BİOLOGY AND ECONOMİC POTENTİAL OF *ARTEMİA SALİNA* İN EXTREMELY SALİNE ECOSYSTEMS

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Abstract: Extreme saline ecosystems are water bodies formed under the influence of climatic and geological conditions, characterized by high salinity and unique physico-chemical properties. In these environments, the *"Artemia salina"* brine shrimp adapts to harsh conditions through its adaptation mechanisms. In addition to maintaining the balance of the ecosystem, the *"Artemia salina"* brine shrimp holds significant economic value as live feed in the aquaculture sector. Its remarkable ability to withstand fluctuations in temperature, salinity, and oxygen levels makes it exceptionally suited for survival in extreme environments. Due to its high resilience and nutritional profile, *Artemia* is widely used in marine hatcheries across the globe. Its role in supporting early larval development of commercial fish species underscores its importance in sustainable aquaculture. This article provides an in-depth exploration of the various functions of ecosystems and the biological adaptations of the *"Artemia salina"* brine shrimp.
Keywords: *"Artemia salina",* aquaculture, breeding, hypersaline environments.

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İntroduction:

Extreme saline ecosystems are water bodies with high salinity and unique physicochemical properties, formed by the influence of climatic and geological conditions. In these environments, the brine shrimp *Artemia salina* adapts to harsh conditions thanks to its adaptive mechanisms. In addition to ensuring the balance of the ecosystem, *Artemia salina* has great economic value as live feed in the aquaculture sector. This article provides an in-depth study of the various functions of ecosystems and the biological adaptations of *Artemia salina* in general.

Zoogeographic Distribution of Artemia Salina Crustacean:

Artemia, also known as brine shrimp, are small *crustaceans* that live in high-salinity environments worldwide. Their unique morphological and biological properties, especially their potential applications in the treatment of cancer, have made them the focus of extensive scientific research. Since the 1930s, newly hatched *Artemia* nauplii (larvae) have become the most widely used live food source in fish and shrimp farms worldwide, as they play an important role in the development of marine fish larvae.

These *crustaceans,* which belong to the genus *Artemia*, are capable of both sexual and asexual reproduction. Sexual reproduction occurs when males and females mate, while asexual reproduction occurs when females fertilize eggs without the participation of males in parthenogenetic populations. In both modes of reproduction, *Artemia* can reproduce either ovoviviparously or oviparously, depending on environmental conditions. Under favorable conditions, females produce thin-shelled eggs, which develop fully within the uterus and are born as nauplii larvae. Under unfavorable conditions, females produce thick-shelled resting eggs (cysts). These cysts can float on the surface of the water, be carried ashore by wind and waves, and survive for long periods of time as long as they remain dry (Bossier & Sorgeloos, 2020).

Figure 1. Brine shrimp *"Artemia salina"*

Artemia crustaceans have a distinctive morphology adapted to their saltwater habitats. Adults are approximately 15 mm long and have a segmented body divided into three main parts: the head, thorax, and abdomen (Lee & Nam, 2019):

• Head: Contains a pair of compound eyes, a middle eye (nauplii eye), and a pair of antennae. The compound eyes provide a wide field of vision, while the middle eye plays a role in phototaxis. The antennae help them sense movement and their surroundings.

• Thorax: Consisting of the second through eighth segments, this segment has paired appendages called thoracopods. These appendages are used for filter feeding and serve to capture microscopic algae, bacteria, and organic debris from the water.

• Abdomen: Consisting of the ninth through eleventh segments, it ends in a forked tail called the furca. The abdomen is involved in locomotion and the furca helps it move quickly through the water.

In terms of internal structure, *Artemia* has a simple digestive system, a heart that provides blood circulation, and a ventral nerve cord consisting of segmental ganglia. The excretory system consists of a pair of green glands located near the base of the antennae. The genus *Artemia* consists of both hermaphroditic species and parthenogenetic (asexually reproducing) populations. Genetic differences such as ecological isolation, variations in heterochromatin composition, different ploidy forms, and reproductive isolation are observed in the genus *Artemia.* Of the hermaphroditic species distributed in North, Central, and South America, *Artemia franciscana* has been the most studied and is considered a "superspecies" due to the reproductive isolation of some populations in nature. *Artemia* persimilis has been found in hypersaline environments of Argentina, southern Chile, and occasionally in the Mediterranean basin. Of the hermaphroditic species distributed in Europe and Asia, *Artemia salina* was once distributed in the Lymington area of England (now extinct) and in the Mediterranean region. *Artemia urmiana* is found in Lake Urmia in Iran, *Artemia sinica* in Central and East Asia, and *Artemia tibetiana* in the Tibetan Plateau of China. Several parthenogenetic populations with different ploidy levels exist in Europe, Africa, Asia, and Australia. In some saline environments, these populations coexist with bisexual populations. *Artemia* brine shrimp are widely distributed in brackish and saline water bodies worldwide, except Antarctica (Hagiwara & Yoshinaga, 2017).

Structure and Biology of the brine shrimp *"Artemia salina"*

Artemia salina is a small crustacean that lives in environments with high salinity. They live mainly in chloride, sulfate or carbonate waters, as well as in compounds of these anions. The ability to adapt to low oxygen levels in high salinity conditions and the ability to form immobile cysts (cysts) in unfavorable environments ensure their adaptation to extreme environments. The genetic diversity of *Artemia salina* is due to the duration of isolation and the effect of natural selection. Their high plasticity leads to morphological variability, which makes their systematic classification difficult. Changes in water mineralization lead to high variability in morphology. In addition, reproductive characteristics and sex ratio can also vary (Lee & Nam, 2019).

Artemia salina belongs to the thermophilic species and is particularly sensitive to heat during the reproductive period. Although adults can tolerate a wide range of temperatures, a narrow temperature range of 20-300C is required for reproduction. Their mass development is observed in water bodies with high salinity (>70 g/l), which limits the development of natural predators. In such conditions, *Artemia salina* develops practically in monoculture due to its high osmoregulation capacity, and its density depends mainly on the nutritional factor (Ogata & Morioka, 2020).

The method of reproduction has a different effect on the quantitative parameters of the life cycle of *Artemia salina*, the sex ratio and the types of egg laying. Reproduction can be carried out by live birth or by egg laying. Two types of eggs are distinguished: thin-shelled (spring) and thick-shelled, diapausing (cysts). Nauplii hatch from thin-shelled eggs immediately after their release by the mother. Thick-shelled eggs contain embryos in the gastrula stage, are covered with a thick shell and remain in diapause. The shell of the cysts consists of three well-defined layers: two chitin layers and an inner embryonic cuticle. The total shell mass of diapausing eggs is approximately 30% of their total mass (Zhou & Li, 2015).

Artemia salina cysts are usually found on the surface and in the depths of the water, accumulate on the shore and dry up. As a result of this dehydration process, the diapause mechanism is inactivated and the cysts begin to continue embryonic development when they come into contact with water under optimal conditions. The transition of diapause eggs to metabolic activity and the breaking of their shells is possible only during full hydration and under sufficient lighting conditions. The newly hatched larvae molt 7 times within 10-16 days and turn into young crabs. After 20-30 days after birth, they molt an additional 4-5 times and reach sexual maturity. The fertility of adult female *Artemia salina* and the viability of nauplii depend on the salinity of the water and the abundance of food. An individual can lay up to 200 eggs at an average interval of 3-11 days. Under unfavorable conditions, the population remains in the diapause egg (cyst) stage. Dehydrated cysts are more resistant to unfavorable conditions than hydrated cysts. Dry cysts can remain in diapause for years, but continue to develop when released into water.

The distinctive morphological features and exceptional biological properties of *Artemia salina* make them an interesting object of study. Their resistance to extreme environmental conditions and potential anticancer properties highlight the importance of continued research into the biology and applications of these organisms (Boyd & Tucker, 2012).

Reproductive Characteristics of the *Artemia salina* Crustacean:

Artemia salina populations, especially in isolated high-salinity lakes, exhibit significant genetic diversity. Geographic and ecological isolation leads to the formation of different *Artemia* species or strains, which ensure their adaptation to specific environmental conditions. For example, populations living in permanent water bodies may have a stable reproduction cycle throughout the year, while those living in seasonal or temporary water bodies produce cysts that are resistant to unfavorable conditions. In addition to sexual and parthenogenetic reproduction, the ability to form cysts also plays an important role among the reproductive strategies of *Artemia salina*. When environmental conditions deteriorate, for example, when salinity or temperature changes, females produce thick-shelled cysts. These cysts are resistant to desiccation and can remain dormant for years. When favorable conditions are restored, new individuals develop from these cysts, thus ensuring the continuity of the population (Sugumar & Philip, 2011).

The ability of *Artemia salina* to survive in extreme environments is related to their physiological resilience and versatile reproductive strategies. Their ecological role, scientific and industrial importance make it important to study and conserve these organisms in greater depth. In particular, as human impacts on hypersaline ecosystems increase, the conservation of *Artemia* populations is important to maintain their ecological and scientific value. As environmental changes and human activities affect hypersaline ecosystems, the conservation of *Artemia salina* populations is important to maintain their ecological and scientific value. These *crustaceans,* with their ability to survive in extreme conditions and their diverse reproductive strategies, are valuable model organisms for evolutionary and ecological studies (Boyd & Tucker, 2012).

The Economic and Biological Importance of *Artemia salina* brine shrimp:

Artemia salina is a unique group of *crustaceans* that have developed unique survival strategies in environments with extreme environmental conditions. These creatures form special egg forms called diapause in order to ensure the continuity of life. Diapause eggs can be stored in a dry state for a long time, preventing population decline in difficult and variable conditions. When these eggs enter water, they develop rapidly and appear as nauplii. Thus, *Artemia salina* is of great importance both biologically and economically. Diapause eggs of these crustaceans are formed in response to seasonal changes in the environment. During high salinity, temperature and other stress factors, the egg-forming mechanism is activated for the survival of the population. Diapause eggs have great commercial potential, as they can be stored in dry conditions for a long time. Keeping them in a dry state reduces transportation and storage costs, as well as allows them to be traded in accordance with market conditions. Additionally, the hatching process is extremely rapid: eggs begin to hatch within the first 15-20 hours, and this rate reaches 90% within 24-30 hours, making a significant contribution to increasing productivity in the aquaculture industry (Food and Agriculture Organization of the United Nations, 2021).

Artemia salina is also widely used as live food. After their eggs develop into nauplius stage in a short period of time, they create conditions for rapid growth and early sexual maturity of marine fish and other aquatic organisms due to their rich protein and fatty acid content. Thus, this living organism prevails as live food in aquaculture farms and has high value in terms of nutritional quality. In addition, the production of *Artemia salina* is also of great economic importance. Large-scale cultivation activities are carried out in salt basins in regions such as America and Asia. For example, production carried out in 100-hectare salt ponds with qualified and additional labor allows for an annual income of one hundred thousand dollars. This not only contributes to the regional economy, but also increases employment opportunities. From an ecological point of view, *Artemia salina* populations support the effective filtration of phytoplankton and bacteria by accumulating calcium and other ions present in the water in their bodies. In addition, *Artemia salina* populations play the role of the main food source and habitat for many bird species. Flamingos and migratory birds in particular benefit from the rich nutritional value of these creatures, thus contributing to the biodiversity of the natural environment. At the same time, *Artemia salina* has also found its place in research laboratories, being among the model organisms widely used in toxicity tests (Ogata & Morioka, 2020).

Conclusion:

The brine shrimp *"Artemia salina"* stands out with its special adaptation mechanisms in extreme saline ecosystems. Its diapause eggs ensure the continuation of the population in harsh conditions and are widely used as high-quality live feed in the aquaculture industry. This organism maintains the balance of the ecosystem by supporting the natural filtration processes of water bodies and adds significant value to the regional economy. At the same time, the biological characteristics and economic potential of *"Artemia salina"* create broad prospects for future research. Its commercial value, meeting the growing demand in local and international markets, expands development and investment opportunities in the field and contributes to the protection of the ecosystem.

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