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19. Risk assessment analysis of the selected Invasive Alien Secies (IAS) in the Lakes of the Kızılırmak Deltaic Area

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Abstract: Our world has been threatened by many vectors such as chemicals and biological pollution, overpopulation, and climate change. Each of these threats is changing the quality of life of living organisms. Invasive alien species have one of the most catastrophic impacts on their invaded area. The Kızılırmak Deltaic area is a naturally protected area and it has three levels of protection to protect the sustainability of the natural resources and at the same time support the public economy. 7 IAS species were chosen for making risk assessments. The method for evaluation of the risk levels of the species was “A minimum set of standards for the risk assessment of alien species (MSRAS)” According to this method, ***Carassius gibelio*****,** ***Gambusia holbrooki*****,** ***Gambusia affinis*****,** ***Pseudorasbora parva*****, and** ***Mnemiopsis leidy****i* were found the most invasive species in the aquatic system in the delta. ***Rapana venosa*** has a moderate (medium) impact on the aquatic environment and they are high economic income resources for the public who live in the delta. ***Mugil soiuy*** has a low impact of the delta ecosystem's. ***Mugil soiuy*** is a economicaly valuable IAS for the local people.
Keywords: Invasive alien species (IAS), Kızılırmak Delta, aquatic environment, fishes, invertebrates, risk assessment

INTRODUCTION

Our world has been threatened by many vectors such like chemicals and biological pollution, overpopulation, and climate change. These threats will force human beings to struggle with these great problems for centuries even in future. While human beings have a chance to live much more comfortably with technological developments, they also cause changes of the world's future who they live in, both themselves, plants and animals living around them.

The deltas are very delicate, fertile environments and they support all ecosystem services. The Kızılırmak Delta is cover 56.000km^2 and 11.600 km^2 of it’s wetland areas. The combination of different habitats (habitats) such as sea, rivers, lakes, reeds, swamps, meadows, pastures, forests, sand dunes, and agricultural areas have provided the delta to have a uniquely important biological diversity. Kızılırmak Delta is the only wetland on the Black Sea coast that has not lost its delta feature. 22,000 hectares of this area was declared RAMSAR area in 1998. 5,174 hectares of land have been declared as a wildlife development area. It was determined to be a habitat for waterfowl in 1994 (MEU, 2019) (Figure 1).

One of the important and long lasting and not reverse threats on human being and biodiversity might be considered invasive alien species. The EU regulation (EU No: 11141/2014) has explained the introduction of the species from their natural habitat to another that the appearance of alien species, whether animals, plants, fungi, or micro-organisms, in new locations is not always a cause for concern. However, a significant subset of alien species can become invasive and have a serious adverse impact on biodiversity and related ecosystem services, as well as other social and economic impacts, which should be prevented. Some 12.000 species in the environment of the Union and in other European countries are alien, of which roughly 10 to 15 % are estimated to be invasive. The definition of the alien species is "a species, subspecies, or lower taxon, introduced outside its natural past or present

distribution; includes any part, gametes, seeds, eggs, or propagule of such species that might survive and subsequently reproduce" and invasive species is " an indigenous or nonindigenous species that spreads, with or without the aid of humans, in natural or semi natural habitats, producing a significant change in composition, structure, or ecosystem processes or causing severe economic losses to human activities " (CBD COP6 Decision VI/23, 2002; Copp et al.,2005 respectively).

There can be considerable confusion definitions and delimitation of the describing risk analysis and associated processes such as risk assessment. The wide explanation for the “Risk assessment” can be defined as “the evaluation of entry, exposure and consequence” (Roy et al., 2017).

The IAS risk may invade by global trade, transport, tourism, and climate change. The threat to biodiversity and related ecosystem services that invasive alien species (IAS) pose takes different forms, including severe impacts on native species and the structure and functioning of ecosystems through the alteration of habitats, predation, competition, the transmission of diseases, the replacement of native species throughout a significant proportion of range and through genetic effects by hybridisation. Furthermore, invasive alien species can also have a significant adverse impact on human health and the economy (EU 1141/2014) and their impact on the ecosystem is very much severe as it causes irreplaceable damage on the invaded areas.

There are some methods to determination of the risk states of the IAS in their invaded area. One of the method is called Convention on Biological Diversity (CBD) as a guide to assess the risks of alien species invasions. Its principle is for the prevention, introduction, and mitigation of impacts of alien species in their threaten ecosystems, habitats, or species (CBD COP6 Decision VI/23 2002). the CBD has three approaches, The precautionary approach (eradication, containment, and control), 3-stage hierarchical approach (preventing the introduction, early detection, and rapid action) and ecosystem approach. Another method for determination of the IAS risk assessment is called DPSIR (driving forces–pressures–state–impact–response) recommended by The European Environmental Agency’s method. "Minimum standards for the risk assessment of alien species" (Roy et al., 2017) method is also used for the risk assessment which was used in our study under the IASON (CBC-BSB-1121) project.

This manuscript consist of a part of the IASON (CBC-BSB-1121) project, which is the evaluation of the Kızılırmak Deltaic area aquatic IAS species risk assessment.

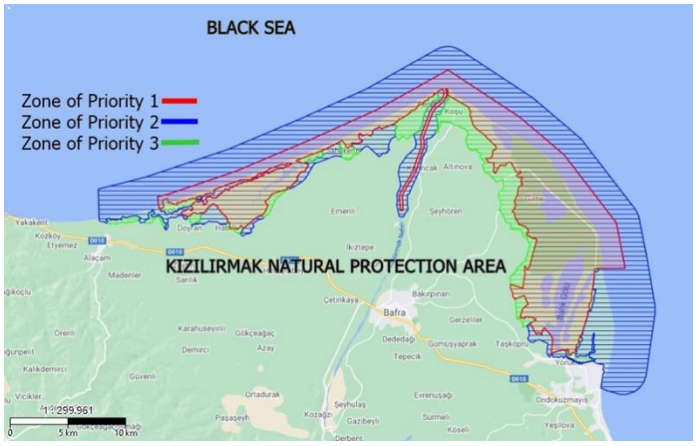
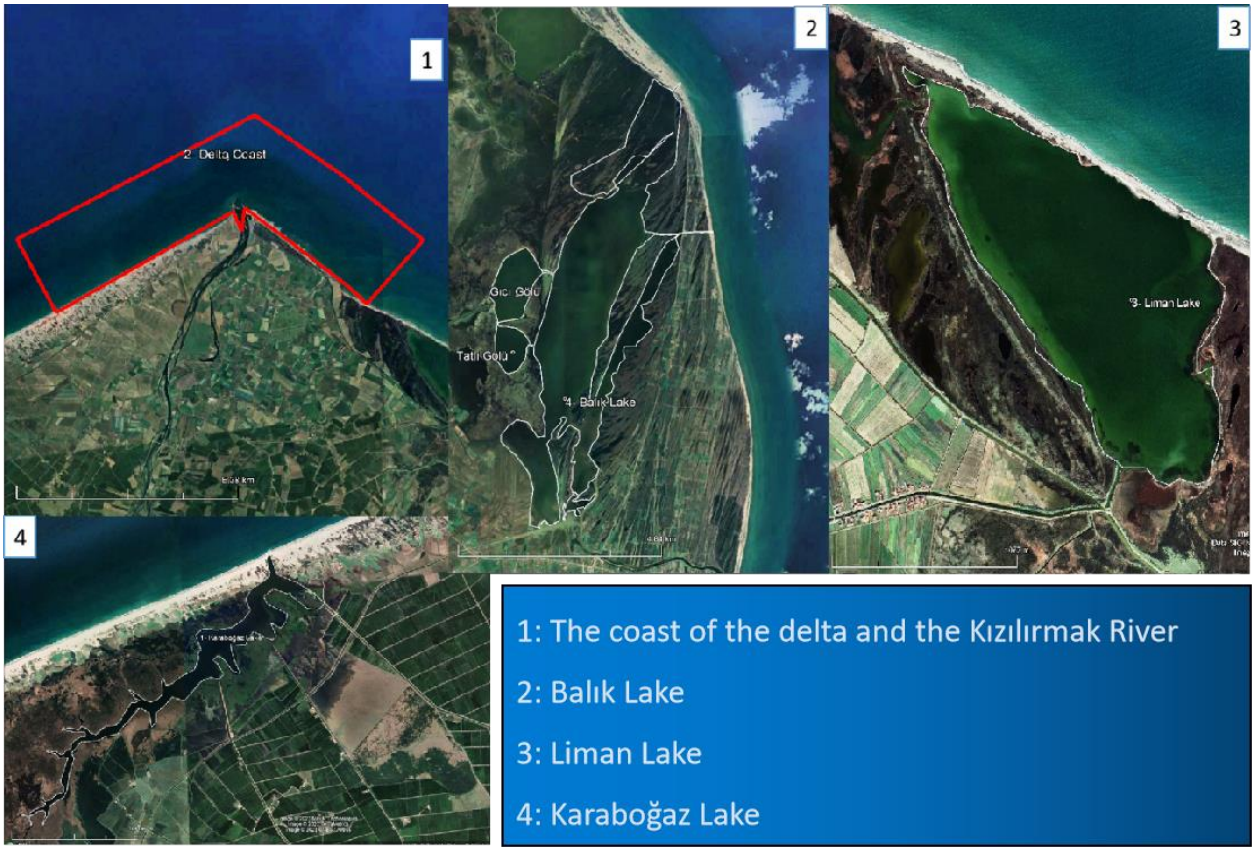


Figure 1:Red zone : Priority 1:Natural Protected Area no activity is feasible other than any scientific study for the purpose of protection. Blue zone: Priority 2: Natural Protected Area which might be put into service considering the public interest, along with protection and improvement of the natural structure. Green zone: Priority 3:Natural Protected Area of which might be put into service for house building, considering the potential and utilization of the locality with protecting and improving the natural structure (MEU, 2019).

MATERIALS METHODS

Sampling area

Kızılırmak Delta is one of the longest rivers of Türkiye and the only deltas on the Turkish coast of the Black Sea. The sampling areas were three lakes (Balık, Liman, and Karaboğaz Lakes), one along the Kızılırmak River, and one on the mouth of the Kızılırmak River discharge into the Black Sea were sampled. The sampling was not at a point station but at many places in the sampling sites. The map and the coordinates of the sampling areas were demonstrated in Figure 2 and Table 1.



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Figure 2. Sampling areas in The Kızılırmak Delta (modified from MEU, 2019)

Table 1. Sampling sites and coordinates

Sampling site	Sampling Coordinates
Lake Balık	41°33'13.59" N- 36° 5'9.34" E ;41°33'44.81" N- 36° 4'35.83" E
Lake Liman	41°41'34.06" N- 36° 1'11.19" E ; 41°41'23.36" N- 36° 1'23.64" E
Lake Karabogaz	41°40'39.76" N- 35°48'19.88" E ; 41°40'35.96" N- 35°48'7.71" E
Kızılırmak coast	41°43'22.63" N- 35°53'47.91" E; 41°43'13.21" N- 36° 0'12.07" E
Kızılırmak river	41°43'44.52" N- 35°57'24.28" E; 41°39'16.81" N- 35°54'51.51" E

Selecting and collecting samples:

7 marine/brackish water IAS species were sampled according to the requirements of their species specifications. Fishes were sampled with Gilnet (Length: 300 m; mesh size: 6, and 8 cm; time: 12h) and electroshock invertebrates (Rapa whelk) were collected by beam trawl in the sea coast of the Kızılırmak River. The beam trawl used was identical to the ones used by professional dredge 3 m in length, and

0.6 m in height, with a 1 m in cod-end length, 90 mm mesh sized net bag. The zooplankton samples were collected horizontally tow by Hensen plankton net (mount opening 50 cm, mesh size 200 µm).

Risk methodology:

The selected method for the assessment of the IAS risk level for the selected IAS in the Kızılırmak Delta's aquatic area is called "A minimum set of standards for the risk assessment of alien species (MSRAS)" (Roy et al., 2017). The MSRAS method was based on "EU regulation 1143/2014" which consisted of the international convention, and scientific expert decisions. "A minimum set of standards for the risk assessment of alien species method (MSRAS)" has 14 descriptors;

1. Description taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio- economic benefits),
2. Likelihood of introduction, establishment, spread and magnitude of impact,
3. Description of the current and potential distribution, spread and magnitude of impact,
4. Inclusion of multiple pathways and vectors of introduction and spread both intentional and unintentional,
5. Assessment of environmental impacts with respect to biodiversity (and ecosystem) patterns and processes,
6. Assessment of adverse impacts with respect to ecosystem services,
7. Assessment of adverse socio-economic impacts,
8. Status (threatened or protected) of species or habitat under threat,
9. Possible effects of climate change in the foreseeable future,
10. Data limitations,
11. Information sources,
12. Summary of the different components of the risk assessment in a consistent and interpretable form and an overall summary,
13. Uncertainty (confidence),
14. Quality assurance,

RESULTS AND DISCUSSIONS

IAS risk assessment analysis was started with selected species from previous studies. The list was consisted of 26 species which were 9 fish species, 4 crustaceans,1 bivalve, 5 zooplankton, 5 phytoplankton, 1 macro algae. The list was revised according to the monitoring studies, expert decisions, fishermen observation. During the monitoring studies caught fishes/invertebrates and the public reaction have been taken into account also. At the end, 7 species were chosen for the further risk analysis. Phytoplankton species was not included in the risk assessment analysis because of the direct impacts of them were not noticed by fishermen and public but very important for ecosystem services.

The highest number of the IAS species under the investigating taxons was Pisces. The most surprising results were that very small fish species were threatening the aquatic area of the delta and their negative effects on the environment were not taken into account by fishermen and decision-makers and the public. The pressure of these secret enemies has been growing everyday (Panov et al., 2009).

The results of the risk analysis (MSRAS) are demonstrated in Table 2. The level of the risk assessment was three levels which were low (1), Medium (3) and High (5). 2

Table 2: The results of the risk assessment of alien species (MSRAS) in the Delta "

Species	**Risk Level** Low (1), Medium (3) High (5)
Carassius gibelio (Bloch, 1782)	High (=5)
Gambusia holbrooki (Mosquito Fish)	High (=5)
Gambusia affinis (S. F. Baird and Girard, 1853)	High (=5)
Pseudorasbora parva (Temminck & Schlegel, 1846)	High (=5)
Mugil soiuy (Basilewsky, 1855))	Low (=1)
Mnemiopsis leidyi (Agassiz, 1865)	High (=5)
Rapana venosa (Valenciennes, 1846)	Medium (=3)

The results of the risk analysis were;

1. Kızılırmak Deltaic area's aquatic environment has been miserable from many invasive alien species. 26 aquatic IAS species have been selected at the beginning of the study. The number of IAS was revised based on two monitoring studies and the number of IAS was reduced to 7 invaded species in the study area. The impact of these IAS for a long time has been noticed by scientists, fishermen, and the public.
2. The risk analysis has been done with selected 7 species that might have a high negative impact on the ecosystem for decades.
3. The selected 7 IAS have belonged to the taxonomic group of Chordata, one from Ctenophora, one from Mollusca, and one from Arthropoda phylum. These species have consisted of 6 different families under these phyla.
4. The geographical distribution of the IAS species was from marine (29%), Seawater-brackish water (43%), and Freshwater-Brackish water (28%) demonstrated in Figure 3.
5. The main entrance pathways of them were intentional (43%) such as aquacultural purposes and vectors for biological control and ornamental purposes, and unintentional (57%) by ballast water and natural waterways.
6. The ratio of the socio-economic benefits of the IAS was determined by only 14% high, 29% less benefit and 57% of them have no benefits by means of public interests. The ratio might have been changing with time. For instance, *R.venosa* used to have no economic income for the Blak Sea fishermen but time being they have been very economically valuable after a certain time.
7. There have been many vectors for transporting IAS from their natural waters to the Kızılırmak Delta such as ballast water, and natural waterways (unintentional). In addition to that intentional transport have been another vector for the IAS (intentional).
8. Although alien species were brought to the region for a purpose, they caused environmental disasters far beyond the expected positive effect. For instance, mosquito fish have been introduced to this area for biological control of the mosquito but their negative impact on the environment is much higher (Table 3).
9. Unfortunately, the impact of small invasive species on the environment is not noticed by the public or fishermen or is noticed too late. This situation, which could not be diagnosed early, causes irreversible environmental damage in the delta when noticed.
10. According to the MSRAS risk analysis, 5 of 7 IAS have been a very high risk for the aquatic environment, the economy of the public, and also for ecosystem services. Two of them have medium risk the reason was the species are economically valuable and support the income of the public. Three of them have very little impact on the environment (Table-3). Of course, their impact on aquatic life and ecosystem services should monitıoring continuously together with high-impact species. In the future, their impact of them may change. Before the catastrophic impact according to the scientific investigations of studies decision makers should find solutions to protect the fragile deltaic ecosystem.
11. 11. IAS species might be impacted the climate changes and the affect might be expanding the species into the larger area. According to the literature survey *P.parva* was expanding by time, but *R. venosa* and *M. soiuy* population have fishing pressure. Especially *R.venosa* supply very good economic income to the fishermen. Decision makers and fishermen should be arrange the optimum fishing pressure to *R. venosa* for sustainable fishing. Their taxonomic groups were listed in Table-4.

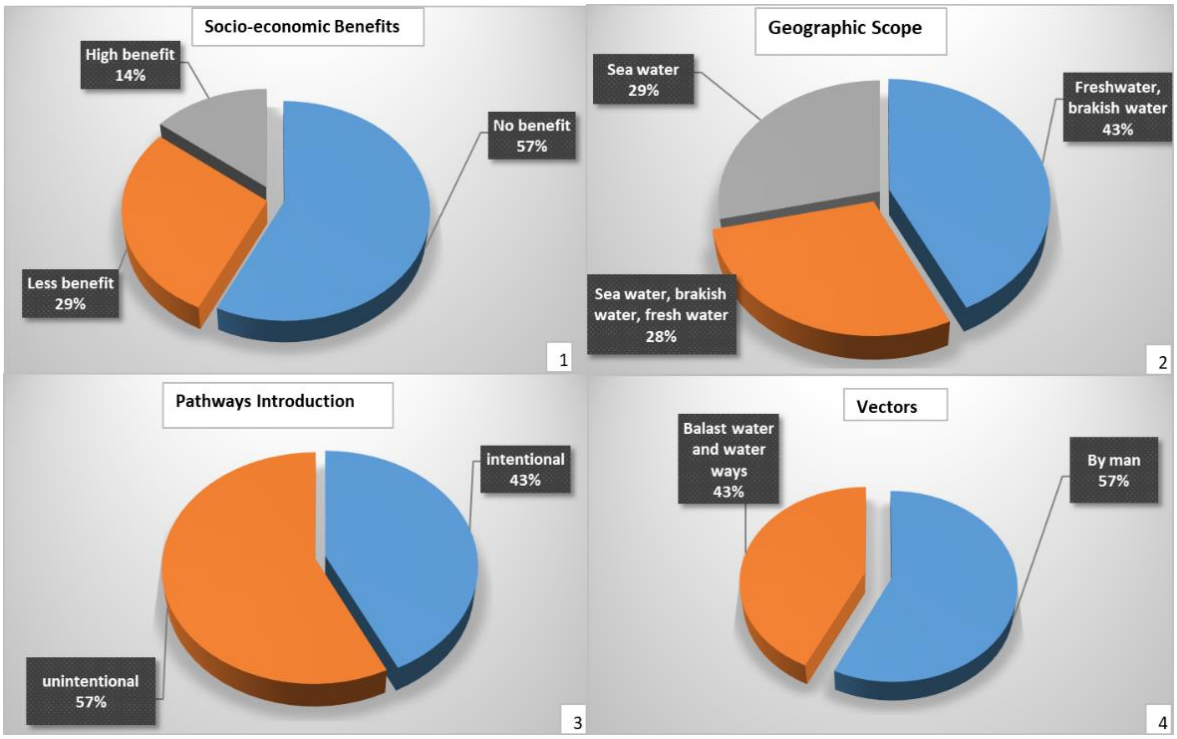


Figure 3: Invasive level of the species in the Kızılırmak Delta

Table 3: The MSRAS risk assessment result of the IAS species in the Kızılırmak Delta

1. Description taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio- economic benefits)							
	Carassius gibelio (Bloch, 1782)	*Gambusia holbrooki* (Girard, 1859)	*Gambusia affinis* (Baird and Girard, 1853)	*Pseudorasbora parva* (Temminck & Schlegel, 1846)	*Mugil soiuy* (Basilewsky, 1855)	*Mnemiopsis leidyi* (Agassiz, 1865)	*Rapana venosa* (Valenciennes, 1846)
Invasion history	Degradation and alteration of habitat quality, high reproduction capacity, damaged ecosystem services, modification of natural bentic communiites, changed gene pool, reduced native biodiversity, negative impact on fisheries, loss of native species	Competition, predation. attacking, aggressive fin-nipping, rapid maturation to breeding age.	Extremely aggressive and attack other fish, shredding fins; alter zooplankton, insect and crustacean communities; potential hosts of helminth parasites	Compete for food; comsume zooplanktonic organism; feed on natural species eggs and juveniles	Compete with native species by food	Catastrophic pressure on native species (feed on fish eggs and larvae, different kinds of smaller holoplanktonic animals, pelagic larvae and even protozoan plankton)	Predator on marine bivalve populations in the Black Sea basin, pressure on native species; large distribution area,
Distribution range	Introduced (first report 1990-1999)	Introduced (first report 1920)	Introduced (first report	Introduced (first report	Introduced	Introduced	Introduced (first record 1946)
Geographic scope	Inhabits a wide variety of still water bodies and lowland rivers. Inland surface waters IUCNC- C1, C2, C3	Inhabits standing and slow-flowing vegetated waters, brackish waters; Inland surface waters C (C1, C2, C3)	Inhabits standing and slow-flowing vegetated waters, brackish waters; Inland surface waters C (C1, C2, C3)	Inhabits standing and slow-flowing vegetated waters, brackish waters; Inland surface waters C (C1, C2, C3)	Shallow coastal waters and freshwaters occasionally A7,C1, C2	Marine habitats A7	Marine littoral rock and sediment and brackish water A1, A2

Socio-economic benefits	Not first choice for public. Less economic benefit.	Widely used for mosquito control and aquarium	Less economic benefit.	No socio-economic benefits	Economically valuable fish.	No socio-economic benefits.	Very high socio-economic benefit.
Native geography	Far east or Eastern Europe	Southern USA (ponds, lakes and streams)	Southern USA (ponds, lakes and streams)	East Asian subregion	Sea of Japan-Amur River estuary	Atlantic coast of North and South America.	
2. Likelihood of introduction, establishment, spread and magnitude of impact							
Introduction	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood
Establishment	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood	Likelihood
Spread	Rapidity	Rapidity	Rapidity	Rapidity	Rate	Rate	Rapidity
Magnitude of impact	Magnitude	Magnitude	Magnitude	Magnitude	Likelihood	Likelihood	Magnitude
3. Description of the current and potential distribution, spread and magnitude of impact							
Current distribution	Invasive	Invasive	Invasive	Invasive	Invasive	Invasive	Invasive
Potential distribution	Invasive	Invasive	Invasive	Invasive	Likelihood	Invasive	Invasive
Spread	Invasive	Invasive	Invasive	Invasive	Likelihood	Invasive	Invasive
Magnitude	Invasive	Invasive	Invasive	Invasive	Not	Invasive	Invasive
4. Inclusion of multiple pathways and vectors of introduction and spread both intentional and unintentional							
Pathways of introduction	For fishing purpose, by human	Biological control, intentional release, pet trade	Biological control, intentional release, medical use, military movement, pet trade	Vector for the Black Sea: Tuna River	Water ways, channels, straits	Shipping activities, ballast water	Ballast water
Vectors of	Aquaculture; fisheries; interbasin;	Intentional	Intentional	Via Tuna River	Artificially, by man	Ballast water from ships	
Spread	Intentional; accidentally	Intentional	Intentional	Unintentional	Intentional	Unintentional	Unintentional
5. Assessment of environmental impacts with respect to biodiversity (and ecosystem) patterns and processes							
Biodiversity (genetic and species)	Negative impact	Negative impact	Negative impact	No information	No information	No information	No information

Impact on natural and semi-natural ecosystem biodiversity	Pressure on native species	Ecosystem change/ habitat alteration; Modification of natural benthic communities; Impacts agriculture; Reduced native biodiversity; Loss of native species	Competition with small fish populations. Pressure on native species eggs, larvae and juveniles	Competition with carp in the aquaculture ponds and eat larger zooplankton. Pressure on natural species	Overgrowing , Competition with local species for food and habitat	A major zooplankton predator.A carnivorous predator on zooplankton (including meroplankton), pelagic fish eggs and larvae, M. leidyi causes negative impacts right through the food chain of the areas it has invaded.	Negative impact on biodiversity. Rapana whelk, which feed on mussels, oysters and other mollusks, caused a decrease in the stocks of mussels and oysters.
Ecosystem services	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact
Food-web	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact
6. Assessment of adverse impacts with respect to ecosystem services							
Biotic impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact	Negative impact
Abiotic impact	No changes	No changes	No changes	No changes	No changes	No changes	No changes
7. Assessment of adverse socio-economic impacts:							
	High negative impact	High negative impact	High negative impact	High negative impact	High negative impact	High negative impact	High positive impact
8. Status (threatened or protected) of species or habitat under threat							
Status of species under threat	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened /Protected
Status habitat under threat	Protected	Protected	Protected	Protected	Protected	Protected	Protected
9. Possible effects of climate change in the foreseeable future							
	Expanding	Expanding	Expanding	Expanding	Expanding	Expanding	Expanding
10. Data limitations							
	No data limitation	No data limitation	No data limitation	No data limitation	No data limitation	No data limitation	No data limitation

Table 4: The taxonomy and literatur survey of the IAS species in the Kızılırmak Delta

Kingdom	Phylum	Order	Family	Species	Literature
Animalia	Cordata	Cypriniformes	Cyprinidae	Carassius gibelio (Bloch, 1782)	CABI, 2023 Innal and Erk'akan,2006; Ekmekçi et al., 2013 MAF, 2018 Kırankaya and Akyol, 2014
Animalia	Cordata	Cyprinodontiformes	Poeciliidae	Gambusia holbrooki (Girard, 1859)	Gürkan et al.,2019 Cakmak and katipoğlu, 2017 Şen and Ünlü, 2014 Korkmaz and İlhan, 2016
Animalia	Cordata	Cyprinodontiformes	Poeciliidae	Gambusia affinis (Baird and Girard, 1853)	CABI, 2023 IUCN, 2023 MAF, 2018 Kurtul and Sarı, 2019 İnnal and Erk'akan, 2006; Courtenay and Meffe, 1989
Animalia	Cordata	Cypriniformes	Cyprinidae	Pseudorasbora parva (Temminck & Schlegel, 1846)	Yoğurtçuoğlu and Ekmekçi,, 2017 CABI, 2023 IUCN, 2023 MAF, 2018 Zengin et al., 2009 Kutsokon and Zolotukhina, 2016 Çiçek et al., 2015 Açık and Bakır, 2017
Animalia	Cordata	Mugiliaformes	Mugilidae	Mugil soiuy (Basilewsky, 1855)	Akyol and Şahin, 2017 Açık and Bakır, 2017
Animalia	Ctenophora	Lobata	Bolinopsidae	*Mnemiopsis leidyi* (Agassiz, 1865)	Yoğurtçuoğlu and Ekmekçi,, 2017 CABI, 2023 IUCN, 2023 MAF, 2018 Kideys and Eleftheriou, 1997 Shiganova et al., 2001. Mutlu and Akçalan, 2007 Çardak and Kideys, 2010
Animalia	Mollusca	Neogastropoda	Muricidae	Rapana venosa (Valenciennes, 1846)	Yoğurtçuoğlu and Ekmekçi,, 2017 CABI, 2023 IUCN, 2023 MAF, 2018 Zengin and Öztürk, 2009 Katagan et al., 2008. Açık and Bakır, 2017

CONCLUSIONS

The Kızılırmak Delta was investigated by means of 10 invasive alien species invasion levels from different taxonomic groups. *Carassius gibelio* was found the most invasive species in the aquatic system in the delta. The individual of this species was found in three lakes, the Kızılırmak River itself even the coastal area. The local fishermen mention that this species invaded all water bodies in the delta. Mosquito fish species especially *Gambusia holbrooki* and *Gambusia affinis* were very dangerous small-size species for the Delta ecosystem. Predation upon the fry and eggs of native fish, and by attacking all sized fish by aggressive fin-nipping, thereby leaving them susceptible to disease. *Mugil soiuy* is an alien species and it has a negative impact on the aquatic ecosystem. This species also support the economy of fishermen. For this reason, it is evaluated as low risk for the ecosystem. *Mnemiopsis leidyi* is a very dangerous and invasive species in the Black Sea. Because of this species, Black Sea fishing collapsed in the 1990s. The species still actively impact the marine environment and ecosystem services in the sea. *Rapana venosa* is another IAS in the Black Sea marine environment where the Kızılırmak discharged. *R. venosa* is introduced and established in the Black Sea for many decades and now these species are very valuable for all Black Sea fisheries. It is an invasive species and the risk value is medium.

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