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# The Invasive Zebra Mussel (*Dreissena polymorpha*) Literature Review and Density Reduction Synthesis

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**Abstract**: In this study, the impacts of zebra mussels on aquatic communities biology, ecology, natural enemies of the zebra mussel, effects on the ecosystems, etc. were evaluated based on the international scientific literature. In the last 30 years, zebra mussel studies have been focused on their distribution, environmental interactions, and harms in different aquatic ecosystems. With this review study, a synthesis was made from studies on zebra mussels that cause damage to many aquatic ecosystems around the world, and the hypothesis for their reduction in the ecosystem was put forward. As a result of this hypothesis, suggestions such as joining the pieces of a puzzle are presented in the last part of the review. With the implementation of the suggestions given as a result of the study, it will be possible to make a great contribution to the economies of the countries by reducing the zebra mussel, which causes a billion dollars of economic damage in aquatic ecosystems. In this context, freshwater lake, which is the most intense in America, and freshwater lake in a similar ecosystem which is rarely seen in Anatolia in Eurasia, should be studied simultaneously. As a result, by preventing the reproduction of the species causing problems in many aquatic ecosystems in the world, a great distance will be covered in terms of protecting water resources for the coming years.

**Keywords**: Freshwater mussel, invasive, aquatic ecosystem, Asia, Europe, America.

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## 1. INTRODUCTION

A biological invasion consists of a species acquiring a competitive advantage following the disappearance of natural obstacles to its proliferation, allowing it to spread rapidly and conquer novel areas within recipient ecosystems in which it becomes a dominant population (Elton 1958). Invasions have stages and there are physical or biological barriers to move from one stage to the next. Biological invasion usually consists of four stages: transportation, promotion, establishment, and expansion. These stages are separated by biological (based on the occupant's physiological or ecological characteristics) or physical boundaries (Blackburn et al. 2011). Another important concept related to biological invasions is based on how they reached a specific place. Biological invasion can be natural or artificial. Natural invasions are mostly caused by the changing geological conditions of the world. Barriers that prevent the movement of large-scale species such as oceans, mountains, rivers can be changed over time by natural processes. However, artificial effects are more unpredictable. Entries can be intentional or accidental (Blackburn et al. 2011). Also, most of economic and industrial actions have completely impact on nature. Water and aquatic ecosystems, which are important life supporters, are exposed to different environmental effects caused by human activities in the water (Selamoğlu 2021a,b). This review study synthesizes the studies on the zebra mussel, which causes destruction in many aquatic ecosystems in the world, and presents a hypothesis for its reduction in the ecosystem.

### 1.1. Literature review

Zebra mussels (*Dreissena polymorpha*) are probably one of the most famous and known invasive species on the planet. Economic and environmental issues related to zebra mussels became more recognizable in the scientific and public areas after reaching the Great Lakes. Their enormous economic costs and the serious environmental changes they cause have made them a serious problem. *Dreissena polymorpha* are bivalve freshwater molluscs native to the lakes of South Russia (Kanmaz 2015). They are typical members of the Dreissenidae family that have been on earth for 230 million years just before Trias. They were described by German zoologist Peter Simon Pallas in 1771, but samples were collected from the bottom floor of the Ural River in 1769. Southern Russia is their natural habitat.

The name "Zebra mussel" comes from non-universal striped shell patterns that are common for all members of the species (Kanmaz 2015). Zebra mussels follow external fertilization and embryology. A female individual can produce 30000 – 40000 eggs in a reproductive cycle (Ackerman et al. 1994). The planktonic developmental stage of this species depends on the water temperature and the amount of food. At the end of this period, which takes 3-5 weeks, their sizes reach up to 220 µm (Neumann and Jenner 1992). The most important reason for the rapid spread of the zebra mussel is that its females can produce 1 million eggs in one breeding season. It is adhering to a wide variety of hard surfaces with grabbing strands and its biomass can exceed 10 kg per $m^2$ (Astanei et al. 2005).

In many inland water ecosystems in Turkey (Terkos, Sapanca, Acarlar, Poyrazlar, Akgöl, Taşkısığı, Bafa, Eğirdir, Kovada, Beyşehir, Burdur and Yarışlı lakes; Hirfanlı, Kesikli, Kapulukaya, Derbent, Keban, Karakaya, Atatürk, Birecik, Karkamış, Seyhan, Aslantaş, Gazibey, İkizcetepeler, Atıkhisar, Bolu Gölköy dam lakes) zebra mussels were distributed (Özen 2017). Also, in Turkey, the reproductive biology of *D. polymorpha* was studied between March 1995 and November 1995 by taking monthly samples in the fishing area of Eğirdir Lake Bridge. Reproduction was reported to occur most intensely in July and August. The number of individuals belonging to the *D. polymorpha* population was calculated as 83.33-2541.66 per square meter. The average height of them varied between 1.51 ± 0.80 mm and 9.00 ± 2.98 mm (Bayhan 1996). The average adult individual density in Eğirdir Lake is calculated as 1985 individual / $m^2$. The average adult individual biome according to dry weight is 321.179 g / $m^2$. These values are lower than the results of many studies conducted in Europe. The average density of veliger larvae for all the lake is 97.707 individuals / $m^3$ (Koç 2009). Aksoylar and Ertan (2002) found the average density of *D. polymorpha* veliger larvae in Lake Eğirdir as 3.103 individuals / $m^3$. In the study conducted in the same lake in 2016, the average densities of mature *Dreissena* were calculated as 12.782 individuals / $m^2$ in Hoyran region, 1.683 individuals / $m^2$ in Kayaağzı region, 5.247 individuals / $m^2$ in Barla region, 6.171 individuals / $m^2$ in Köprü region, 6.039 individuals / $m^2$ in Gelendost region. The average of all stations is reported to be 7.511 individuals / $m^2$ (Erbatur et al. 2017). The fact that Kayaağzı is the narrowest part of the lake in the north-south direction of Lake Eğirdir and where continuous wind and wave movements are most intense, it is likely to affect the distribution of this species in this region (Figure 1) (Apaydın Yağcı et al. 2020).

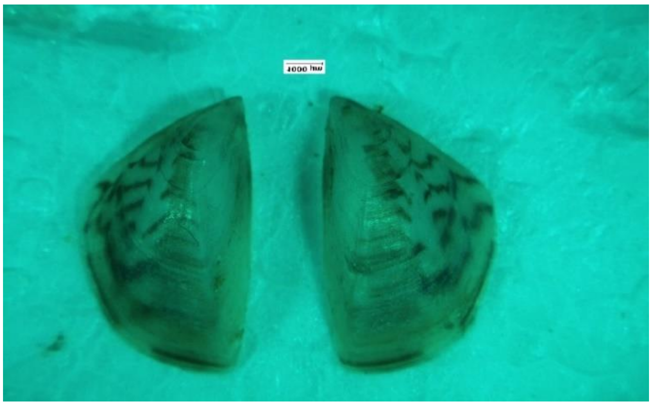

**Figure 1.** *Dreissena polymorpha* from Lake Eğirdir-Turkey (Apaydın Yağcı et al. 2020)

Grigorovich and Shevtsova (1995) calculated the adult *Dreissena* density as 20300 individuals / $m^2$ and their biomass as 4000 g / $m^2$ in their study in Kakhovka Canal in Canada. A negative relationship has been found between the Dreissenid biomass and the zooplankton biomass in the same study. Furthermore, in the bridge station of Eğirdir Lake, Turkey, it was investigated on seasonal variation of the chemical compositions of *Dreissena polymorpha* from bivalve molluscs. Samples were collected seasonally between November 1990 and August 1991. In *D. polymorpha* meat, moisture is 85.3%, dry matter is 14.7%, crude protein is 63.0%, crude oil is 9.2%, crude ash is 15.8%, carbon hydrate is 12.0%, calcium from mineral substances is 14, 80 mg / gr, magnesium 0,14 mg / gr. The energy level was found to be 4.9 kcal/gr in *D. polymorpha* meat (Arık 1992).

Zebra mussels show nutrition by filtering. They consume algae by filtering the water with their siphons. Due to their sessile structure, they need water flow for this process. This is the reason why they prefer to foul pipes with a steady flow of water (Kanmaz 2015). They are monotypic colonists and are extremely successful in attaching to almost every possible surface using their byssus, which is a rare feature for a freshwater bivalve. These surfaces can be natural or artificial. Another organism and even the shells of each other are possible options for them. After the zebra mussel hangs on, it begins to erode the surface and deteriorate its integrity. It stays where it hangs on during its 3-9 years of life. If there is no hard surface to hang on, they form a cluster and hang on top of each other. They also get attached to macro invertebrates during periods of excessive alluviation and fluctuations (Kanmaz 2015). Temperature; According to Zmis (2001), feeding rates decrease after 20 ºC, the best development starts between 18-20 ºC and the ovulation period starts between 8–12 ºC. PH: The pH threshold required for the survival of adults is given as 6.5, and it is recorded that the pH varies between 7.7 and 8.5 in lakes where zebra mussel lives in Europe (Claudi and Mackie 1994; Zmis 2001). The feeding rate increases as the algae rate in seston increases. The development of zebra mussel is related to nutritional quality, not seston concentration (Schneider et al. 1998). Oxygen; In studies conducted in Europe, it has been noted that zebra mussel adults can live in waters with oxygen levels of 0.1–13.3 mg / l, but the potential for mussels to be low in oxygen at less than 4.5 mg /l. Salinity; It is noted that zebra mussel is a freshwater creature but can live in waters with salinity 5‰. Chlorophyll-a; Feeding effect of zebra mussel on phytoplankton causes a decrease in chlorophyll-a amount (Altınyar et al. 2001). The flow rate of water; Young mussels (juveniles) hang on and settle in pipes or underwater areas where the flow velocity is less than 1.5 m / s (Zmis 2001).

As a result of the salinity of Bafa Lake, which was 4 ‰ in previous years, increased to 14 ‰ in recent years, it was noted that there is no zebra mussel in the lake (Altınyar et al. 2001). The history of zebra mussel infestations dates back to the eighteenth century. The underlying reason for their rapid invasion is the construction of artificial watercourses connecting the European rivers. The ships carried them to ballast tanks and hulls. In 1794, zebra mussel was observed in Hungary by the German Zoologist Grossinger. Their presence in the UK and Ireland was documented in the 1820s. *D. polymorpha* was first recorded in The Netherlands in 1827 (Van Benthem Jutting 1954). They reached Sweden in the 1920s (Benson et al. 2020; Kanmaz 2015). In 1988, they were discovered at Lake Claire at first, but further reviews showed that the estimated first entry date was 1986. It was the beginning of the zebra mussel infestation in North America. They are thought to be transported by ships. It was discovered in the eastern basin of Lake Erie in 1988, and only a year later they occupied the entire lake. In the following years, the Great Lakes were completely occupied. Zebra mussel was spotted from Lake Michigan in 1992. Today, zebra mussel infestation still continues despite all measures (Holland 1993). In Ireland, it is believed that the first introduction of the zebra mussel took place in the lower Shannon system in 1994 (Lucy 2010). The *D.poymorpha* species spread from the natural distribution in the Pontacaspian region and entered Eurasia and North America (Stepien et al. 2013; Yoo et al. 2014). Zebra mussel is an important part of this loss of biodiversity in the Great Lakes. (Ricciardi et al. 1998). In Turkey in 2015, North America's invasion of zebra mussels in the Great Lakes, was modeled using individual-based modeling methods (Kanmaz 2015). The nutritional activity of *Dreissena*; turbidity is limited by algae rate, feces, and pseudofeces production. As the concentration of the spherical single cell *Chlamydomonas reinhardtii* with a diameter of 7.4 µs increases, the turbidity decreases, while the Pandorina increases the purples, the turbidity increases. As the concentration of *C. reinhardtii* increases, larger mussels are seen rather than small mussels. It immediately extracts microcystis and other blue-green algae as pseudofeces. *Microcystis* becomes more prevalent in zones with low nutrients due to zebra mussel infestations.

### 1.2. Natural enemies of zebra mussels

The natural enemies of *D. polymorpha* are predators, parasites, birds, and benthic organisms such as crayfish and crab, (Molloy et al. 1997; Altınyar et al. 2001). *Abramis bjoerkna, Alburnus alburnus, Atherina boyeri, Barbus capito pectoralis, Carasobarbus luteus, Cyprinus carpio, Esox lucius, Oncorhynchus mykiss, Scardinus erythohthalmus, Stizostedion lucioperca,* and *Tinca tinca* are predators fish fed on juvenile or adult *D. polymorpha* (Molloy et al. 1997 and references therein; Altınyar et al. 2001). It was stated that rockfish is an important consumer of zebra mussels and the fishing pressure of these fish might have a significant impact on populations of this species in ecosystems with a lot of zebra mussels (Gaygusuz et al. 2007). Tufted Duck and Pochard feed almost exclusively on zebra mussels, whereas Coot and Goldeneye consume them as main and supplementary food (Suter 1982 a,b). Fishing rates of Tufted Duck have been determined to decrease depending on the water depth in Belgium (Draulans 1982). The size of the zebra mussels also should take into account for feeding preferences of birds. For example, Greater and Lesser Scaup in Lake Erie preferred zebra mussels 11 to 13 mm in length (Hamilton et al. 1994), while scaup (primarily Lesser Scaup) in Lake Michigan preferred zebra mussels 4 mm in length.

Crustaceans feed on a different stage of zebra mussels. The predatory copepod *Mesocyclops* may feed on planktonic larvae of *D. polymorpha* (Karabin 1978). In addition to this, *Dreissena* larvae are especially vulnerable to predation by calanoid copepods until the development of their first D-stage Shell (Liebig and Vanderploeg 1995). For example, it was reported that the abundance of *D.polymorpha* was low in Lake Eğirdir due to the abundance of, *Mesocylops leuckarti* during the year (Apaydın Yağcı et al. 2014a). Benthic organisms are also important predators of zebra mussels. Cage experiments in the Hudson River commit that blue crabs could be more effective in reducing zebra mussel abundance than either local fish or invertebrate predators (Molloy et al. 1997).

Malinowskaya, (1976) surveyed that in the Kyshunskoe Reservoir (Kazakhstan) zebra mussels were a predominant food item for *Astacus leptodactylus* females, whereas males ate mainly vegetation. It was determined that coelenterates, turtles, rodents, and annelids species feed on zebra mussel in various water systems (Conn and Conn 1993; Serrouya et al. 1995; Bedulli and Franchini 1978; Smit et al. 1993). Moreover, the recent increase of the crayfish population in Lake Eğirdir may derive from feeding regime of crayfish based on zebra mussel. However, some researchers claimed that zebra mussels present crayfish a with very good camouflage ability to protect them from predators in addition to a potential food relationship (Cilbiz et al. 2019). However, so many different organisms were reported in the mantle cavity of mussels. It is known that some of the host-specific ciliates *(Conchopbthirus acuminatus, C. klimentinus, Hypocomagalma dreissenae, Sphenophrya dreissenae,* and *S. naumiand)* are in the mantle cavity of *D. polymorpha* Also, it has been reported that Ciliates in the families Ophryoglenidae, Ancistridae, Scuticociliatida, and Rhynchodida live in the mantle cavity of zebra mussels (Molloy et al. 1997). Zebra mussels can be to serve as the first intermediate host (e.g., *Bucephaluspolymorphus* and *Phyllodistomum* spp.), second intermediate host (e.g., *Echinoparyphium recurvatuni),* or the only host *(Aspidogaster* spp.). Besides, it was reported that Ascetosporans, Bacteria, Nematodes, Oligochaetes, Leeches, Chironomids, and Mites species are in the mantle cavity of *D. polymorpha* (Molloy et al. 1997).

The trophic state of the lakes also impact the increase of zebra mussels. They mostly reported from mesotrophic lakes and, eutrophication causes a reduction in zebra mussels population. (Stánczykowska and Lewandowski 1992). It also has been noted that turbidity negatively affects the feeding of mussels and the ability to filter decreases as turbidity increases (Claudi and Mackie 1994). In addition, It has been reported that the Zebra mussel changes as to some water quality parameters (secchi disc, chlorophyll, and phosphorus) in the ecosystem, and also bioenergetic application has been reported with the ingestion of algae in the environment by zebra mussel. (Madenjian 1995). In Karacaören I Dam Lake, Turkey, it has been reported that a small number of *D. polymorpha* veliger larvae were encountered, and also it has been reported to adversely affect the larval population because the water level is falling rapidly and the very narrow littoral zone (Gülle 2005).

### 1.3. Environmental and economical impacts of zebra mussels

Feeding filter zebra mussels increase the clarity of the water by filtering and removing the both organic and inorganic particles in the water. In Lake Oneida, after the zebra mussel infestation in 1991, an average increase in water clarity occurred. After the zebra mussel infestation in the lake, there was a 23% increase in light transmittance. The maximum spreading depth of the macrophytes was measured by the divers by hydroacoustic methods and was found as 3.0 m before the zebra mussel infestation, and then 5.1 m (Zhu et al. 2006).

The clarity in large lakes allows the light to flow deeper, thereby providing more benthic photosynthesis. These changes in light positively affect the composition and distribution of the aquatic macrophyte and algae communities. On the other hand, dreissenid mussels facilitate the transportation of plants to nutrients. The development of aquatic macrophytes mostly depends on the phosphorus and other nutrients in the sediment. The mussels carry nitrogen and phosphorus along with the particles from the water column to the sediment through defecation (Zhu et al. 2006). It is reported that benthic production increases in lakes after the invasion of *D. polymorpha*, which affects the food chain (Jaeger 2006). Zebra mussel infestation also affects the zooplankton community. Zebra mussels can absorb microzooplankton, such as veliger and rotifer, but cannot absorb mesozooplankton (0.2-20mm). After the invasion of Lake Erie, the abundance of zooplankton decreased by 55%. Microzooplankton was particularly affected by this. Both large-bodied zooplankton and microzooplankton were affected by 70% reduction in the Hudson River (Benson et al., 2020). Since *Cryptomonas erosa* and *Nannochloropsis limnetica* algae are high quality foods rich in PUFA, they have positive effects on the reproductive success of zebra mussel (Wacker and Elert 2003).

The change in the food chain will also affect the fish. Increasing competition will cause a reduction in the zooplankton biomass, and thus decrease of planktivorous fish biomass will occur. Fish larvae, which fed with microzooplankton, will be more exposed to the negative effects of zebra mussel infestation. Fish that fed on benthic can benefit from this in contrast with planktivorous fish. Changes in the diet of pelagic fish can be seen. Also, the reproduction of macrophytes can change the habitat of the fish. Experiments have shown that zebra mussels negatively affect the development of fish larvae due to their food chain interactions (Benson et al. 2020). It was determined that the primary negative effect of dreissenides on zooplankton was consuming small-bodied zooplankton as feed, the secondary negative effect was consuming food sources of zooplankton, and the third negative effect was decreasing benthic oxygen (Grigorovich and Shevtsova 1995). In open waters, Zebra mussels hang on clams, preventing the functioning of the valve, pressing on the siphon, partnering with the food, limiting its movement and metabolic residues. It eliminates the host with negative effects in the form of evacuation (Benson et al. 2020). The Zebra mussel is a notorious organism due to its biofouling effect (Yıldırım et al. 1996). It causes problems such as blocking the water flow by filling the pipes with the cluster formed on the surface it hangs on, preventing the corrosion of the boats, blocking the water filters, preventing the healthy operation of the boats by entering the engine parts, raising the balance of the boats by clinging to the spine of the boats, increasing the friction coefficient, restricting the life of other creatures naturally found in the aquatic ecosystem. opening it causes both economic and ecological problems (Bobat et al. 2004; Aksu and Yıldız 2017). It settles in pipes in hydroelectric and nuclear power plants. In these systems, they can stop the flow of water by blocking the inside of the pipes. (Benson 2020). It was found that mussels belonging to *Dreissena* were excessively reproduced in lakes and trout breeding farms in lattice nets and ropes attached to them, and they caused problems in cleaning the nets for fishermen (Öktener 2004). It settles in the cooling systems of boat engines, causing overheating and damage to the engine. Intense contamination occurs in transportation buoys and many of them become unusable (Altınyar et al. 2001). Mussel problem in Turkey was reported to occur in the Kovada I Hydroelectric power plant for the first time in 1964. Then, it was recorded that the tunnel and penstock pipes of the Kovada II Hydroelectric Power Plant were covered with mussels and thus the flow rate decreased (Anonymous 1969). It was reported that the damages caused by mussel; the in water transmission facilities are hundreds millions of dollars, in power plants in the period 1993-1999 are $ 3.2 billion in the USA and Canada, in industrial plants and workplaces are 5 billion dollars, and in power stations is 375,000 dollars for each station(Altınyar et al. 2001).

Also, bird botulism is another consequence of zebra mussel infestation. Because of the toxic substances, they accumulated through filtering, they caused thousands of bird deaths fed on them. They can reach any place containing water in the larval stage. For example, pipes create substrates that are quite suitable for them. They continue to colonize until a pipe is partially or completely blocked. For this reason, one of the most typical damages they cause is to supply pipes and power generation stations that supply drinking and processing water to cities and industrial facilities. Zebra mussels also have an impact on ships and docks. They increase the drag by being attached to the hulls of the ships. It increases fuel consumption. In the United States, zebra mussels cost $ 500 million annually to industrial establishments that consume water (Kanmaz 2015). It is noted that zebra mussel communities in the western part of Lake Erie filter the entire body of water once a week. As a result, suspended solids accumulate at the bottom by filtration and their water qualities improve. Therefore, mussels are used in Russia and the Netherlands to clean contaminated water bodies (Neumann and Jenner 1992). It is reported that zebra mussel has a bioindicator feature and it can be understood by looking at the shell composition whether there are any toxic substances in water (Bartram and Balance 1996).

### 1.4. Ecological competitors of zebra mussels

Different organisms were reported as ecological competitors of zebra mussels in the literature such as sponges, amphipods, and bivalves. Sponges; Zhadin (1946) also stated the ability of sponges to compete successfully against zebra mussels in Lake Balaton. Amphipods; The presence of *Dreissena* in rocks increases the amphipod density (Quin 2007). Zebra mussels have been reported to be rare in areas where the *Corophium curvispinum* population (Lake Balaton and Lower Rhine) is located. Also, *C. curvispinum* became the most dominant macroinvertebrate species, and densities of zebra mussels were dramatically reduced in Dutch Rhine (Molloy et al. 1997). Sebestyen (1937) indicated that the establishment of this amphipod in Lake Balaton is facilitated by the appropriate substrate offered by countless crevices in mussel colonies, and the population is dense, zebra mussels are rare. It is stated that *C. curvispinum* species from Malacostraca group is very abundant in the Black Sea and the Caspian Sea, and it is likely that it has arrived at Anatolia through large rivers such as Sakarya, Kızılırmak, and Yeşilırmak. It was stated that the *C. curvispinum* species, which was first registered from Egirdir Lake in 2003, could be a Tethys Searemnant (Özbek 2003). Significant reductions in *D. polymorpha* species populations have been reported in areas where the pollution-tolerant *C. curvispinum* species are found. In the studies carried out in the lake before the 2000s, *C. curvispinum* species was not reported and *D. polymorpha* species was observed abundantly in Eğirdir Lake during these periods. Although the *C. curvispinum* species was found in all stations in Barla station especially in Eğirdir Lake in 2010, the rare occurrence of *D. polymorpha* species is supported by the literature. *C. curvispinum* species Eğirdir Lake played an active role for zoobenthic fauna (Apaydın Yağcı et al. 2013; Apaydın Yağcı et al. 2014b). Bivalves; Some bivalve species (for example, when *Mytilaster lineatus* was found in the Caspian Sea, Mediterranean, Black, and Azov Sea in the 20th Century, the density of the *Dreissena andrusovi* species in the Caspian Sea decreased (Starobogatov and Andreeva 1994). In the Great Lakes (in the Great Lakes *Dreissena bugensis* is expanding in areas where *D. polymorpha* is dominant (Molloy et al. 1997).

Macrophytes; It is stated that zebra mussels colonies decrease in the areas where *Cladophora* is located (Sebestyen 1937). At the same time, it was stated that there are no *zebra mussels* colonies in the stone fragments covered with macroalgae in the Rhine and Meuse Rivers (Smit et al. 1993). In the St. Lawrance River (New York) adult zebra mussels have been reported to be killed by the Bryozoan *Pectinatella magnifica* species (Conn and Conn 1993).

Parasite; Only one parasite, trematode *Bucephalus polymorphus*, is well documented to be seriously debilitating to zebra mussels in Europe. However, the freshwater trematodes in the Bucephalidae (e.g., *Bucephalus*) and Gorgoderidae (e.g., *Phyllodistomum*) have been demonstrated as parasites in the North American fauna. Efficiency in reducing *Dreissena* density consistently over the long term has not yet been demonstrated. As in Europe, there will be the cumulative effect of a group of enemies that have a continuous but limited role in suppressing zebra mussel populations in the future (Molloy et al. 1997).

## 2. Conclusion and future prospectus

In Europe and the former Soviet Union, there is a long tradition of *D.polymorpha* work, where it has been around for 150 years. The ecosystem and community level effects of *D.polymorpha* are reported in the literature in Lake Erie, Saginaw Bay, Hudson River, and Oneida Lake (Benson et al. 2020). Considering the last 25 years in Eğirdir Lake (Turkey), it has been observed that the *D.polymorpha* has increased 3 times in the period from the past to 2016. According to the international records, the density is 10 times lower compared to Eğirdir Lake. Strayer et al. (2019) analyzed 67 long-term data sets from 50 different studies in Europe and North America with joint researchers. The results of the study expressed the importance of understanding Dreissenid mussels long-term population dynamics and mechanism. In addition, understanding the dynamics in the Freshwater ecosystem has been stated as the most important indicator in controlling zebra mussels (Strayer et al. 2019). Considering the studies conducted with *Dreissena* from past to present, the following 13 items conclusions can be made.

a) With the invasion of *Dreissena*, light transmittance, macrophyte, and benthic production increase.
b) Algae bursts may occur because the zebra mussel does not use some algae in phytoplankton.
c) Zebra mussel invasion is effective in reducing zooplankton.
d) Some fish, crayfish, crab, birds feed on zebra mussels.
e) *Mesocyclops leuckarti*, which is Zooplankton, consumes the zebra mussel.
f) Zebra mussel has water cleaning feature.
g) When birds consume zebra mussels, mussels may be toxic in dense areas.
h) The development of fish larvae is negatively affected when the zebra mussel limits the life of the fish larvae.

i) The *C.curvispinum* species was not found intensely in environments where *D.polymorpha* is present.
j) *C.curvispinum* plays an active role in fauna in the ecosystem.
k) In areas with *Cladophora*, Bryozoan, and some Bivalve species, *D.polymorpha* is scarce.
l) In the ecosystem with Trematode *Bucephalus polymorphus* parasite, *D.polymorpha* invasion is less.
m) In the ecosystem where *D.polymorpha* is located, other dominant *Daphnia* species replace the existing *Daphni*a species.

According to the above-mentioned statements, it has been observed that more than one living group is effective in the absence of *Dreissena*, which creates a big problem in the waters (See the above section d, e, i, k, l).

We can piece together the puzzle by using the findings of the related literature. How can we achieve this. In order to end the *Dreissena* invasion in the ecosystem, we have to work compulsory for 3 year on a monthly basis, in the simultaneous periods of *Dreissena*'s low water body and the intense aquatic ecosystem. In the ecosystem, we can see which species *Dreissena* interacts within approximately 30 years of studies. It will guide us to find the most important factor in the increase of this creature as a result of 3 year monitoring of all parameters of the two lakes in the ecosystem (water quality, plankton, benthic organisms, fish fauna, birds, other invertebrates, fish stomach content studies, etc.). At different times, plankton, water quality, parasite, etc. studies have been done so far. The simultaneous study of two different lakes, which is the last study not done with a holistic approach, maybe the most important key in achieving the result. It is an undeniable fact to carry out this study to protect the water and aquatic ecosystems that may be the most important problem of the future, to manage them properly, and to meet the needs of people from these areas in the future.

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N/A

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**Conflict of Interest**
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