refractometer was used to measure the salinity and mineralization of water. Water temperature was measured using an alcohol thermometer. Observations of water transparency were made at each station using a Secchi disk with a diameter of 20 cm, and temperature was measured from the surface layer of water (0.2 m) and additionally at the sites of maximum depth.

3 Results and Discussion

During the scientific research, investigations were conducted on all age groups of Artemia in the cyst (C), naupliar (N), metanaupliar (MN), juvenile (J), pre-adult (PA), and adult (A) stages, and the dynamics of Artemia development in the Aral Sea were determined.

The population structure of the dominant representative of zooplankton in the Aral Sea, Artemia, was studied. Three to four generations of Artemia were observed. After the winter diapause, the peak of nauplii abundance was observed in mid-April when the water temperature rose above 5 degrees Celsius. This was followed by a second peak in June or July, depending on the environmental conditions of the Artemia habitat, such as food interactions, temperature, etc. (Fig. 2 and 3).

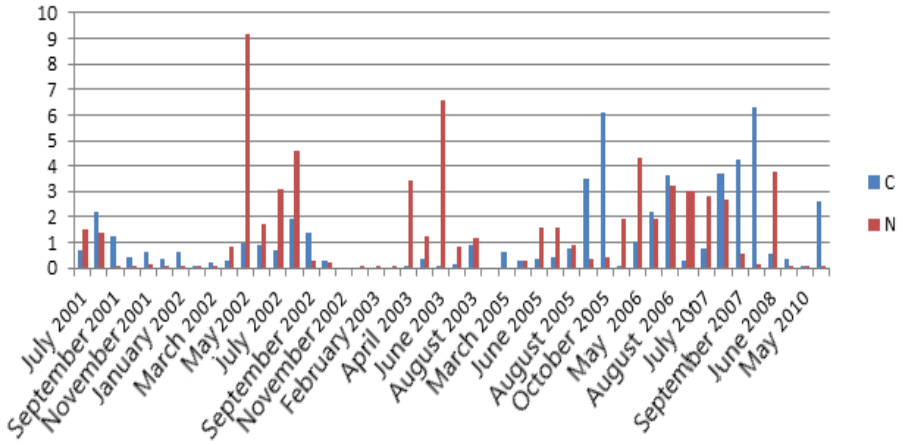

Fig. 2. Scheme of the presence of Artemia cysts (C) and nauplii (N) in the Western Aral Sea from July 2001 to August 2010 (ind./l).

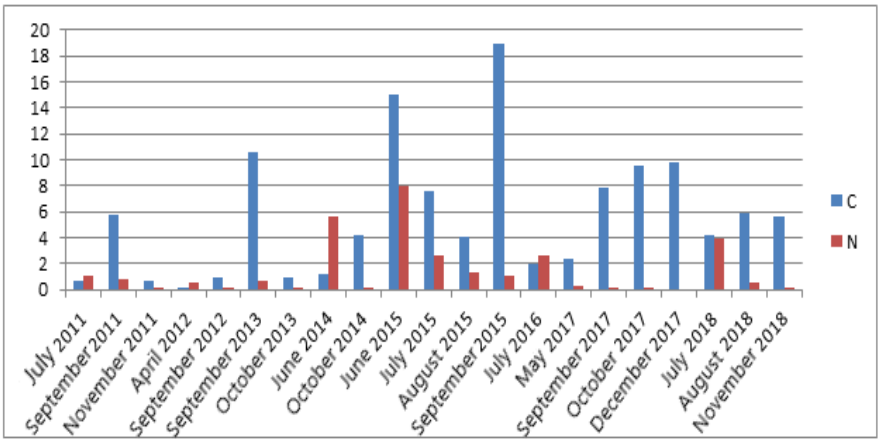

Fig. 3. Scheme of the presence of cysts (C) and nauplii (N) of Artemia in the Western Aral Sea from July 2011 to August 2018 (ind./l).

The third peak occurred in August-September, which was also depended on the environmental conditions of their habitat. This demonstration of hatching of overwintered cysts from mid-April to early May, following the period of sexual maturation (~42 days in the natural environment, 18 days in the laboratory or in an ideal habitat), and subsequent

productivity with two peaks in June-July and August-September, is an example of the population generation of Aral Artemia (Fig. 4 and 5).

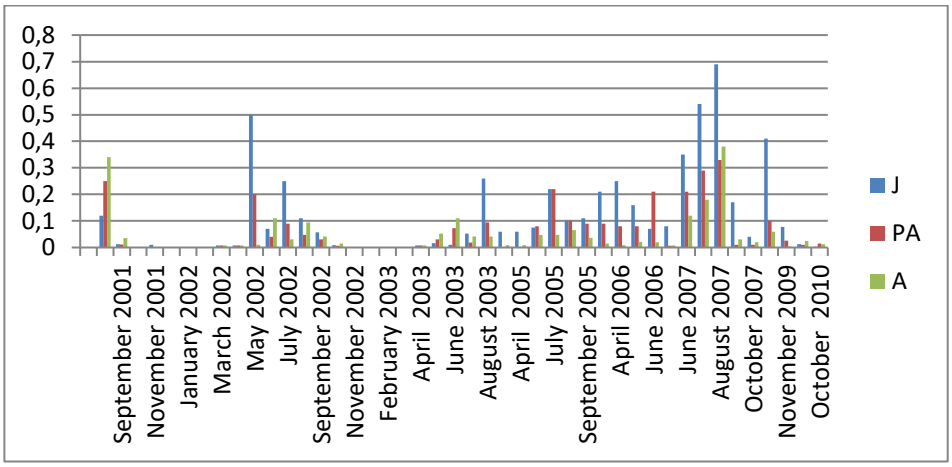

Fig. 4. Dynamics of the population of juveniles (J), pre-adult (PA), and adult (A) Artemia from July 2001 to August 2010 (ind./l).

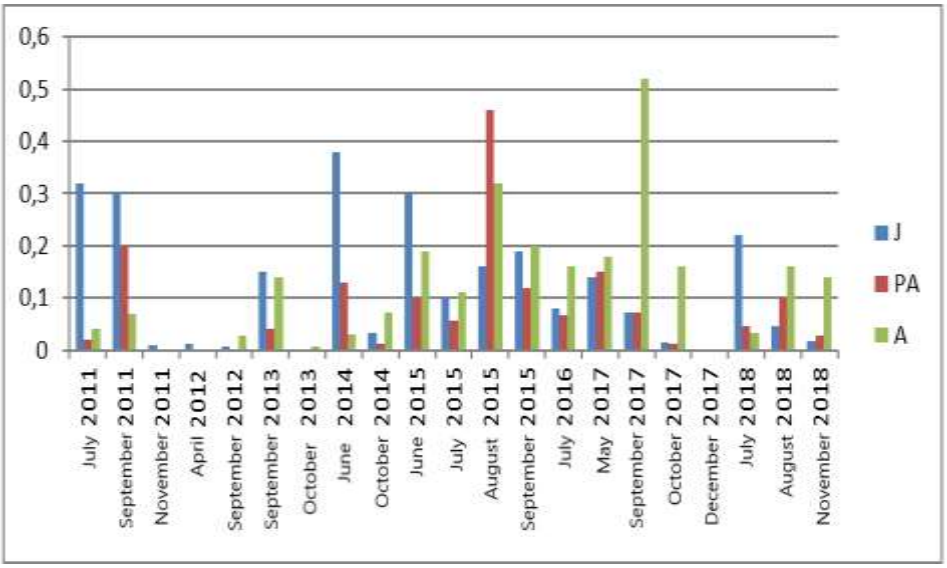

Fig. 5. Dynamics of juvenile (J), pre-adult (PA), and adult (A) populations of Artemia from July 2011 to August 2018 (ind./L).

The reproductive biology of Artemia in cold climates contributes to the fact that overwintered cysts are most viable for population replenishment in the spring when environmental conditions become favorable. The beginning of hatching, growth, survival, and the onset of reproduction are significant in terms of the annual reproductive potential of Artemia. Our results show that 0.5 to 5.0 cysts per liter are the necessary amount for successful population growth in the spring. However, there is no confirmation that this is the optimal amount for achieving maximum population growth and reproduction during the summer. For large saltwater bodies, the most commonly acceptable amount is from 5 to 20 viable cysts per liter of water [2]. "Winter cysts" (cysts that are released into the water in a state of diapause) remain in the water column at certain locations along the coast and

throughout the winter. In the spring, environmental conditions (primarily water temperature) reach a level suitable for beginning metabolic activity. This increase in metabolism inevitably ends with the hatching of cysts. Hatched Artemia - nauplii - go through a series of developmental stages, ending with the formation of a sexually mature adult (in the case of Aral Artemia, 99% are female).

The time to maturity for the first generation is about 40-45 days. However, the time required for maturation cannot be accurately calculated without more frequent sampling in the spring (preferably observing the population weekly or every two weeks). Juveniles appear in May. The first count of sexually mature females can be conducted in early June, although they may already be observed in early May. The number of sexually mature females in the studied period ranged from 0.01 to 0.19 ind./L (Fig. 6).

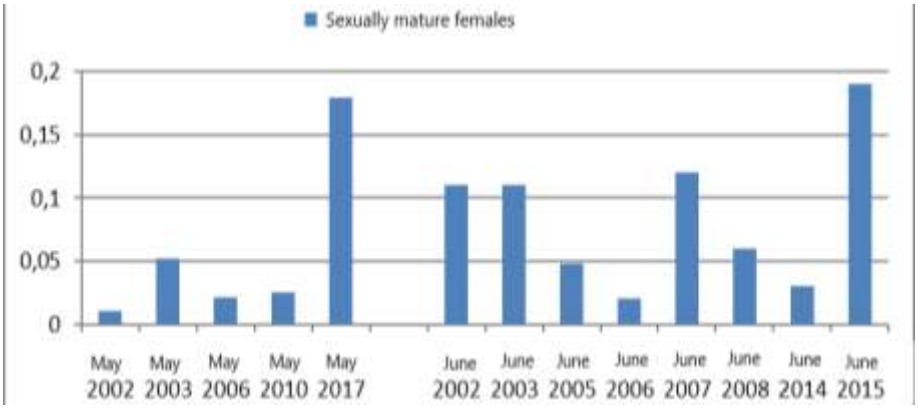

Fig. 6. Distribution of adult female Artemia in the Western Aral Sea in May and June from 2002 to 2017 (ind./l).

Based on the analysis of samples, it can be concluded that there is a significant difference in the reproduction of female Artemia throughout the year. The main form of reproduction for the first initial generation is viviparous, with the highest reproductive volumes (an average of 63.5 nauplii per individual) occurring during spring when phytoplankton is relatively abundant compared to the shorter days of late summer and autumn. A shift towards reproduction through cyst laying occurs in July-August, with more than 90% of reproduction occurring this way (see fig. 7).

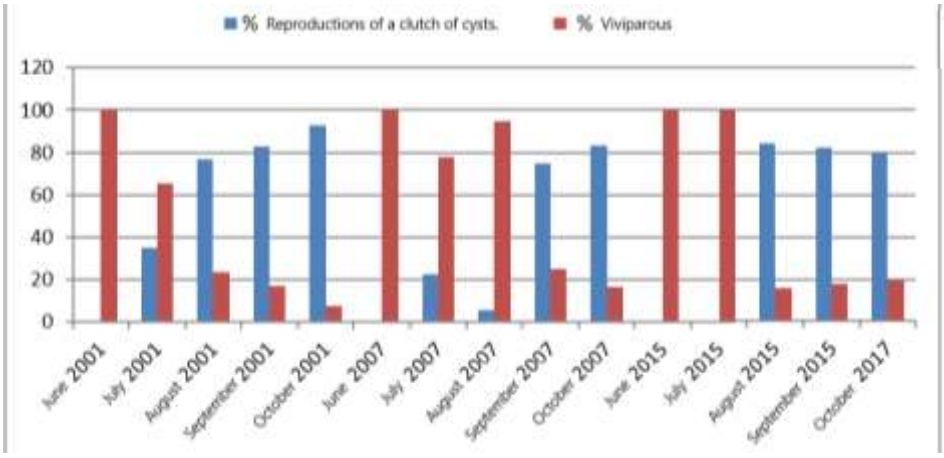

Fig. 7. Comparison of reproduction methods through cyst hatching and live-bearing populations of Artemia from the Western Aral Sea.

The seasonal temperature fluctuations in the Aral Sea force the Artemia population to reproduce using viviparous method during short periods (less than 2 months) and then switch to reproduction through cyst release to ensure the survival of their offspring. The dual reproductive strategy enables them to increase their chances of successful reproduction and passing their genes to the next generation [1,12]. Live crustaceans can immediately take advantage of the favorable conditions in their habitat, while cysts must go through a period of diapause, during which they enter a dormant state, to survive in harsh conditions (such as food shortage, low temperature, etc.) and be ready to hatch when the conditions improve. Many studies have shown that physical and chemical factors such as photoperiod, temperature, and salinity (especially photoperiod) act as symbolic stimuli for female reproduction [3, 12, 4, 14]. This life cycle strategy is inherent to the Aral Sea, and it is mainly governed by temperature and food availability.

The method of reproduction through viviparity occurs under the influence of habitat conditions - primarily factors that allow the crustacean to survive, such as an adequate food base and water temperature above 10°C. The second generation of mature female individuals usually has a short duration to reach adulthood and produces a third generation. Based on our observations, the production of summer cysts falls on the second generation, occurring from the end of June to the end of July. Subsequent reproduction in autumn and early winter practically represents only cyst deposition. This pattern is similar to the situation in other large saline water bodies [15, 5, 13].

Thus, due to significant annual climatic fluctuations, the Aral Artemia population undergoes a life history path similar to that of salt lakes with large annual temperature changes. Our research results show that the Artemia population has strengthened in the western part of the Aral Sea. The increase in salinity has led to an improvement in the conditions for the development of the Artemia population, mainly through the development of a level of mineralization at which no other species of zooplankton and fish can exist.

4 Conclusion

The results of the conducted research demonstrate a high dynamic of development of the Aral Artemia population. All age stages of Artemia - nauplii, metanauplii, juvenile stage, and adult crustaceans - are observed practically evenly throughout the Uzbekistan part of the Aral Sea every year. During the studied period, reproduction was observed both by viviparous reproduction and by cyst production, with females producing thin-shelled cysts and nauplii in addition to diapausing cysts. All of this indicates active, dynamic, and stable development of the Aral Artemia population.

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