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Aquat Res 3(4), 177-187 (2020) • https://doi.org/10.3153/AR20016 *Review Article*

Possible effects of COVID-19 on sustainability of aquatic ecosystems: An overview

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ABSTRACT

Coronavirus is an envelope virus that is persistent in the environment and easily inactivated by the use of chlorine disinfectants. It is a virus novel to human and the first occurrence (SARS-CoV) was detected in Hong Kong in 2003 and a new strain (SARS-CoV-2) in Wuhan, China in 2019. The pandemic had spread throughout the world and is spread through respiratory droplets and fecal-oral routes. The use of chlorine disinfectants has been reported to be the best economic solution to the virus and its use has been on the rise leading to increased wastewater generation. Presently, the existence of coronavirus has been reported in wastewater from indoor and outdoor sources and exposure of the aquatic ecosystem to this elevated concentration of chlorine in wastewater can threaten its sustainability and biodiversity. When aerosols or leakages occur from the sources of wastewater, humans can be infected by the virus by inhaling through the respiratory outlets. This review, therefore, highlights the possible presence and effect of the virus in waste water-based and how the aquatic environment can be sustained.

Keywords: Wastewater, Disinfectants, Sustainability, Aquatic environment, COVID-19

Introduction

Ever since the first case of the strain of the coronavirus (COVID-19 also known as novel coronavirus) in Wuhan, Hubei Province in China, it has increasingly spread across the world at an alarming rate. The World Health Organization (WHO) has declared the virus as a Public Health Emergency of International Concern (Adhikari et al. 2020; WHO, 2020a). As of 17th May, 2020 WHO reported that COVID-19 has spread over 216 countries of the world with a total of 4 534 731 confirmed cases and 307 537 deaths. Americas top the list of cases both by WHO regions and by country, territory or area with 1 966 932 confirmed cases (Table 1) and 1 409 452 confirmed cases (Table 2) (WHO, 2020b). Severe acute respiratory syndrome coronavirus (SARS-CoV) is the strain that causes respiratory illness and is a highly pathogenic strain that was first identified in the mid-1960s. It is an enveloped single-stranded RNA virus that can infect birds, mammals, and humans through aerosols or fecal-oral route (Gundy et al. 2009).

Table 1. Case comparison of COVID-19 across WHO regions (WHO, 2020b)

WHO Regions	Confirmed cases
Americas	1 966 932
Europe	1 870 545
Eastern Mediterranean	335 088
Western Pacific	167 755
South-East Asia	135 036
Africa	58 663

Table 2. Case comparison of COVID-19 by Country, Territory, or Area (WHO, 2020b)

Country, Territory or Area	Confirmed cases
United States of America	1 409 452
Russian Federation	281 752
The United Kingdom	240 165
Spain	230 698
Italy	224 760
Brazil	218 233
Germany	174 355
Turkey	148 067
France	140 008
Iran	120 198
India	90 927
Peru	84 495

The SARS-CoV was first discovered to have links with wastewater in March 2003 when an outbreak occurred in a housing estate in Hong Kong which involved over 300 people and caused over 8 000 infection cases and mortality rate of 10% (Centre for Disease Control, 2004). The outbreak was traced to a faulty sewage system (Peiris et al. 2003). An outbreak also occurred in 2004 from a research laboratory in Beijing, China, and was traced to bats because it was novel to humans at that time and spread through respiratory droplets (Manocha et al. 2003). At this time, a new strain of coronavirus known as SARS-COV-2 has been reported to the cross-species barrier and can be transmitted through respiratory droplets over a short distance to humans by binding to the receptor angiotensin-converting enzyme 2 (ACE2) (Letko et al. 2020; Hoffman et al. 2020), through the environment, fecal-oral routes and wastewater systems (Zhang et al., 2020a).

Before 17th March 2020, it was believed that the coronavirus was less stable in the environment and can easily be oxidized by chlorine; therefore, the virus can be rendered inactive by simple filtration and disinfection of wastewater (Aquatech, 2020). As of 12th April 2020, traces of the virus were reported to be detected in wastewaters in the USA, Netherlands, and Sweden (Igomu, 2020). The virus was also being reported to be found in the fecal samples of infected individuals (Holshue et al. 2020). As a result, the use of chlorine disinfectant on indoor and outdoor surfaces has drastically increased. If this persists, a worldwide secondary disaster in aquatic ecosystems can occur which will threaten the existence of biodiversity (Zhang et al. 2020a) as ecosystem productivity. Presently, there has not been any report on the transmission of the virus from humans to land and aquatic animals (Goldstein, 2020) or from wastewater to aquatic animals but the effects of chlorine toxicity on the water quality and fish species have been reported (Sanders, 2020). Chlorine is a major constituent of disinfectants. Its toxicity can affect the sustainability of the aquatic ecosystem causing hypoxia, affecting organs and respiratory system, hepatic and renal injury, inflammation and steatosis (Xu et al. 2020; Rismanbaf and Zarei, 2020), and could migrate to the aquatic biota by surface run-off if pandemic persists (Zhang et al. 2020b), thus harming the aquatic organism and aquaculture. Due to the increasing spread of the virus worldwide, it is important to understand the virus in the aquatic environment and effective measures by which the aquatic environment can be sustained.

Coronavirus and Wastewater

The concept of sustainability of aquatic systems takes cognizance of the fate of the coronavirus and how it can affect life in the aquatic system. The virus is present in wastewater and

can remain active over some time in waters originating from hospitals, sewage and fecal discharge from individuals infected by the virus (Hung, 2003; Zhang et al. 2020a). The virus is very persistent in wastewaters and the duration in which the virus is viable in wastewater is not yet known. It is therefore a point of call to know the longevity of the virus once discharged into wastewater to preserve aquatic ecosystems (Leung et al. 2003). Based on the SARS-CoV pandemic in 2003, it was reported that the virus can survive and multiply within a short period if disinfection is not done and can be contagious (Wigginton et al. 2015; Choudri and Charabi, 2019).

The survival of coronavirus in wastewater depends on the following factors:

i. **Temperature**: the virus is sensitive to temperature and can be inactive if the temperature of wastewater is above or below the survival range. For instance, it was reported that the virus (i.e. coronaviruses) is inactivated faster in fresh water at 23°C than in fresh water at 4°C (Gundy et al. 2009).

ii. **Organic matter**: the virus can absorb materials in the water thereby shielding light

iii. **Exposure to light**: the virus can be inactivated in water by exposure to solar or ultra-violet radiation

iv. The presence of antagonistic microbes in wastewater (Naddeo and Liu, 2020)

Based on the recurrent happenings of this aggressive virus; from the 2003 SARS-CoV case to the 2019 SARS-CoV-2 case in China, the need for more information into the potential transmission via environmental measures such as wastewater pathways is of great importance (Chattopadhyay and Taft, 2018). Specific monitoring programmes for the virus in water can be carried out and models developed to provide information on the potential activities of the coronavirus.

The 12 facts about COVID-19 in water (Figure 1) and the importance of water access and hygiene in times of crisis have been summarized as follows (Tu Delft, 2020):

1. **Cultivation of COVID-19 virus from stool is difficult**

   Wölfel et al. (2020) observed a high concentration of COVID-19 virus in the stool of hospitalized patients with COVID-19 and reported that the virus can be readily isolated from the throat and lungs of patients but not from feces.

2. **Genetic material of COVID-19 virus found in sewage water**

   The virus was first detected in sewage by Medema et al. (2020) when sewage samples from 7 cities and an airport were tested during the outbreak in the Netherlands. It was proposed that the virus can be monitored in a population using sensitive monitoring tool such as the use of sewage detection. The genetic material is only found in water if it is contaminated with sewage.

3. **Poor survival of SARS-CoV-1 (very similar virus to COVID-19) in water >20°C indicates inactivity of COVID-19 virus in water**

   The survival of coronavirus SARS-CoV-1 in feces, urine, and water at different temperatures were investigated by Wang et al. (2005). It was reported that the SARS-CoV-1 was inactivated faster in wastewater at 20°C (2 days) than at 4°C (14 days).

4. **Other viruses, e.g. rotavirus, are more persistent in water than the COVID-19 virus**

   It was reported by Raphael et al. (1985) from their study on the loss of rotavirus in water that at 20°C, it took about 10 days for the occurrence of a reduction in rotavirus plaque to 99.0%. Gundy et al. (2008) who compared the survival of SARS-CoV-1 and poliovirus in water reported that coronaviruses can stay longer in water, except in tap waters at 4°C.

5. **Access to good water supply and sanitation can reduce the occurrence of infectious diseases including COVID-19**

   A technical guide on the use of water, water sanitation, and management of wastes from health care facilities has been published by the World Health Organization (WHO, 2020c). This is very useful in preventing viral outbreaks including coronaviruses.

6. **Household water treatment can remove viruses from water**

   Household water treatments have been reported to successfully fight against protozoa and bacteria but not for viruses. It is therefore important to select a suitable technology of water treatment in households against viruses such as boiling, chlorination, and ultrafiltration. To this end, the World Health Organization has published two reports (Round I and II) on the various household water treatment procedures and

their effectiveness in the removal of viruses (WHO, 2020 d,e).

7. The possible presence of COVID-19 virus on the toilet and other surfaces

The toilet areas of hospital and health facilities treating cases of COVID-19 patients have been reported to be the most contaminated areas (Ding et al. 2020). Human coronavirus can be persistent on inanimate surfaces such as metal, glass, or plastics. This statement was substantiated by the reports of Kampf et al. (2020) and revealed that human coronaviruses such as SARS and MERS, or HCoV can persist on metal, glass, or plastic for up to 9 days. Surface disinfection with 62–71% ethanol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite was recommended as an effective procedure to inactivate coronaviruses within one minute.

8. The spread of the virus through surfaces can be effectively prevented by regular washing hands with soap

The World Health Organization has published guidelines on hand hygiene in health care situations (WHO, 2020f e). Siddharta et al. (2017) evaluated the recommended 2 alcohol-based formulations used for outbreak-associated infections and reported that Zika virus (ZIKV), Ebola virus (EBOV), SARS, and MERS could be efficiently inactivated. This substantiates the use of alcohol-based formulations in healthcare systems and situations of the viral outbreak.

9. COVID-19 virus spreads through water droplets from coughing, sneezing or contaminated surfaces

During the COVID-19 outbreak in Wuhan city, China, six family members were studied after visitation to a hospital in the city. It was concluded from the findings of the study that person-to-person transmission of the virus is very consistent in hospitals, family settings, and infected travelers from other regions (Chan et al. 2020). The stability of SARS-CoV-2 in aerosols and on surfaces such as plastic and copper were evaluated by studies of Van Doremalen et al. (2020). Throughout the 3-hour experiment, the virus was observed to remain viable in aerosols, it was viable up to 72 hours after application on plastic and steel, no viable virus was detected after 4 hours on copper and after 24 hours on cardboard.

10. Presence of infectious COVID-19 virus is very unlikely

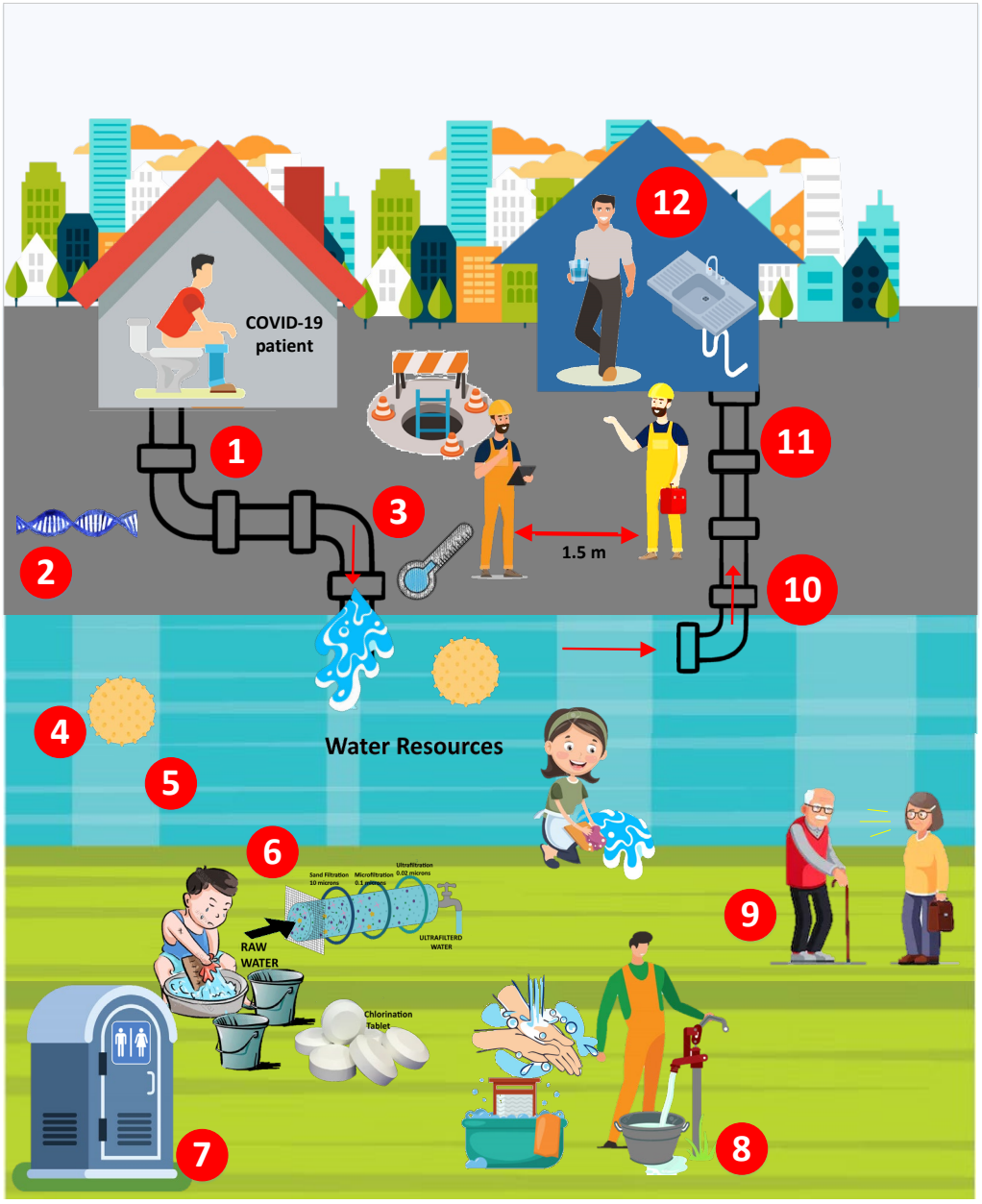
Based on the findings that infectious COVID-19 virus could not be extracted from contaminated feces (Wölfel et al., 2020) and its likely inactivation in water within days (Wang et al., 2005), the presence of infectious COVID-19 is therefore very unlikely to be in drinking water intakes.

11. The treatment plant acts as a barrier against the COVID-19 virus and other viruses

COVID-19 is very sensitive to disinfectants when compared with other viruses in water (Wang et al., 2005). The design and technologies of UV irradiation, ozonation and membrane filtration in water treatment plants has made possible the inactivation of the most persistent viruses in water and very effective against the COVID-19 virus.

12. Safely managed tap water is well protected against COVID-19 virus

The World Health Organization has published guidelines, which have eliminated the presence of viruses in drinking water. With these guidelines in place, tap water can be safe from all viruses including the COVID-19 virus and humans, animals and fishes that depend on the water are free from contamination.



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8. The spread of the virus through surfaces can be effectively prevented by regular washing hands with soap
9. COVID-19 virus spreads through water droplets from coughing, sneezing or contaminated surfaces
10. Presence of infectious COVID-19 virus is very unlikely
11. The treatment plant acts as a barrier against the COVID-19 virus and other viruses
12. Safely managed tap water is well protected against COVID-19 virus

Figure 1. 12 facts about COVID-19 in water: The importance of water access and hygiene in times of crisis (modified from Tu Delft, 2020)

Case Studies on the Presence of Coronavirus in Wastewater

Scientific researchers have reported the possibility of human infection of viruses from water and wastewaters (Choudri and Charabi, 2019). The virus can remain active for days in sewage and it can be transmitted from wastewater to humans if aerosols are generated (Hung, 2003; Casanova et al. 2009). This was the scenario in the SARS-CoV outbreak in 2003 where wastewater from a residential leaking sewage pipe was aerosolized and caused an outbreak of the virus in Hong Kong (Hung, 2003). This illustrates another way by which the coronavirus can be transmitted to humans' asides the known ways through respiratory droplets and fecal-oral route. The presence of the coronavirus has been reported in a community wastewater system in the USA, Netherlands, and Sweden (Igomu, 2020).

Netherlands

Traces of SARS-CoV-2 were detected in wastewater by researchers at the Netherlands National Institute for Public Health and the Environment in Bilthoven, Netherlands. The wastewater was generated from the Schiphol Airport in Tilburg four days after the country detected its first case of the virus through clinical testing. Based on these results, researchers have been tasked to sample the 12 provinces in the country and their capitals as well as the 12 areas with no confirmed cases of the virus (Mallapaty, 2020)

France

The virus was reported to be found in the Paris sewage system after it studied for one month. The results from the study presented a fluctuating pattern in the presence of the virus, which was similar to the pattern observed from the outbreak in the region (Leste-Lasserre, 2020).

Australia

It took about two months (March – April 2020) for the presence of the virus to be confirmed in wastewater from Brisbane in Australia. The trend observed from wastewater sampled was similar in pattern to the trends detected through direct human testing.

United States of America

The country has employed the use of wastewater to investigate the presence of the virus. Traces of the virus have been observed by scientists who analyzed the wastewater from an urban water treatment facility in Massachusetts.

Ways of Minimizing Coronavirus in Wastewater

Disinfection remains a major way of minimizing the virus in water. Based on the widespread of the virus, some procedures have been developed for disinfecting wastewater to inactivate the virus pathogens. In the United States, guidelines for the treatment of wastewater were released in February 2020 by the Occupational Safety and Health Administration (OSHA) to protect the public and aquatic ecosystem from the coronavirus. The procedure involves the processes of oxidation of wastewater with free chlorine and the use of ultraviolet radiation for virus inactivation in wastewater treatment (OSHA, 2020).

Chlorine disinfectants

The use of chlorine for disinfection remains the best economical solution for inactivation of the virus; although chlorine can combine with the ammonia in the wastewater to form chloramide. It was reported by the China Ministry of Ecology and Environment (2020) that in China where the strain of the virus was discovered has applied chlorine treatment of more than 5000 tons in Wuhan city alone both indoors and outdoors to minimize the effects of the virus. The increased volume of wastewater containing a high concentration of chlorine may find its way into aquatic systems thereby causing secondary infection and threaten the survival of aquatic biodiversity. Zhang et al. (2020b) stated that chlorine toxicity can affect the sustainability of the aquatic system in the following ways:

i. They can harm aquatic organisms directly by damaging their cell walls or their protein by oxidation

ii. The chemicals in the disinfectant can bond with other materials and form harmful compounds in water

iii. They can bind with Nitrogen to form Chloramide or N-nitroso-dimethyl amide, which is carcinogens.

iv. The synthesis of disinfection byproducts such as trihalomethanes or haloacetic acids which is very toxic to aquatic life can occur in surface waters because of high organic matter

Bleach as disinfectant

It is a very strong disinfectant which inactivates bacteria, viruses, and fungi. It contains the active ingredient sodium hypochlorite. Based on this, the WHO (2020g) recommended the use of sodium hypochlorite at 0.5% to clean surfaces. It is readily available and can be used in households or surface cleaning in hospital facilities. Its limitations are that it can irritate the mucous membranes in humans and react easily with other chemicals in the water. It should, therefore, be used as

stipulated with care and in a well-ventilated place (WHO, 2014).

Alcohol as disinfectant

It is very flammable and can be used to disinfect small external surfaces such as equipment's. Based on its flammable property, its use must be limited and in a well-ventilated area. If used repeatedly on a particular surface, it may result in thickening, hardening, discoloration or cracking of such surfaces. The use of alcohol (70% ethyl alcohol) is very effective in fighting against the influenza virus (WHO 2014, 2020g).

Possible Solutions for the Sustainability of the Aquatic Environment

With the increased volume of wastewater generated due to the advent of the virus, a central collection reservoir, which can receive the volume of wastewater from major sources such as the hospitals and health centres, can be created. The reservoir can be likened to a waste stabilization pond that retains the wastewater for a certain period and the pathogens can be destroyed over time. During the wastewater retention period, the intensity of sunlight, pH, and the biological activity in the wastewater speeds up and equates to the rate of destruction of the pathogen (Zhang et al. 2020 c). A virus inactivation treatment procedure can be employed at the central collection reservoir so that the environmental loading and secondary transmission of the virus can be minimized. It is also important to understand the potency of methods of disinfection employed in coronavirus inactivation (Li et al. 2017).

The virus outbreak has resulted in an increased use of disinfectants and bactericides on indoor and outdoor surfaces and in water to limit the spread. In the long run, this act can make abundant the presence of antibiotic-resistant bacteria in the environment and can pose an indirect impact on the aquatic ecosystem and human health.

The use of molecular methods and nucleic acid targets by researchers to investigate the virus can also be carried as stated by the Centres for Disease Control (CDC). This method can be used to detect the presence of the SARS-CoV-2 virus in wastewater samples through the use of genetic markers. This method may be carried out when the wastewater is received and after it has been treated in the facility to check for the presence and level of the virus in wastewater before it is discharged into the environment (Brandt, 2020).

Individuals suspected to have the virus may have isolated toilets or latrines whereby their fecal materials can be collected and the toilets must have lids to prevent wastewater droplets that may spatter or form aerosol clouds. If isolation of latrines is not possible, the general latrines should be constantly disinfected and the plumbing system should be of the standard to prevent leakages or the formation of aerosol clouds which may air ventilation systems thereby spreading the virus as it occurred for SARS-CoV in Hong Kong in 2003 (Yu et al. 2004) and the concerns currently raised about the spread of SARS-CoV-2 from faulty plumbing systems in toilets (Regan, 2020). It is important to observe strict surveillance on sewage disposal systems to assess the effectiveness of the strategies of the disposal system on the disease prevention and control (Brandt, 2020).

Conclusion

It can be seen that the coronavirus is present in wastewater and humans are prone to infection of the pathogen from this source if aerosol clouds are formed and dispersed in the air. The occurrence of the SARS-CoV and SARS-CoV 2 indicates the persistence and existence of the virus and measures to reduce its effects on the aquatic ecosystem and humans is utmost. The aquatic system is the sink that receives water from various sources and the measures taken on potential water aquifers and wastewater treatment plants will determine the health of the aquatic ecosystem in terms of water quality and sustainability of biodiversity. To this end, aquatic ecological integrity assessment must be integrated into water management measures by countries of the world to constantly check and monitor the state of our aquatic systems. In addition, the creation of central reservoirs and proper plumbing systems to avert leakage and aerosol forming situations can be looked into as a measure for reducing the impacts of wastewater on aquatic ecosystems. With these, humans and all forms of aquatic biodiversity such as fish, crustaceans etc. can be protected from life threats that may originate from polluted waters in the environment.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: -

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Current status of economically important diadromous fish species of Turkey; European eel, Black Sea trout and sturgeon species

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ABSTRACT

Turkey has a rich variety of fish species in its rivers with a total length of 177 714 km. Freshwater fish live in rivers, streams, creeks, dam lakes, natural lakes, wetland areas, etc.

The life of migratory fish is threatened by the anthropogenic impact on aquatic habitats. Human activities that disrupt river integrity can be listed as; dam and hydro power plant constructions, high levees, sluices, weirs and bridges, sand-gravel quarries, recreational works, wetland depletion, water pollutions, overfishing, habitat losses, climate changes, water pumping from a river to other river basins, drinking water, dried river beds etc. The most important diadromous fish species in Turkey are sturgeon species (Acipenseridae), European eel (*Anguilla anguilla*) and Black Sea trout (*Salmo trutta labrax*). In this study, the past and present status of these species are reviewed.

Keywords: European eel, Black Sea Trout, Sturgeon species, Endangered, Recovery

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Introduction

Diadromous fish are described as fish that prefer to live in both inland freshwaters and marine habitats depending on their life cycles. They are categorized as anadromous and catadromous fish. Anadromous fish are the ones that breed in inland freshwaters and migrates to the seas to spend their adult lives till the point at which they return to freshwaters for breeding. On the contrary, catadromous fish are the ones that breed in marine habitats and return to freshwater for growth and development until they migrate to breeding grounds. Salmonids come to mind as an example for anadromous fishwhereas eels are a well-known catadromous fish species (Gross et al 1988; McDowall, 1988).

Fish migration terminology, explains how fish move among marine, estuarine, and freshwater environments (e.g., anadromy, catadromy, marine residents, estuarine stragglers, etc.). Such terms are useful in describing broad patterns of habitat use and can aid in species and habitat conservation efforts. For instance, knowing that an anadromous sturgeon requires unimpeded access to large rivers for reproduction leads to an emphasis on dam removal in their conservation (Secor, 2015). Anadromous fish are more common in temperate regions of the world where oceans are more productive in terms of food availability. Yet, in tropical latitudes, freshwater habitats are more productive and this results in common dispersal of catadromous fish (Gross et al., 1988).

Turkey has 409 freshwater fish species and 47.4% of them are endemic. There are 33 rivers with a total length of 177 714 km and 25 river basins such as rivers, dam lakes, natural lakes, etc in Turkish water system. Some diadromous fish species in the aquatic system are; *Salmo trutta labrax, Acipencer stellatus, Acipenser gueldenstaedtii, Huso huso, Anguilla anguilla, Atherina boyeri*, *Lampetra lanceolata*, *Alosa fallax*, *Mugil cephalus and Platichthys flesus,* etc. (Çiçek et al., 2018; Ekmekçi et al., 2016).

Main anadromous species like Salmonids and sturgeon species are dispersed in the Black Sea region, migrating from sea to the freshwater where spawning occurs and also catadromous eels (European eel, *Anguilla anguilla*) are found in the West Black Sea and Mediterranean region entering the rivers for feeding and growing. In this review paper, the situation of the most important three diadromous fishes in Turkey is summarized and evaluated.

Sturgeon Species in the Black Sea Basin (*Acipenser sp., Huso sp.)*

The sturgeons (*Acipenseridae*) constitute one of the oldest orders of fish still in existence. Six species of sturgeon are reported in the Turkish Black Sea basin and its drainage area: Beluga (*Huso huso*), Russian sturgeon (*Acipenser gueldenstaedtii*), common sturgeon (*A. sturio*), ship sturgeon (*A. nudiventris*) and stellate sturgeon (*A. stellatus*) and sterlet sturgeon (*A. ruthenus)*. These species are known to migrate into large rivers like Sakarya, Yeşilırmak, Kızılırmak and Çoruh Rivers to spawn and they are naturally present in the northern part of the Anatolian peninsula and Trakya. Until 1970's sturgeons were economically important in the Black Sea region and were known to have an important fishing potential mainly in Çarşamba, Bafra, Karasu and Istanbul (Arısoy, 1968; Çelikkale, 1994; Rosenthal et al., 2015; Ustaoğlu Tırıl and Memiş, 2018). Edwards and Doroshov (1989) reported that *A. sturio, Huso huso, A. gueldenstaedti, A. stellatus* and *A. nudiventris* were found in the fishing ports of the Turkish coast. And also, they stated, the most common species of sturgeons were *A sturio* and *H. huso* in the past.Turkey signed CITES agreement at 22 December 1996 and all sturgeon fisheries were banned after 1 April 1998.Until today, the situation has completely changed and sturgeons are at the brink of extinction in Turkish waters. It is known that anthropogenic impacts like over-fishing, construction of dams and HPPs (Hydro Power Plants), flood control barriers and pollution in rivers played a very significant role in the depletion of wild populations of migratory fish species (Rosenthal et al., 2015; Ustaoğlu Tırıl and Memiş, 2018).

Reported sturgeon species number had fallen to five (*H. huso, A. nudiventris, A. gueldenstaedtii, A. stellatus, A. sturio*) by late 1980'ies (Edwards and Doroshov, 1989). Three of these, *H. huso, A. gueldenstaedtii and A. stellatus*, were observed till 2000'ies, and are studied and reported by researchers (Celikkale et al., 2003; Zengin et al., 2008, Memis, 2014).

Beluga (*H. huso*) is a well-known species from the Caspian Sea, Black Sea, Azov Sea and the Adriatic Sea basins. This species vanished from the Adriatic and Azov Seas because of overexploitation and destruction of breeding grounds due to dam constructions. It is an anadromous native fish species for Azerbaijan; Bulgaria; Georgia; Iran; Moldova; Romania; Russian Federation; Serbia and Turkey. In spring, sturgeons migrate from the Black Sea to the Turkish rivers such as Yeşilırmak, Kızılırmak, Sakarya and Çoruh Rivers.

Russian sturgeon (*A. gueldenstaedtii*) is another native anadromous sturgeon species in Turkey. This species originates from the Caspian Sea, Black Sea and Azov Sea basins. This species is currently reported from the Caspian Sea where it breeds in the rivers Ural and Volga, and the Black Sea where breeding grounds are located in the lower Danube and Rioni rivers and Sakarya River (Kolman and Zarkua, 2002). Presently, the species is not abundant in the Black Sea basin and

Turkish rivers mostly because, almost all of the species' breeding grounds had been damaged and lost due to human made obstructive constructions.

Stellate sturgeon (*A. stellatus)* inhabits the Caspian Sea, Black Sea and Azov Sea, and rarely reported from the Aegean Sea. The Volga, Ural, Terek, Sulak, Kura, Don, Danube, Kuban and Sakarya River are the major breeding grounds of this species (Chebanov and Galich, 2013). The reason for decreasing in the wild population of stellate sturgeon is primarily due to marine over-fishing, especially increased catch of large and mature sturgeon resulting in fewer individuals that can successfully reproduce. Some of the sturgeon species are amongst the largest fish in the world, and they produce one of the most valuable natural resource, caviar. Therefore, sturgeons have been heavily exploited by the surrounding countries of the Black Sea even till the present time.

The earliest reports about sturgeon fishing in Turkey are from the early 1950'ies, which intensified rapidly during the 1960s. Archives from Istanbul Kumkapı fish market from the late 1960'ies and 1975 shows that landings reached 300 tons per annum. But, landings declined rapidly towards the end of the 1960s but increased sharply in the early 1970s reaching previous levels. Annual caviar production from these catches reached over 8 tons/year in the 1970s. Catches dropped rapidly under ten tons after 1975 and the sturgeon fishery almost collapsed. This sharp decline was not just due to the decreased fishing effort but also due to a lack of available fish. This indicated that increments in landing during early 1970 were a result of increasing fishing effort. The sturgeons used to enter and spawn in major rivers, namely Kızılırmak, Yeşilırmak and Sakarya, running into the Black Sea. There are few specimens still entering or trying to enter these rivers. Yeşilırmak River is a major river located at the province of Samsun and is used by most of the migratory species, while the River Sakarya situated in the western part of the Turkish Black Sea coast is also still used by species such as Stellate, Russian sturgeon and Beluga. According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), sturgeon fishing is banned after 1 April 1998 in Turkey (Celikkale et al., 2003; Zengin et al., 2008, Memiş, 2014).

Ministry of Agriculture and Forestry conducted a Restocking Program for sturgeons in 2011 (Rosenthal et al., 2015). 5500 individual Russian sturgeons and 4500 individual stellate sturgeon were tagged and released to Yeşilırmak and Sakarya River in 2011. About 250-tagged sturgeon were reported after releasing. % 2.5 sturgeon were informed by the fishermen. Tagged sturgeon information was from Bulgaria/Burgaz to Georgia/Batum. Besides, a few sturgeon were reported from the Marmara Sea.

Memiş et al. (2019) reported that a wild young *A. stellatus* was caught on August 2014 in the freshwater section of Sakarya River, close to the river mouth. This wild specimen was too small (25gr) to migrate long distances in the marine environment which suggested that mature stellatus had spawned in the lower Sakarya river (Khodorevskaya et al., 2009; Memiş et al. 2019) Thus, this river must be protected and reopened for migration till up-stream of Adasu Hydro Power Plant. And also this Hydro Power Plant which has dysfunctional fish passages should be revised for sturgeon species at least for *A.stellatus*. According to Anon. (2018a) there is an urgent need for coordinated efforts and centralized facilities in order to save this species which may be the last living sturgeon species in Lower Sakarya River habitat.

Black Sea Trout (*Salmo trutta labrax*)

Salmonidae family members are dispersed in the northern hemisphere and brown trout is naturally distributed from Norway, Northeast Russia down to Northern African Atlas Mountains. The distribution and evolution of brown trout as a species is influenced by the latest ice age in Europe between 70 000 - 10 000 B.C. (Behnke, 1972; Berg, 1985; Bernatchez, 2001; Berra, 2001; Çiftçi, 2006; Kocabaş, 2009) (Figure 1).

Trout species are widely distributed in clean, clear and cold waters where oxygen is abundant and these fish are both important in terms of recreational fisheries and commercial production, so their wild stocks are supported systematically. It was reported that *Salmo trutta* spp. had been carried to 24 different countries to support natural stocks during 1852 – 1938 (Klemetsen et al. 2003). *Salmo trutta labrax* is an indigenous species in Turkey (Aras, 1976; Geldiay and Balık, 1988; Arslan et al., 2000; Kuru, 2004; Kocabaş, 2009).

Salmo trutta has been classified according to their ecology and phenotypes under different species and sub-species (Figure 2) (Kocabaş, 2009). Berg (1962) was the first to describe Black Sea trout (*Salmo trutta labrax*) in the Black Sea (Arıman and Kocaman, 2003). Turan et al., (2009) divided Black Sea trout into two species according to their molecular and morphometric characteristics. They defined *Salmo trutta labrax* (Black Sea trout) as *Salmo coruhensis* (Çoruh trout) and *Salmo trutta macrostigma* as *Salmo rizeensis* (mountain trout or red spotted trout).

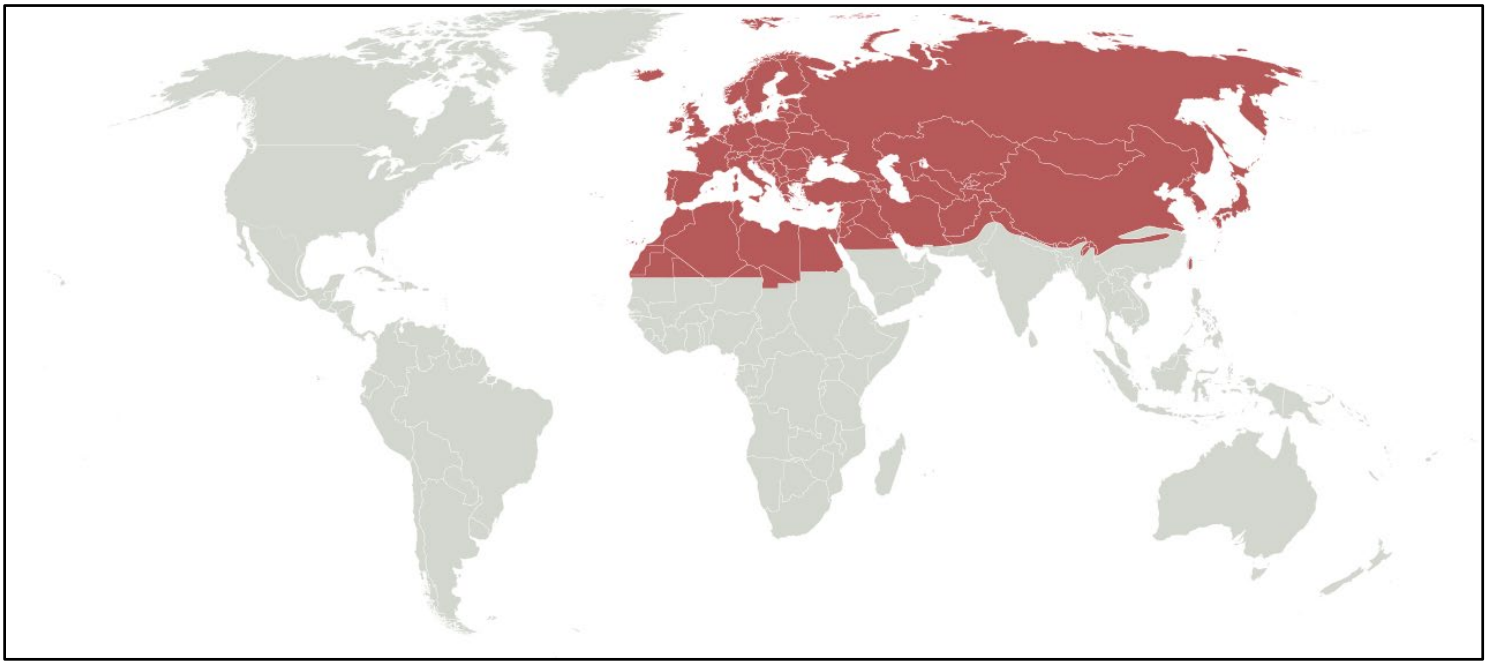

Figure 1. Distribution of *Salmo trutta*, Palearctic Region (red) (Anon., 2016).

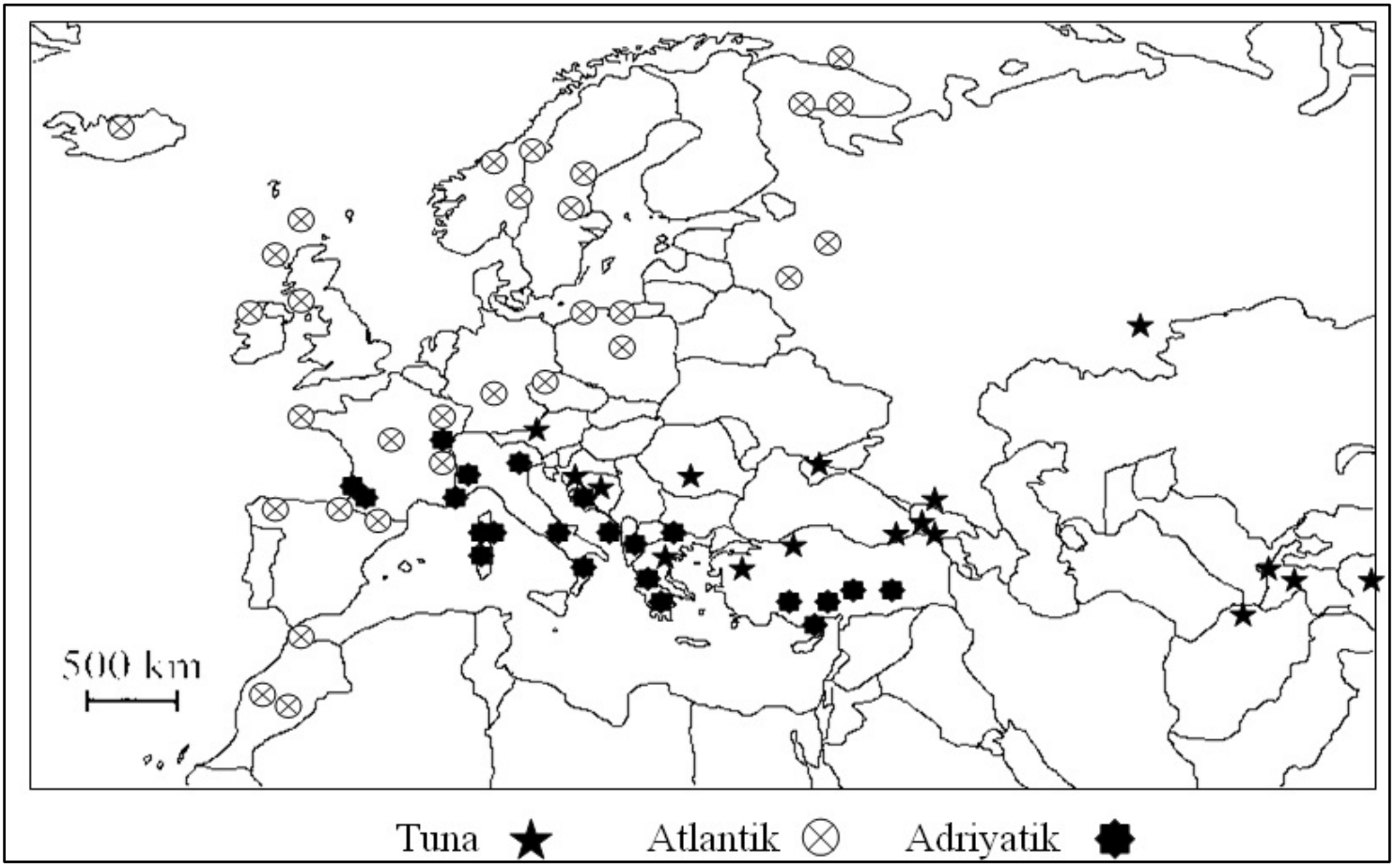

Figure 2. Geographic distribution of different strains (Kocabaş, 2009).

Black Sea trout is accepted as an important rival for *Oncorhynchus mykiss* (rainbow trout) with its appealing appearance, fast growth, high meat yield and commercial value. As it is an indigenous fish and its natural habitat is under pressure. Black Sea trout has become an important species in aquaculture in the recent years (Elliott, 1994, Kocabaş, 2009; Turan et al., 2009; Tunçelli and Memiş, 2020). Natural stocks of this species are fished to its limits with illegal methods, breeding and feeding grounds are destroyed by human activities and water pollution resulted in endangered species status (IUCN red list) (Aydın and Yandı, 2002). According to Turkish Government Fishing Rules, Black Sea trout (*Salmo trutta labrax*, syn *Salmo coruhensis*) fishing is banned whole year round (Statement Number: 2016/36). As a result, academic, governmental and commercial trials on Black Sea trout (*Salmo trutta labrax*) have gained speed (Aksungur et al., 2007; Başçınar et al., 2007; 2010a, 2010b). A restocking program for Black Sea trout is managed by Ministry of Agriculture and Forestry. Tagged fishes is released to the rivers where their natural living areas by the General Directorate of Nature Conservation and National Parks and the General Directorate of Fisheries and Aquaculture (Table 1) (Anon., 2013; Anon., 2019). A joint restocking program was also carried out with Istanbul University Faculty of Aquatic Sciences and Ministry of Agriculture and Forestry where a total 15 000 Black Sea trout were released to the Akçay River in Sakarya Province in 2018. All released fishes was tagged with visible implant elastomer tag which was in yellow and red colors (Anon., 2018b).

Table 1. Salmonid Restocking Program (Ministry of Agriculture and Forestry)

Year	Region	Number of released fish
2010-2017	Turkey (Trabzon, Rize, Gümüşhane, Artvin etc.)	14 528 500
2018	South Marmara Region (Akçay River in Sakarya Province)	15 000

Mostly, private private establishments in the eastern Black Sea region of Turkey started the commercial production of this species with compliance to national regulations. Aquaculture practices are very important for the survival of this endangered trout species (Freyhof, 2013).

European Eel in Turkey (*Anguilla anguilla*)

The European eel is a catadromous fish; breeding at sea and spending its growing period in freshwater. It is known to breed in the South West Atlantic Ocean in the region of the Sargasso Sea. The natural distribution of the European eel (*Anguilla anguilla*) is in inland freshwater habitats near the North Atlantic, Baltic and Mediterranean Seas. It has been introduced to Asia, South and Central America. Males spend 6 to12 years in freshwater whereas females stays in inland waters for 9 to 20 years. They choose to populate river bottoms, beneath the stones, in the mud or in the crevices. After spending their adult time in freshwater habitats, sexually maturation is reached and they start their migration to the Sargasso Sea (McClave et al., 1988, Moriarty and Dekker 1997). It is reported that panmicitic population of the eels are in decline since 1980'ies. Global climate change and its effect on marine habitats like shifts in Gulf Stream result in reduced survival rate for the leptocephali during their migration to freshwater habitats. Combined with overfishing, migration route blockage by man-made obstructions, habitat losses and environmental pollution, loss of global population is inevitable (Feunteun, 2002, Dekker 2003).

The larval eel, known as leptocephali, cross the ocean from west to east before entering European coastal waters. The Gulf Stream carries the leptocephali to the coast of Europe. During this migration, they metamorphose into the transparent glass eels. This drifting migration lasts up to three years. Most glass eels continue their migration to estuaries and then to the fresh water habitats. At this stage, actively swimming upstream, the glass eels undergo es another metamorphosis, their color darkens as pigmentation develops, and are known as elvers from that point. These elvers become small eels before entering freshwater habitats (Tesch, 1977; Keith et al., 1992; Dekker, 2002).

Eels are commercially important in the world. The most valued product is smoked eel which is widely accepted around the world. Eels were captured by fyke nets in the past and kept in clean water to cleanse the muddy odor in ponds before the trade to European countries (Geldiay and Balık, 1988). Eels are present in Turkish rivers and streams draining into the Marmara Sea, the Mediterranean Sea, the Aegean Sea and the Black Sea and also in the lakes connected to these seas. It was reported that this fish was found in Amik Lake, Asi River, Özlen Creek (Karadere, Fethiye), Manavgat, Aksu and Alara rivers in Turkey during 1960'ies to 1970'ies (Geldiay and Balık, 1988; Arslan et al., 2000; Oray, 1987; İkiz et al., 1998; Güven et al., 2016).

The monitoring of the glass eel collection in two Turkish regions are proposed by the Turkish Ministry of Agriculture

and Forestry, one in the south-western region and another in the south-east of the Mediterranean Region. Özlen Creek/ Fethiye, is located in the south-west of Turkey. This small creek (total length 5 km) flows into the Mediterranean Sea. Elvers can be collected using traps, mesh-nets, blanket nets, fine meshed seine net and various other traps.

The Asi River Basin is located in the south-east of Turkey (380 km river length). Recruitment monitoring is possible on the coast at Samandağı. About 50 km from the sea, at Demirköprü, a bridge crosses the River Asi. The river is 35-40 m wide and 0.3- 2.5 m deep and the mean annual flow is 15.5 m^3/s. At this site, a trap for yellow eel could easily be built. About 116 km from the sea, at Tahtaköprü, there is a dam and reservoir built in the river Karasu, a tributary of the Asi River. At this place, there is a dam with 43.50 m high (from the river bed). The migration of eel over this dam is impossible. Thus, building an eel ladder and a trap is possible on this dam, these locations are potential areas for the monitoring of eel migration in Turkey (Dekker, 2002).

Eels migrate to Bafa Lake (Muğla) via Büyük Menderes River (about 35 km) and arrive in Bafa Lake in May-June. From October to November adult eels start their returning voyage back to Mediterranean Sea. Seven-ton European eel was exported to South Korea in 2017. Eel export is organized by S.S. Serçin Fishery Cooperation from Bafa Lake (Personal communication with President of Serçin Fishery Cooperation, 2018). Local fishermen reported that 4 kg eels from Bafa Lake were caught in the past yet presently maximum caught fish are 1.5 to 2 kg.

European eel (*Anguilla anguilla*) has no fishery regulations in Turkey. But according to CITES, there are export quotas and eel catch is determined as 100.000 kg in 2020 by The Ministry of Agriculture and Forestry. Also, eel catching below 50 cm is forbidden (Statement number: 2016/35). Özden et al. (2018) reported that European eels (*Anguilla anguilla*) were caught by fyke nets in the Asi River in the south-east of Turkey. The aim of this study was to determine some toxic metals (Hg, Pb, Cd and As) in the flesh of captured eels. According to the data, they did not a find toxic level of metals and it can be said that there is no risk for the consumers.

Küçük et al. (2016) reported the population decline of elvers in natural habitat mainly at the Antalya Bay, Kardelen Stream, Alara River, Karpuz Stream, Manavgat River, Ilıca Stream, Sarısu Stream, Köprüçay River, Aksu Stream, Boğa Stream, Alakır River, Eşen Stream and Gözlen Creek (Fethiye-Muğla). Their observation showed that the eel population completely vanished from these parts of the region due to the interruption of elver passages towards middle and upper sections of large rivers between 2014 and 2016. As reported by scientists around the world, there is a steep decline in wild eel populations similar to the global fisheries measurements, since the early 1980'ies. The situation is not different in Turkey. If suitable catching methods have been selected and adapted to the local circumstances at the selected stations this can help monitoring and management of eel stock in the rivers (Dekker, 2002).

There is a lack of experimental studies on eel culture although chemical and physical water parameters are suitable for this species and commercial production is not much practiced in Turkey. Recently, two projects about eel culture had been proposed and managed by the Ministry of Agriculture and Forestry via Mediterranean Fisheries Research Production and Training Institute (Antalya) in Turkey.

The project, "Culture of European eel (*Anguilla anguilla* L. 1758) under controlled conditions (Duration: 01.01.2018 – 31.12.2019)" aims to obtain sperm and eggs, achieve fertilization, hatching, feeding and on growing of eels. The second Project is "Habitat characteristics and population parameters for eels in Köyceğiz and Beymelek Lagoons (Antalya) and Dalaman and Ozlen Rivers (Muğla) (Other rivers which pour to the Mediterranean are added to this project)" 011.01.2017-31.12.2018 (time extended). The project's aim is to collect valuable data on sustainable fisheries management of European eel which is widely spread in Turkish inland waters with its high economic and ecologic value. Although there are many studies conducted on eels, available data on this fish lacks many important aspects to ensure a sustainable fisheries management of this species.

Conclusions

The main threats for diadromous species can briefly be classified as; habitat loss (dam construction, gravel extraction, pollution, river flow regularization, discharge reduction), overfishing (sea, estuaries and rivers) and climate changes (global warming). Diadromous fish need a structural approach to meet the conservation targets in Turkey. The strategy is to provide clear and realistic choices and statements on priority Rivers, most important fish migration routes, target species and fishing quotas. Especially for the endangered diadromous fish, there is a need for the revision of the rules, legislations, bans and ways of stock enhancement by aquaculture.

River connectivity has been shown to be increasingly important for the conservation of native biodiversity and is necessary to ensure healthy migratory fish populations. In the whole world, there are issues with river connectivity, caused by river barriers, influencing the life cycle and population status of migratory fishes. Around the world, researchers and governors have been working for many years to improve the situation for migratory fish by developing the efficiency of

fish passages, dams or weirs removal, river rehabilitation, improve political and public awareness and exploring other solutions. We need a strong legislation for the protection of diadromous fish and maintaining healthy ecosystems.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

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İndopasifik *Dioithona oculata*'nın Türkiye'nin güney kıyısal sularındaki dağılımı

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ÖZ

Türkiye'nin güney kıyıları (Levant Denizi) yabancı türlerden en fazla etkilenen alanlardan biridir. *Dioithona oculata* ise son yıllarda İskenderun Körfezi kıyısal sularına geçiş yapmış indopasifik bir türdür. Bu çalışmada, tropikal sularda yoğun kümelerine rastlanan bu türün Levant Denizi'nin kuzeyinde mevsimsel ve alansal dağılımındaki mevcut durum araştırılmıştır. Bu bağlamda, zamansal dağılımını incelemek için daha önce rapor edildiği İskenderun Körfezi kıyısal sularında mevsimsel örneklemeler gerçekleştirilmiştir. Buna ek olarak, Çevre ve Şehircilik Bakanlığınca yürütülen ve TÜBİTAK-MAM koordinasyonluğunda gerçekleştirilen "Denizlerde Bütünleşik Kirlilik İzleme 2017-2019 programı" kapsamında 2017- 2019 yılları arasında geç yaz erken sonbahar periyodunda Türkiye'nin güney kıyısal suları boyunca örneklemeler yapılmıştır. Bu çalışmalar sonucunda İskenderun Körfezi'nde sadece sonbaharda bulunan *D. oculata* türüne 2018 yılı itibariyle yaz mevsiminde 2019 yılı itibariyle ise ilkbahar ve kış mevsimlerinde rastlanmıştır. Aynı şekilde sadece İskenderun Körfezi'nde varlığı bilinen bu türün alansal olarak batıya doğru Mersin Taşucu kıyısına kadar dağılım gösterdiği bulunmuştur. *D. oculata* bolluğu bölgede daha önce rapor edilen değerlerden düşüktür (en yüksek 110 birey/m^3). Buna karşın bu türün alansal ve zamansal olarak dağılımını genişlettiği görülmekle birlikte, Türkiye güney kıyıları boyunca etkin olan önasya akıntısının bu türün taşınmasına ön ayak olduğu düşünülmektedir.

Anahtar Kelimeler: *Dioithona oculata,* İndopasifik, Kopepod, İskenderun Körfezi, Levant Denizi

ABSTRACT

The distribution of indopasific *Dioithona oculata* in souhthern coastal waters of Turkey

The southern coast of Turkey (Levantine Sea) is one of the most affected areas from alien species. *Dioithona oculata* is an Indo-Pacific species that has passed to the coastal waters of Iskenderun Bay in recent years. In this study, the current status of the seasonal and spatial distribution of this species, having dense swarm in tropical waters, was investigated in the north of Levant Sea. In this context, seasonal samplings were carried out in the coastal waters of Iskenderun Bay, which is previously reported, to examine the temporal distribution. In addition, samplings were done in the late summer-early autumn of each year from 2017 to 2019 along the southern coastal water of Turkey in the framework of "Integrated Marine Pollution Monitoring 2017-2019 Programme" which was carried out by Ministry of Environment and Urbanization and coordinated by TUBITAK-MAM. According to the results of this study, *D. oculata*, which was found only in the autumn in Iskenderun Bay, started to be observed in summer by 2018 and in spring and winter by 2019. On the other hand, it was found that this species, which is known only in İskenderun Bay, extended spatially westward to the Mersin Taşucu coasts. The abundance of D. *oculata* in the study area is lower than previously reported values (max 110 individuals/m^3). However, it is observed that its distribution was expanded both spatially and seasonally. Asia minor current, which is effective in the southern coast of Turkey, was thought to instigate for the transportation of this species.

Keywords: *Dioithona oculata,* Indopacific, Copepod, İskenderun Bay, Levant Sea

Giriş

Türlerin farklı denizler ve okyanuslar arasında taşınması, ulaştıkları ekosistemdeki canlıların dağılımını derinden etkileyen ve biyocoğrafik bölgelerin yapısını değiştiren küresel değişimin antropojenik bir etkenidir (Occhipinti-Ambrogi ve Galil, 2010). İklimsel değişiklikler; deniz suyu sıcaklıklarının artışına, hidrodinamiklerin değişimine, pH ve karbonat döngüsünde dalgalanmalara yol açmış olup, çeşitli yollarla farklı bölgelere ulaşan (Lesepsiyen göç, balast suları, kanalların açılması, akuakültür) yabancı türlerin, iklimsel değişimlerden etkilenen yerel türlerle rekabetini etkileyerek geçiş yaptıkları ekosistemlerde başarılı bir şekilde yerleşmesine olanak sağlamıştır (Galil, 2008; Walter ve ark., 2009; Huang ve ark., 2011; Katsanevakis ve ark., 2014). Yabancı türlerin geçişlerinden en çok etkilenen bölgelerden biri de Akdeniz'dir. Yaklaşık 1000 yabancı türün geçiş yaptığı ve bunlardan yarıdan fazlasının Akdeniz biyoçeşitliliğini ve ekosistemini etkilediği bilinmektedir (Katsanevakis ve ark., 2014). Akdeniz bölgesinde ortalama sıcaklık endüstri öncesine oranla 1.4 ºC artmış olup, küresel ölçekte olandan 0.4°C daha fazladır (Cramer ve ark., 2018). Aynı doğrultuda Akdeniz'in yüzey sularının sıcaklığı yaklaşık 0.4°C yükselmiştir (Kapsenberg ve ark., 2017). Bu sıcaklık artışına paralel olarak tuzluluğunda artışı ve yabancı termofilik türlerin Akdeniz ekosisteminde kendine yer bulması, bu yarı kapalı iç denizin tropikalleşme sürecini göz önüne sermiştir (Bianchi ve Morri, 2003). Yirminci yüzyılın büyük bir kısmında Akdeniz'e Süveyş Kanalı'ndan giren yabancı termofilik türler, Levant Denizi ile sınırlansa da son yıllarda iklim kaynaklı hidrografik değişiklikler, bu yabancı termofilik biyotanın Akdeniz'in orta ve batı bölgelerine yayılmasına olanak sağlamıştır (Occhipinti-Ambrogi ve Galil, 2010).

Dioithona oculata küçük siklopoid kopepod türü olup, denizel alanların kıyısal sularını tercih etmektedir (Hamner ve Carleton, 1979). Bu tür köken olarak indopasifik bölgelerde dağılım göstermekle birlikte, kuzey ve güney yarım kürede Atlantik, Pasifik ve Hint Okyanus' larının tropikal ve subtropikal bölgelerinde dağılım göstermektedir (Dakin ve Colefax, 1933; Tanaka, 1960; Björnberg, 1963; Vervoort, 1964; González ve Bowman, 1965; Emery, 1968; Yeatman, 1976; Sander ve Moore, 1979; Hamner ve Carleton, 1979; Bradford-Grieve ve ark., 1999; Lo ve ark., 2004; Sterza ve Fernandes, 2006; Ara ve ark., 2017; Araujo ve ark., 2017). Özellikle tropikal bölgelerde kumlu alanlarda algler, mercan resifleri ve mangrovların yakınında bu türün yoğun kümelerine sıklıkla rastlanmaktadır (Hamner ve Carleton, 1979; Ambler ve ark., 1991; McKinnon, 2000; Ueda ve ark., 1983). *D. oculata* gündüzleri deniz tabanına yakın kümelenmekte, geceleri kıyısal suların yüzey bölgesinde dağılmaktadır (Björnberg, 1972). Bu türün yoğun kümeleri demersal balıkların juvenilleri ve diğer karnivor kopepodlar için besin kaynağıdır (Björnberg, 1972; Ueda ve ark.,1983). Özellikle balıkçılık alanlarında diğer kümelenen türlerle birlikte bu türün kümelenme alanları mevsimsel dağılımı, kümelenme boyutları araştırmaların önemli bir parçası haline gelmiştir (Ueda ve ark., 1983).

Bu türün Akdeniz'de varlığı ilk kez 2013 yılında İskenderun Körfezi'nde tespit edilmiştir (Terbıyık Kurt, 2018). Levant Denizi dışında herhangi bir alanda gözlenmemiş olmakla birlikte, farklı alanlarından da dağıldığına dair henüz bir bilgi bulunmamaktadır. Bu çalışmayla birlikte, *D. oculata*'ın İskenderun Körfezi'ndeki son durumu ile Türkiye'nin Akdeniz kıyısal sularındaki dağılımı hakkında yeni bilgiler verilmiştir.

Materyal ve Metot

Çalışma Alanı

Levant Denizi, kuzeyde Türkiye, güneyde Mısır, doğu da İsrail, Lübnan ve Suriye arasında konumlanmış olup, batısında ise Girit Geçidi ile sınırlıdır (Şekil 1) (Alhammouud ve ark., 2005; Oğuz ve Tuğrul, 1998). Levant Denizi'nde su kolonunun ilk 150 ila 200 m tabakasında sıcaklık kış döneminde 15-16 °C, tuzluluk ise ‰38.8-39.0 arasında değişim göstermektedir. İlkbaharın gelmesiyle yüzey suyu sıcaklığı artmakta ve ilk 25-50 m lik su kolonunda 25 °C ye çıkmaktadır. Tuzluluk ise ‰39.1-39.2 civarına çıkmaktadır. Sıcaklık termoklinin altında hızlı bir şekilde düşüş göstererek 150-200 m civarında 16 °C'ye düşmektedir (Oğuz ve Tuğrul, 1998; Özsoy ve ark., 1993). Akdeniz genel itibariyle oligotrofik bir basen olup, doğu baseninin oligotrofi düzeyi batı basenine göre daha yüksektir (Mermex Group, 2011). Levant Denizi'nde de ultra oligotrofik koşullar hakimdir. Bölgede Nil Deltası ile İskenderun ve Mersin Körfez'leri dışında Levant Denizi'nde hemen hemen hiç geniş kıta sahanlığına sahip bölge bulunmaz (Oğuz ve Tuğrul, 1998). Özellikle İskenderun ve Mersin Körfez'lerini içine alan Kuzeydoğu Akdeniz'in kıyısal sularında nehir ve kara kökenli girdiler bu bölgelerin besin tuzlarınca zenginleşmesine diğer alanlara göre daha yüksek birincil üretim değerlerine yol açmaktadır (Tuğrul ve ark., 2016).

Doğu Akdeniz'in genel dolaşım sistemi, boyutları birkaç kilometreyi bulan çeşitli girdaplar ile bunların arasında geçen akıntılardan oluşmaktadır (Pinardi ve ark., 2006; Golnaraghi ve Robinson, 1994) Sicilya Boğazını geçerek Levant Denizi'ne ulaşan akıntılar Girit Geçidine geçmeden önce güneye dönerek Afrika kıyılarına ulaşır. Bu akıntı daha sonra Orta Akdeniz Jeti (OAJ) ve Güney Levant Akıntısı (GLA) olarak dallanır (Pinardi ve ark., 2006). OAJ güneye doğru olan Mersa Matruh Girdap Sistemi ile Rodos Girdabı arasında serbest açık okyanus akıntısı (Jet) olarak tanımlanmıştır (Golnaraghi ve Robinson, 1994). OAJ daha sonra kollara ayrılarak Ön Asya Akıntısı'na katılacak olan Batı ve Güney Kıbrıs Akıntı'larını oluşturur (Özsoy ve ark., 1993). Güney Levant Akıntısı ise kuzey Afrika kıyıları boyunca doğuya doğru ilerler. Bu akıntı İsrail kıyılarına ulaştıktan sonra Lübnan, Suriye ve Türkiye kıyılarına ulaşır. İskenderun Körfezi'ni de etkileyen bu Ön Asya akıntısı Türkiye güney kıyıları boyunca batıya doğru ilerler.

İskenderun Körfezi, Levant Denizi'nin kuzeydoğu köşesinde yer almaktadır (Şekil 1). Körfezin ortalama derinliği 70m olup, ağız açıklığına gidildikçe artmaktadır (en yüksek 100m) (Avşar, 1999; Yılmaz ve ark., 1992). Körfez yüzey suyu sıcaklığı kış aylarında ve ilkbahar başında en düşük düzeyde olup (16ºC), yaza doğru ısınarak geç yaz periyodunda en yüksek değerlere (29.3 ºC) ulaşır (Yılmaz ve ark., 1992). Havaların ısınmasıyla birlikte oluşan termoklin sonbahardan sonra havaların soğumasıyla kaybolur ve kış karışımı etkisiyle homojen hale gelir. Tuzluluk değerleri ise ortalama yaklaşık ‰39 olup, nehir girdilerinin olduğu bölgelerde ‰ 37-38' e kadar düşmektedir (Yılmaz ve ark., 1992). Körfezin sığ yapısına ilaveten karasal girdiler nedeniyle körfezin birincil üretim değerleri açık denize nazaran 2-4 kat yüksektir (Yılmaz ve ark., 1992). İskenderun Körfezi genel akıntı sistemi, ağız açıklığının geniş olmasından ötürü, Akdeniz genelinde hakim olan siklonik kenar akıntısından ve bölgedeki hakim rüzgarlardan etkilenmektedir. İskenderun Körfezi'nde biri yazın ve diğeri kışın etkin olmak üzere iki sirkülasyon modeli önerilmiştir. Yaz aylarında Körfez akıntısı sistemi kabaca batısına ulaşan yüzey akımlarının yönlendirdiği iki birbirine zıt dönen girdaptan oluşurken, kışın körfezin kıyıları boyunca ilerleyen akıntı ile karakterize edilmiştir (Collins and Banner; 1979; Özsoy ve Sözer, 2006).

Örnekleme ve Laboratuvar Çalışmaları

Çalışmada iki farklı veri seti oluşturulmuştur. Bunlardan birincisi, *D. oculata*'nın mevsimsel değişimlerini, diğeri ise alansal dağılımını karakterize etmek için kullanılmıştır. Mevsimsel değişimin belirlenmesi için kullanılacak ilk veri seti için örnekler 2017-2018 yılları arasında 5 istasyondan, 2019 yılında ise 3 istasyondan mevsimsel olarak alınmıştır (Nisan, Temmuz, Ekim ve Aralık) (Şekil 1, Tablo 1). İkinci veri seti ise sadece geç yaz-erken sonbahar periyodunda Türkiye'nin tüm güney kıyılarını kapsayacak şekilde konumlanmış 13 istasyondan elde edilen veriler ile oluşturulmuştur (Şekil 1, Tablo 2). Tüm örnekler 200 mikrometre ağ göz açıklığına sahip WP-2 plankton kepçesi ile dibin 3m üstünden yüzeye doğru dikey olarak alınmıştır. Derinliğin 200 m den fazla olduğu istasyonlarda örnekler 200 m den yüzeye çekilerek alınmıştır. Alınan örnekler sonuç konsantrasyonu %4 olacak şekilde deniz suyu formaldehit çözeltisinde fiks edilmiştir. Türün bolluğu metreküpte birey sayısı olarak hesaplanmıştır (birey/m^3). Öncelikle laboratuvara getirilen örneklerden folsom ayıracı ile alt örnekler alınmış, daha sonra alınan alt örnekler stereomikroskop yardımıyla sayılarak teşhisleri yapılmıştır. Süzülen suyun hacmi ise kepçenin yarıçapı ve çekim derinliği kullanılarak hesaplanmıştır.

Tablo 1. İskenderun Körfezi'ndeki (SuGözü kıyıları) istasyonlara ait bilgiler

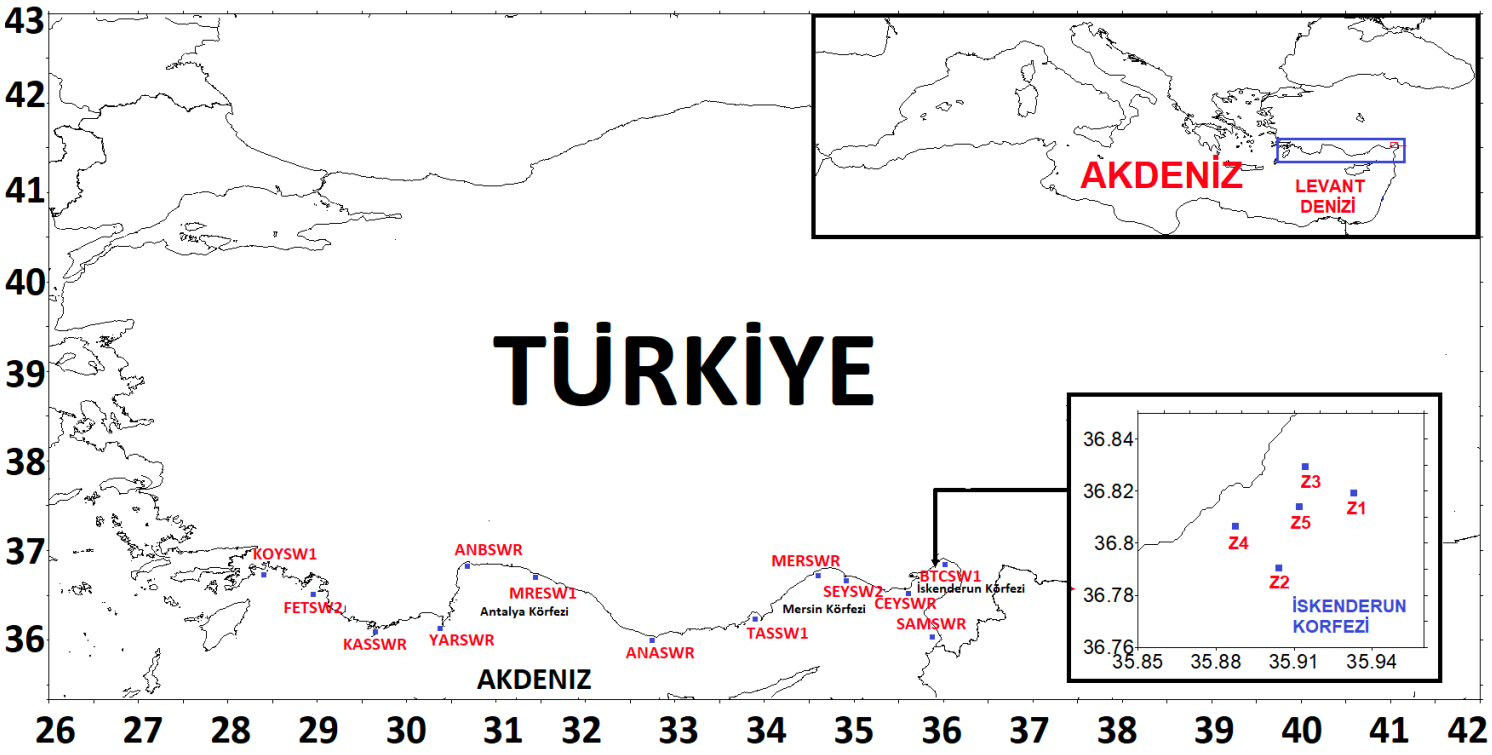
İstasyon Kodu	Enlem	Boylam	Örnekleme tarihi	Çekim derinliği
Z1	35.93267333	36.81907683	Nisan, Temmuz, Ekim, Aralık 2017, 2018	15m
Z2	35.90415583	36.79085412	Nisan, Temmuz, Ekim, Aralık 2017, 2018, 2019	15m
Z3	35.9144805	36.82999083	Nisan, Temmuz, Ekim, Aralık 2017, 2018, 2019	5m
Z4	35.88773383	36.80658751	Nisan, Temmuz, Ekim, Aralık 2017, 2018	5m
Z5	35.91251417	36.81425733	Nisan, Temmuz, Ekim, Aralık 2017, 2018, 2019	10m

Tablo 2. Türkiye güney kıyısal sularındaki istasyonlara ait bilgiler

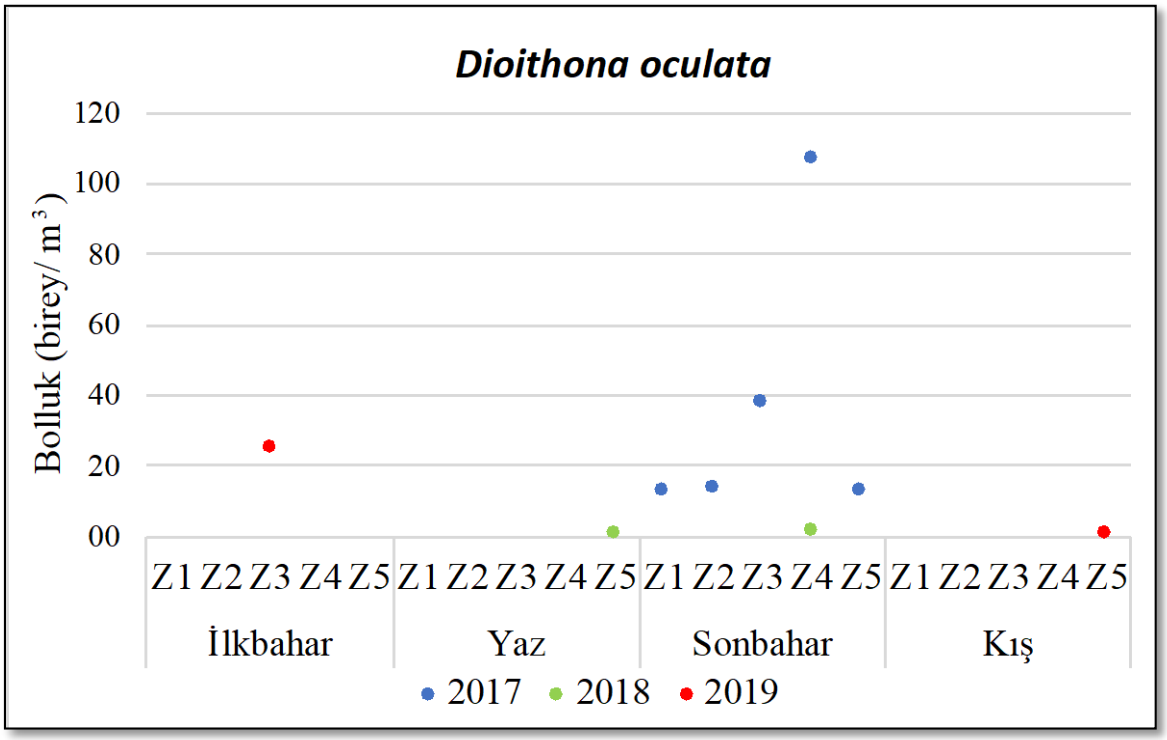
Sıra No	İstasyon Kodu	Örnekleme Tarihi	İstasyon Derinliği	Örnekleme Derinliği
1	SAMSWR	17.08.2017	84m	80m
		14.08.2018	121m	119m
		04.09.2019	87m	85 m
2	BTCSW1	16.08.2017	32m	28m
		15.08.2018	33m	30m
		04.09.2019	38 m	34m
3	CEYSWR	16.08.2017	9m	6m
		15.08.2018	9m	7m
		05.09.2019	11m	8m
4	SEYSW2	15.08.2017	17m	11m
		13.08.2018	15m	12m
		03.09.2019	15 m	12 m
5	MERSWR	15.08.2017	18m	16m
		13.08.2018	16m	13m
		03.09.2019	18 m	15 m
6	TASSW1	18.08.2017	35m	32m
		12.08.2018	36m	33m
		02.09.2019	37m	34 m
7	ANASWR	18.08.2017	45m	42m
		12.08.2018	46m	43m
		06.09.2019	46m	43 m
8	MRESW1	19.08.2017	19m	16 m
		11.08.2018	24m	21m
		08.09. 2019	23 m	20 m
9	ANBSWR	19.08.2017	47m	38m
		11.08.2018	48m	45m
		08.09.2019	47 m	44m
10	YARSWR	20.08.2017	129m	125m
		10.08.2018	155m	152m
		08.09.2019	132 m	130m
11	KASSWR	20.08.2017	300m	200m
		10.08.2018	192m	190m
		09.09.2019	310 m	200m
12	FETSW2	20.08.2017	465m	200m
		09.08.2018	700m	210m
		09.09.2019	671 m	217m
13	KOYSW1	21.08.2017	100m	98m
		06.09.2018	95m	92m

Bulgular ve Tartışma

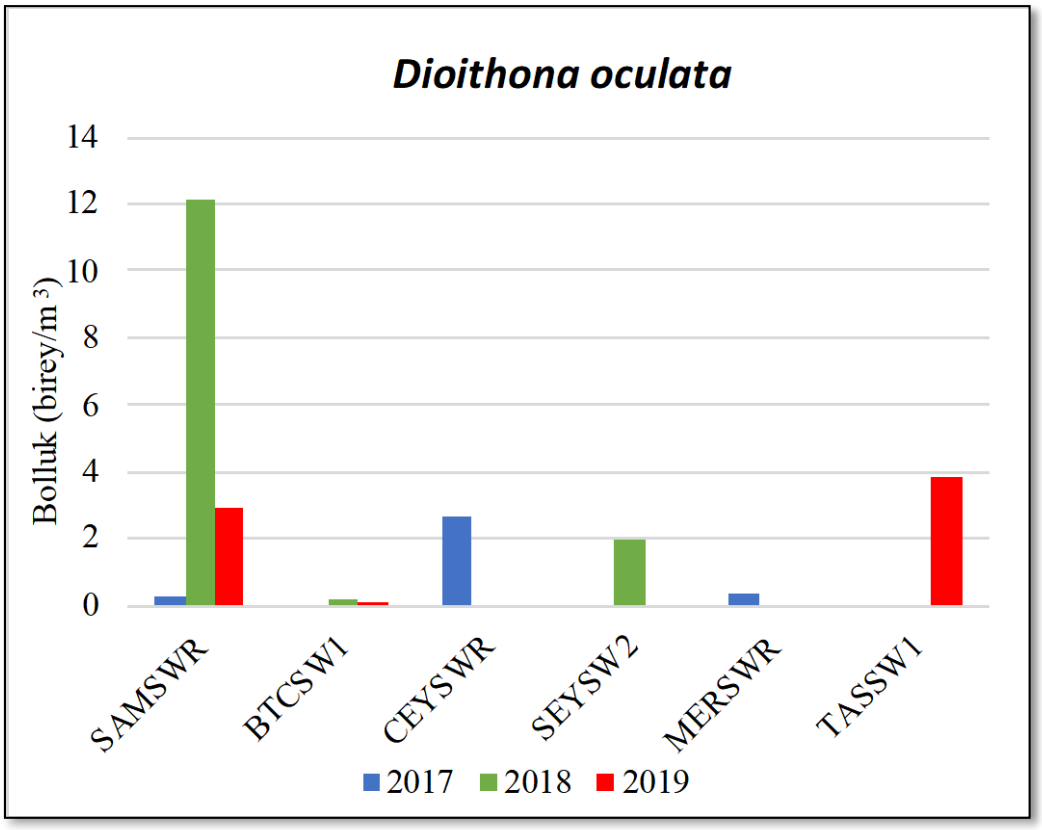
2013-2016 yılları arasında İskenderun Körfezi kıyılarında sadece sonbahar döneminde (Ekim) dağılım gösteren bu tür (Terbıyık Kurt, 2018), 2018 yılından itibaren zamansal dağılımını arttırmaya başlamıştır. *D. oculata,* 2016 yılında bölgede kıyıya en yakın olan Z3 ve Z4 kodlu istasyonlarda (Yaklaşık 700 ve 850 birey/m^3) yüksek bolluklara ulaşarak baskın tür olarak gözlenmiştir (Terbıyık Kurt, 2018). Fakat bu çalışmanın devamı nitelindeki mevcut çalışmada 2017 yılında bolluk değerleri düşük düzeylerdedir. Terbıyık Kurt (2018) de rapor edildiği gibi, mevcut çalışmada 2017 yılında da sadece Ekim ayında bulunmuş olup, en yüksek değer Z4 kodlu istasyonda 110 birey/m^3 olarak gözlenmiştir (Şekil 2). İlerleyen yıllarda ise bolluk düşmüş, fakat mevsimsel dağılım genişlemiştir. Bu tür 2018 yılında yaz ve sonbahar periyotlarında dağılım gösterirken, 2019 yılı itibariyle kış ve ilkbahar periyotlarında bulunmuştur (Şekil 2). Böylelikle bu türün İskenderun Körfezi hidrografik koşullarında tüm yıl boyunca dağılım gösterebildiği söylenebilmektedir. *D. oculata*'nın dağılımı 2017-2019 yılları arasında sadece mevsimsel olarak değil, alansal olarak ta genişlemiştir. İskenderun Körfezi'nin farklı alanlarında da bulunan bu tür (Samandağ kıyıları, Ceyhan nehri ağzı), Mersin Körfezi'nde de (Seyhan nehri ağzı ve Mersin iç Körfez) gözlenmiş olup, dağılımını Taşucu kıyılarına kadar ilerletmiştir (Şekil 3). Böylelikle türün dağılımı İskenderun Körfezi ile sınır kalmamış, batıya doğru giderek artmıştır. Fakat bu alanlardaki bolluk değerlerinin İskenderun Körfezi'nde rapor edilen değerlerden (Terbıyık Kurt, 2018) oldukça düşük olduğu görülmektedir. Bu düşük değerler istasyon derinliği ile ilişkili olabileceği gibi örnekleme periyodunda da kaynaklı olabilir. Terbıyık Kurt (2018) bu türün en yüksek bolluğunu çekim derinliğinin 5 m olduğu alanlarda gözlemlemiş olup, derinliğin 15 m olduğu alanlarda keskin bir şekilde düştüğünü bildirmiştir.



Şekil 1. Örnekleme alanı ve istasyonlar



Şekil 2. *D. oculata*'nın örnekleme periyodu boyunca mevsimsel dağılımı



Şekil 3. *D. oculata*'nın örnekleme periyodu boyunca alansal dağılımı

D. oculata tropikal ve subtropikal bölgelerde geniş ölçüde dağılmakla birlikte, Kaliforniya kıyıları, Japon Denizi, Meksika Körfezi ve Türkiye kıyıları bu türün Kuzey yarım kürede gözlendiği en yüksek enlemlerdir (Razouls ve ark., 2005–2020). *D. oculata* ile ilgili sınırlı bilgi bulunmakta, dağılımı ile ilgili literatür bilgisi daha çok tropikal alanları kapsamaktadır. Tropikal Kochin sularında yılın büyük çoğunluğunda dağılım gösteren bu tür genellikle Eylülden Aralığa kadar olan periyotta bolluk bakımından en yüksek değerdedir (Thompson, 1991). Genellikle yaz aylarında bu türün bireylerine pek rastlanmamış olup, çoğunlukla ‰25 in altındaki tuzluluk koşullarında yaygın olduğu bildirilmiştir (Thompson, 1991). Hsu ve ark. (2008) yarı kapalı tropikal lagün olan Tapong Körfezi'nde *D. oculata*'nın benzer olarak sonbahar periyodunda (Ağustos- Aralık) oransal olarak önemli türlerden olduğunu (%16) bildirmiştir. Ayrıca bir önceki çalışmanın aksine türün dağılımında tuzlukla herhangi bir ilişkisi saptamamış olup, sıcaklıkla belirgin bir pozitif ilişkili bulmuştur. Fakat Tapong Körfezi'nde ölçülen en düşük tuzluluk yaklaşık ‰30 civarındadır (Hsu ve ark., 2008). Bu tür, Kaneohe Körfezi (Hawaii)'nin kuzeyinde düşük bolluk düzeyinde rapor edilmiştir (Jungbluth ve Lenz, 2013). Subtropikal Santa Catalina Körfezi'nde (Güney Kalifornya) ise *D. oculata*'nın, *Acartia clausi* ve Acartia kopepoditleri ile birlikte sahile yakın alanlarda artış göstererek farklı komunite yapısının oluşmasına yol açtığı bildirilmiştir (Barnett ve Jahn, 1987). Bazı tropikal alanlarda bu türe ait yüksek bolluk değerleri rapor edilmiş olup, Tapong Körfezi' nde 5755 birey/m^3 (Lo ve ark., 2004), Tanabe Körfezi' nde 4000 birey/m^3 (Ueda ve ark., 1983), Mucuri Nehri ağzında 3451.5 birey/m^3 (Magris ve ark. 2011) olarak ölçülmüştür. Palau kıyılarında ise *D. oculata*'nın oluşturduğu kümelerdeki birey sayısı 1,500,000 birey/ m^3' e ulaşmıştır (Hamner ve Carleton, 1979). Espírito Santo Körfezi (Oliveira Dias ve Bonecker, 2008), Bracui kıyısal suları (Araujo ve ark., 2017), Malacca Boğazı (Rezai ve ark., 2004) ve Vitória Körfezi haliç sistemi (Sterza ve Fernandes, 2006) gibi bazı bölgelerde ise düşük bolluk değerleri rapor edilmiştir.

D. oculata'nın kaydı, Akdeniz genelinde İskenderun Körfezi dışındaki herhangi bir alanda bulunmadığından, Terbıyık Kurt (2018) bu türün balast sularla geçmiş olabileceği ihtimalinin daha yüksek olduğunu vurgulamıştır. Bununla birlikte, bu türün alansal dağılımının genişlemesinde Levant Denizi'nde hakim olan kenar akıntısının büyük oranda etkisi olduğu düşünülmektedir. Bu siklonik akıntı Levant Denizi'nin kuzeyinde batıya doğru dönerek Türkiye güney kıyıları boyunca ilerler (Pinardi ve ark., 2006; Occhipinti-Ambrogi ve Galil, 2010). Bu akıntı körfez ağız açıklığının geniş olmasından ötürü zaman zaman İskenderun Körfezi iç akıntı sistemiyle etkileşim halindedir (Özsoy ve Sözer, 2006). Levant kıyıları boyunca yabancı türlerin batıya doğru taşınmasında Asya minör akıntısı etkin rol oynamaktadır (Yökeş ve ark., 2007).

D. oculata özellikle tropikal kıyısal sularda aşırı yoğun bireylere sahip kümeler oluşturmasına rağmen, yayılımcı olduğuna dair bir atıf yoktur. Bununla birlikte yabancı tür olarak kaydı da oldukça sınırlıdır (Ara ve ark., 2017).Yabancı türler geçiş yaptıkları ekosistemlerde her zaman istilaya sebebiyet vermeyebilirler. Bulundukları ekosistemlerde istilacı dahi olsa farklı alanlara geçtiklerinde düşük yoğunluk düzeylerinde kalabilirler (Simberloff. 2002). Bununla birlikte bir bölgede istilacı olmayan bir tür, yeni eriştikleri ekosistemde uygun koşullar altında istilacı olabilir (Zenni ve Nunes, 2013). Bir türün istila başarısı girme çabası (Propagule effort), abiyotik ve biyotik direnç, genetik kısıtlamalar, mutualist yaşam sürdüğü canlıların eksikliği gibi koşullara bağlı olarak gelişir (Zenni ve Nunes, 2013). *D. oculata* İskenderun Körfezi'nde 2013 yılından bu yana popülasyonlarda varlığını korusa da populasyon büyüklüğü 2016 yılı hariç düşük düzeylerde kalmıştır (Terbıyık Kurt, 2018). 2016 yılında ise kıyıya yakın alanlarda göreceli olarak baskın tür olmasına rağmen, bolluk değerleri yine de aşırı yüksek değerlere ulaşmamıştır (Terbıyık Kurt, 2018). Dolayısıyla *D. oculata*'nın bölgede doğallaşma başarısına rağmen, popülasyon yoğunluğunun çeşitli faktörler tarafından baskılanmış olabileceğini düşündürmektedir (Allee etkisi, rekabet, abiyotik koşullar gibi). Hangi faktörlerin etkilemiş olabileceğini tahmin etmek mevcut çalışma verileriyle pek mümkün değildir. Türün küçük boyutu da düşünüldüğünde, 200 µm ağ göz açıklığı ile yapılan örneklemeler bu türün popülasyonlarını belirlemede yetersiz kalmaktadır. Dolayısıyla daha sık zamansal aralıklarda belirli derinlik gradyanlarında örneklemeler yapılarak ve ayrıca bu türün popülasyonlarını etkileyebilecek abiyotik faktörler (ışık, fotoperiyot, sıcaklık, tuzluluk, zemin yapısı vb.) ve biyotik faktörlerle (aynı nişi paylaşan rekabetçilerin varlığı, av ve predatörleri gibi) ilişkileri belirlenerek yapılacak çalışmalarla ancak türün popülasyon değişimleri hakkında daha ayrıntılı bilgi edinmek mümkün olacaktır. Genellikle epipelajik ve kıyısal alanları tercih eden *D. oculata* özellikle mercan resifleri, mangrovlarda ve kumluk alanların üstünde farklı şekil

ve boyuta sahip yoğun sürüler oluştururlar (Emery, 1968; Hamer ve Carleton, 1979; Ueda ve ark., 1983). Dolayısıyla bu türün bolluğu ve dağılımı bentik bölgenin yapısına göre değişmekte, çevresel koşullarla ilişkisi değerlendirilirken muhakkak zemin yapısıda dikkate alınmalıdır.

Sonuç

Mevcut çalışmada *D. oculata*'nın düşük bolluk düzeylerinde de olsa, hem alansal hemde zamansal olarak dağılımını genişlettiği gözlenmiştir. İskenderun Körfezi'nde ise bolluk değerlerinin bir hayli düştüğü görülmekle birlikte, bu türün popülasyonundaki değişimlerin farklı veri setleriyle kombine edilerek etkileşimlerinin belirlenmesi gerekmektedir.

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Chemical composition of the Black Sea trout (*Salmo labrax* Pallas, 1814): A comparative study

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ABSTRACT

In this study, the chemical composition of the Black Sea trout (*Salmo labrax*), which were obtained from different environmental and feeding conditions, were evaluated. Wild trouts were captured from Altındere and Çağlayan rivers, while culture form obtained from aquaculture facilities. According to the results, wild forms had the highest crude protein and fat compared to culture forms, while moisture and crude ash was higher in culture forms. Glycine, alanine, glutamic acid, and aspartic acid were higher in the individuals caught from wild, whereas culture forms had the highest isoleucine, threonine, and valine. All essential amino acids were detected in all groups, and total essential amino acids exhibited the highest values in the culture forms. While the total monounsaturated and polyunsaturated fatty acids showed the highest values in the wild, they were in lower amounts in the culture forms. Linoleic acid and linolenic acid, which are essential for humans, were detected in all groups. Docosahexaenoic acid (DHA), linoleic acid, and eicosapentaenoic acid (EPA) were found to be the highest polyunsaturated ones, respectively. In filial generations, there are no statistical differences found neither in total essential amino acids nor in fatty acid contents between different generations of Black Sea trout.

Keywords: *Salmo trutta labrax*, Chemical quality, Seafood, Aquaculture, Salmon

Introduction

Fish and other aquatic food sources are known to be biologically beneficial and indispensable throughout life in the human diet. In scientific studies, it has been shown that aquatic foods contain a high proportion of polyunsaturated fatty acids and essential amino acids, which are necessary for the human diet (Sahena et al., 2009). Essential amino acids and essential fatty acids are known that micronutrients are requisite for the maintenance of metabolic activities, the protection and development of organs and tissues (Ballantyne, 2011). Despite the continuous increase in consumer expectations, many species are at risk of extinction in the reason of uncontrolled fishing, environmental conditions, etc. This case is also an essential problem with the view to provide qualified food resources. In the food sector, one of the ways of providing qualified raw materials regularly and continuously is to use aquaculture products.

Today, Salmonids have become an integral part of the aquaculture sector because of their high economic value (Yeakley & Hughes, 2013). In Europe, Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) cover 60% of the total aquaculture and have great importance to the sector, economically (Liu et al., 2016). Therefore in Turkey, Black Sea trout (*Salmo labrax* PALLAS, 1814), which is an endemic subspecies of brown trout, is promising species for the aquaculture sector. Black Sea trout can be found as three forms in Turkey; sea, stream, and lake (Tabak et al., 2001). The natural distribution of the Black Sea trout is briefly can be called the Black Sea and the rivers flowing into the Black Sea (IUCN, 2020). It predominantly distributed in the northeast coast of the Black Sea, the Azov and Caspian Sea basins (Okumuş et al., 2004). In Turkey, primarily due to excessive hunting pressure, Black Sea trout stocks become endangered in nature (Çakmak et al., 2019).

The decrease in the natural stocks of the Black Sea trout has led researchers to the culturing of this fish. The first studies started in 1998 with the sampling of broodstock fish from the rivers Fırtına, Çaglayan, and Kapistre, which poured into the Black Sea. As a result of the studies carried out in recent years, Black Sea trout have been cultured, and finally, the fifth filial generation was achieved when the study conducted (Çakmak et al., 2018). During the domestication process, the culture characteristics and meat yield of the Black Sea trout have been enhanced with selectivity programs and have become an alternative aquaculture species in the Eastern Black Sea region (Çakmak et al., 2019). Parallel with this development, broodstock belongs to the third filial generation is donated to local facilities in the Eastern Black Sea Region to promote the local aquaculture industry. Nowadays, 19 fish farms are culturing Black Sea trout extensively with the amount of 2000 tons per year (Çankırılıgil et al., 2017; Turkish Statistical Institute, 2018). The aquaculture sector should focus on the cultivation of locally endemic species similar to Black Sea trout (Teletchea & Fontaine, 2014). With all these developments, for the food sector and the consumer, the meat quality is one of the most important subjects to be investigated in aquaculture species. Therefore, in this study, the meat quality of the Black Sea trout individuals, which they obtained from wild, fish farms, and different filial generations such as third (F3), fourth (F4), and fifth (F5) generations were compared.

Material and Methods

Chemicals, Reagents and Other Consumables

The chemicals, reagents and other consumables that used in all analyses are; hydrochloric acid huming 37% (Merck, 1.13386.2500), sulphuric acid (Merck, 1.00731.2511), boric acid (Merck, 100731.2511), sodium hydroxide (Merck, 1.06462.1000), methanol (Merck, 1.06009.2500), chloroform (Merck, 1.02445.2500), N-heptan (Merck, 1.04365.2500), hekzan (Merck, 1.04368.2500), boron trifluroid methanol complex (BF3) (Merck, Germany, 801663.0100), sodium chloride (Merck, 1.06404.1000), sodium sulphate (Merck, 1.06648.1000), Kjeldahl catalyst tablet containing 3.5 g K_2SO_4, 0.0035 g Se, borate buffer (Agilent, U.S.A., Agt-5061-3339), o-phthalaldehyde reagent (OPA) (Agilent, Agt-5061-3335), 9-fluorenylmethyl chloroformate reagent (FMOC) (Agilent, Agt-5061-3337), acetonitrile GC grade (Merck, 1.00030.2500), methanol GC grade (Merck, Germany, 1.06018.2500), sodium phosphate dibasic solution (Na_2HPO_4) (Merck, 1.06342.1000), amino acid standard solutions which is mixture of L-alanine, L-arginine, L-aspartic acid, L-cystine, L-glutamic acid, glycine, L-histidine hydrochloride monohydrate, L-isoleucine, L-leucine, L-lysine hydrochloride, L-methionine, L-phenylalanine, L-proline, L-serine, L-threonine, L-tyrosine, L-valine stored in 0.1N HCl (Agilent, Agt-5061), amino acid standards of amino acids sensitive to acidic pH such as L-glutamine, L-asparagine, L-tryptophan and L-4-hydroxyprolin in the powder form (Agilent, Agt-5062-2478), Zorbax extend C18 column for amino acids (Agilent, 3.5µm, 4.6x150 mm) (Agt-764953-902), GC column for fatty acids (Shimadzu, 50 m), fatty acid methyl ester standard (FAME's) (SupelcoTM Component FAME mix, 47885-U), autoclave bottle (100ml) (Isolab, 061.01.100), Whatmann filter (1.2 µm, 0.45 µm) (Aldrich, WHA1001045), 1.5ml amber vials with politetrafloroetilen caps (Agt-5182-0716), vial insert (0.2 mL, konic) (Isolab,

097.05.110) and syringe filters (Isolab, 0.45µm, politetrafloroetilen) (Isolab, 094.01.002), syringe (10 mL) (Isolab, 094.91.010), pipette tip (1000 µL) (Isolab, 005.01.003).

Fish Material and Sampling

The study material was selected as wild and culture forms of Black Sea trout (*Salmo labrax* PALLAS, 1814). The Black Sea trout individuals belong to river form were caught from rivers of Altındere and Çağlayan in May 2017, and June 2018, respectively, and they were compared to cultured ones. Culture forms of the Black Sea trout were obtained from aquaculture facilities operated in the same rivers. In addition to this, a culture form was obtained from aquaculture facilities operated in Borçka Dam Lake, which is an important production area for the *Salmo labrax*. There is no wild form of Black Sea trout that was captured from Borçka Dam Lake with the reason of this lake is not the natural habitat of the *Salmo labrax*. All fish samples were selected approximately equal to each other in terms of weight ranged from 240.22 to 260.31 g. Finally, different filial generations of the Black Sea trout such as third (F3), fourth (F4) and fifth (F5) generations which were cultured in 2009-2010, 2012-2013 and 2016-2017 breeding seasons, respectively were obtained from Central Fisheries Research Institute in order to determine possible differences between achieved culture lines. Individuals belong to first (F1), and second (F2) filial generations did not exist anymore; that is why they were not analyzed in this study. In the analysis, while three individuals were used for each river in the analysis of wild forms, ten individuals were used for culture forms and culture lines (approximately 200 g). Ultimately, obtained fish were filleted and homogenized with for the chemical analysis. Besides that, fillets of individuals belong to culture lines were divided into three parts called the dorsal, abdomen and caudal muscle tissues to determinate possible differences be formed during the domestication period throughout the years. Besides, liver tissues were analyzed to determine possible excessive fat accumulation. All samplings and other treatments were carried out following ethical rules of ARRIVE guidelines (Kilkenny et al., 2010). Obtained fillets stored at +4 ºC for analyses. The Black Sea trout and the partition of the fillets were shown in Figure 1, whereas sampling locations were shown in Figure 2.

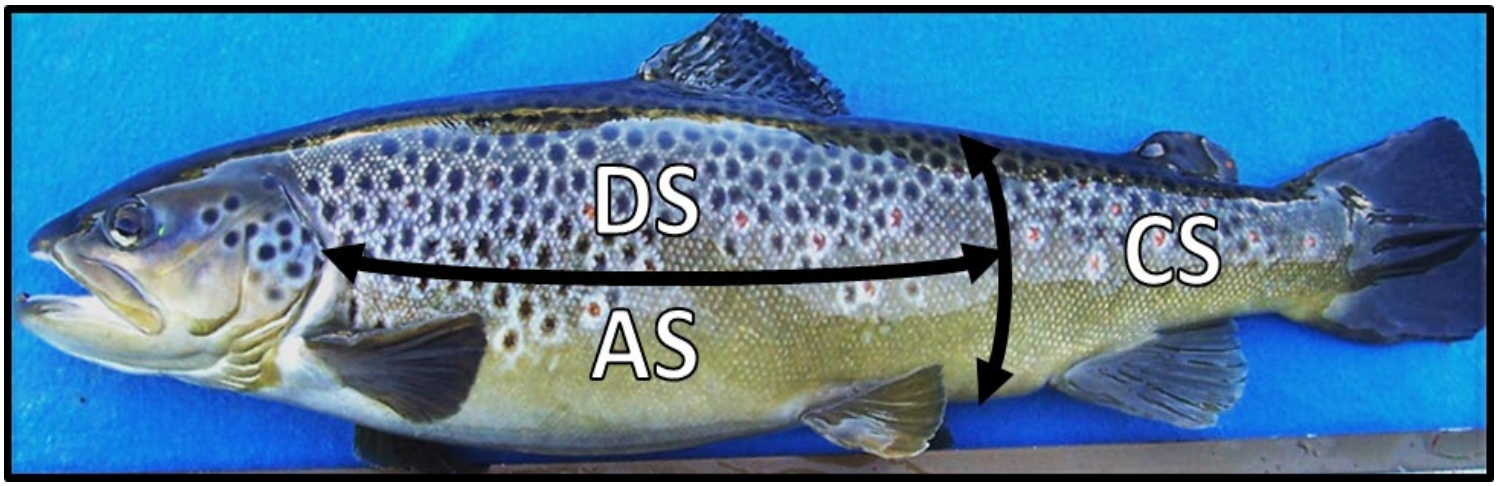

Figure 1. The Black Sea trout (*Salmo labrax* PALLAS, 1814): Fillets of the Black Sea trout were divided into three parts which are dorsal section (DS), abdomen section (AS) and caudal section (CS) as shown in the figure for the analysis of different culture lines such as third (F3), fourth (F4) and fifth (F5) lines.

Figure 2. Sampling stations and aquaculture facilities that fish obtained from. a: Sampling station on the Altındere River (40°40′08.77″N, 39°39′58.86″E), b: An aquaculture facility operated in Altındere River (40°42′10.23″N, 39°39′06.04″E), c: Central Fisheries Research Institute's research units (40°57′35.56″N, 39°51′17.62″E), d: Sampling station on the Çağlayan River (41°14′16.01″N, 41°15′55.51″E), e: An aquaculture facility operated in Çağlayan River (41°15′19.70″N, 41°13′49.52″E), f: An aquaculture facility operated in Borçka Dam Lake (41°19′15.22″N, 41°43′44.24″E).

Determination of Proximate Composition

Water (moisture) analysis was carried out, according to Horwitz (2000). Homogenized samples weighted as 1 g to petri plates and dehydrated with drying oven at 100 °C for 24 hours and calculated according to method. Crude protein analysis was carried out with the Kjeldahl method (AOAC, 2000). Fish meats digested with 15 mL H_2SO_4 and Kjeldahl catalyst at 120 °C and distilled with NaOH. Obtained samples were titrated with 0.1 N HCl and calculated as percentage. The crude fat analysis was conducted according to the method of Folch et al. (1957). Crude fat extracted with methanol-chloroform complex (2:1) and were filtrated with 1.2 µm Whatman filters. Finally obtained mixtures evaporated at 65 °C with a rotary vacuum evaporator (Eyela, N-N 1521) and calculated as percentage according to the method. Crude ash analysis was carried out according to Horwitz (2000). Homogenized samples weighted and burned with muffle furnace (Protherm) at 600 °C for 6 hours. Obtained ash was weighted and calculated as percentage.

Amino Acid Analysis

Firstly, fish meat was digested with the HCl at 110 °C in 24 hours as a preliminary treatment for the amino acid analysis (Çankırılıgil et al., 2020). Obtained hydrolysates were filtered by 0.45 µm PTFE syringe filters and diluted as 10^{-1} with pure water. In the following, samples transferred to 1.5 mL amber vials having PTFE caps and stored until the analysis. The amino acid analysis was done under the method of Henderson et al. (Henderson et al., 2000) in HPLC (Agilent Infinity II) system equipped with a diode-array detector and Agilent standards were used (Agilent, Agt-5061). In the analysis, 0.5 µL of the samples were derivatized with borate, OPA, and FMOC by auto-sampler. Derivatized samples were injected into the system having an amino acid column as a solid phase and mixture of MeOH:ACN:H_2O (%45:%45:%10) and 40 mM Na_2HPO_4 solution which has 7.8 pH adjusted with 10 N NaOH as a mobile phase. The gradient conditions of the mobile phase were shown in table 1. Detection was carried out in two wavelengths as 262 nm for FMOC amino acids and 338 nm for OPA amino acids. All samples were analyzed for the five times, and detected pikes were auto-integrated with

system's software. Finally, obtained data were compared with calibration curves which constituted via the Agilent amino acid standards and expressed as g/100g.

Table 1. HPLC mobile phase gradient conditions

Time (min)	A (MeOH:ACN:H_2O)	B (Na_2HPO_4)	Flow (mL/min)
1.90	0%	100%	2
18.1	57%	43%	2
18.6	100%	0%	2
22.3	100%	0%	2
23.2	0%	100%	2

Fatty Acid Analysis

Firstly, 0.15 g fat weighted from crude fat samples, which were obtained before and 5 mL 0.5 N methanolic NaOH, were put in volumetric flasks for evaporation, which is executed with Soxhlet evaporator at 65°C. During evaporation, 5 mL BF_3 and 2 mL heptane were added to mixtures in the 15th and 17th minutes, respectively. Obtained mixtures were blended with saturated NaCl, and emerged phase in the samples were filtered with 0.45 µm syringe filters for the analysis. The fatty acid analysis was perfomed with gas chromatography (Shimadzu, GC-17A) having 50 m fatty acid column and flame ionization detector and fatty acid methyl ester standard (FAME's) (Supelco™ Component FAME mix, Germany, 47885-U) was used. Heptane was injected into all samples with auto-injectors in the amount of 1 µL as a dissolver. The column oven temperature was adjusted as 140 °C in starting and stabilized in 240 °C with increasing by 20 °C every minute, whereas the detector and injector block temperature was 260 °C. Helium (He) with 30 mL/dk flow, hydrogen (H) with 40 mL/dk flow, and air with 400 mL/dk flow were used as carrier gasses with 22.8 mL/dk total flow. All samples were analyzed five times and obtained data expressed as a percentile (IUPAC International Union of Pure and Applied Chemistry, 1979).

Data Analysis

IBM SPSS 23 software was used in statistical analysis. Results of all chemical analyses were analyzed with one-way ANOVA method after the normality and homogeneity were checked by Anderson–Darling and Levene tests, respectively.

Results and Discussion

The proximate composition of the Black Sea trout obtained from different environmental conditions was shown in Table 2. According to food legislation, if the moisture content of the food is higher than the 50 %, it called water content instead of moisture. So, the term of water used in this article due to fish meat has 60-80 % water content, parallel with our results. The highest amount of water was found in cultured fish, crude protein and crude fat ratios were found in fishes sampled from Altındere and Çağlayan rivers, and the highest amount of crude ash was determined in third, fourth and fifth filial generations ($P \leq 0.05$).

The proximate composition of the Black Sea trout filial generations according to different body parts, as shown in Table 3. When the muscle tissues from different body parts of the Black Sea trout were examined, no statistical differences could be detected in individuals of all generations ($P \geq 0.05$). The highest crude protein content was found in the dorsal and caudal parts, and the highest crude fat content was in the abdominal ($P \leq 0.05$). In the research, the liver fat ratio was found to be higher than muscle tissues ($P \leq 0.05$), and no statistical difference was found between generations ($P \geq 0.05$). Meat quality of fish depends on some specific environmental features such as species, sex, length, age, reproduction stage, temperature (Nurnadia et al., 2011). Altındere and Çağlayan rivers, which are the sampling area of fish which caught from nature, are high flow rated and cold in spring due to melting snow waters (Fidan et al., 2017). In addition to the crude fat content of fish, which grow in cold waters, the amount of long-chain fatty acids is also high (Farkas et al., 1980). Besides, trout, which is usually caught from nature and reach high swimming speeds, shows more muscle development than the culture forms (Sanger & Stobier, 2001; Totland et al., 1987). Therefore, crude protein and fat ratios were found to be high in-stream forms. In salmonids, the myotomal muscle bundles (white muscle tissue) in the dorsal and caudal parts are responsible for providing the pushing force required to swim and contain more muscle bundles than the abdomen. The abdominal part is the muscle part where fat accumulation is frequently seen in trouts (Totland et al., 1987; Videler, 1993). Therefore, while the amount of crude protein ratio was higher in the dorsal and caudal parts, the amount of crude fat was higher in the abdomen ($P \leq 0.05$). Similarly, lipids accumulate in muscle tissue and adipose fin in fish and are stored in the liver (Özel et al., 2017).

Table 2. Proximate composition of the Black Sea trout obtained from different conditions (%)

	Water	Crude protein	Crude fat	Crude ash
Wild				
Altındere River	71.61±0.18^{d}	17.94±0.10^{a}	8.11±0.21^{a}	1.35±0.03^{b}
Çağlayan River	72.07±0.20^{c}	17.90±0.09^{a}	7.89±0.18^{a}	1.26±0.04^{c}
Culture				
Altındere River	73.34±0.16^{a}	17.77±0.12^{ab}	6.52±0.08^{c}	1.26±0.04^{c}
Çağlayan River	73.38±0.21^{a}	17.68±0.11^{b}	6.56±0.09^{c}	1.25±0.05^{c}
Borçka Dam lake	72.79±0.19^{b}	17.52±0.18^{b}	7.10±0.11^{b}	1.40±0.03^{a}
Filial Generations				
F3 *Generation*	73.22±0.19^{a}	17.81±0.09^{ab}	6.22±0.12^{d}	1.45±0.06^{a}
F4 *Generation*	73.33±0.21^{a}	17.75±0.08^{ab}	6.24±0.17^{d}	1.40±0.02^{a}
F5 *Generation*	73.34±0.29^{a}	17.69±0.09^{b}	6.13±0.18^{d}	1.38±0.02^{ab}

Values are expressed as mean ±SD, mean values in a column with different superscripts were significantly different (P≤0.05).

Table 3. Proximate composition of the body parts of Black Sea trout's filial generations (%)

	Water	Crude protein	Crude fat	Crude ash
F3 Generation				
Dorsal section	74.73±0.25^{a}	17.97±0.18^{a}	4.98±0.04^{d}	1.32±0.03^{b}
Abdomen section	70.82±0.23^{c}	16.39±0.20^{b}	10.63±0.15^{b}	1.16±0.04^{c}
Caudal section	73.51±0.21^{b}	17.93±0.14^{a}	6.22±0.17^{c}	1.29±0.06^{b}
Liver tissue	64.89±0.18^{d}	14.96±0.19^{c}	14.02±0.16^{a}	1.41±0.03^{a}
F4 Generation				
Dorsal section	74.75±0.21^{a}	18.10±0.21^{a}	5.16±0.15^{d}	1.35±0.04^{b}
Abdomen section	70.32±0.19^{c}	16.41±0.20^{b}	10.79±0.16^{b}	1.11±0.03^{c}
Caudal section	73.49±0.20^{b}	17.95±0.11^{a}	6.13±0.07^{c}	1.28±0.05^{b}
Liver tissue	64.22±0.13^{d}	15.33±0.08^{c}	14.32±0.10^{a}	1.38±0.06^{a}
F5 Generation				
Dorsal section	74.41±0.17^{a}	18.02±0.13^{a}	5.06±0.08^{d}	1.31±0.04^{b}
Abdomen section	70.44±0.16^{c}	16.26±0.09^{b}	10.59±0.19^{b}	1.15±0.04^{c}
Caudal section	73.23±0.21^{b}	18.23±0.14^{a}	6.09±0.08^{c}	1.30±0.06^{b}
Liver tissue	65.34±0.11^{d}	15.02±0.16^{c}	14.24±0.11^{a}	1.42±0.05^{a}

Values are expressed as mean ± SE, mean values in a column with different superscripts were significantly different (P≤0.05).

Table 4. Amino acid composition of the Black Sea trout obtained from different conditions (g/100g)

	Wild forms		Culture forms			Filial Generations		
Amino acids	**Altındere River**	**Çağlayan River**	**Altındere River**	**Çağlayan River**	**Borçka Dam Lake**	**F3 Generation**	**F4 Generation**	**F5 Generation**
ASP	0.84±0.04^{a}	0.89±0.04^{a}	0.68±0.03^{b}	0.65±0.04^{b}	0.70±0.03^{b}	0.71±0.04^{b}	0.68±0.03^{b}	0.73±0.03^{b}
GLU	1.76±0.03^{a}	1.73±0.02^{a}	1.60±0.03^{b}	1.62±0.04^{b}	1.70±0.02^{ab}	1.59±0.05^{b}	1.55±0.05^{b}	1.58±0.04^{b}
ASN	0.58±0.04^{a}	0.59±0.04^{a}	0.56±0.02^{a}	0.61±0.06^{a}	0.60±0.03^{a}	0.60±0.05^{a}	0.58±0.03^{a}	0.59±0.06^{a}
SER	1.43±0.12^{a}	1.43±0.09^{a}	1.48±0.08^{a}	1.50±0.12^{a}	1.49±0.11^{a}	1.46±0.13^{a}	1.46±0.07^{a}	1.43±0.08^{a}
GLN	0.85±0.05^{a}	0.85±0.04^{a}	0.81±0.03^{a}	0.81±0.05^{a}	0.79±0.10^{a}	0.83±0.04^{a}	0.78±0.07^{a}	0.79±0.06^{a}
HIS	0.49±0.03^{a}	0.49±0.05^{a}	0.44±0.03^{a}	0.46±0.03^{a}	0.50±0.04^{a}	0.45±0.04^{a}	0.48±0.02^{a}	0.48±0.06^{a}
GLY	0.83±0.03^{a}	0.85±0.04^{a}	0.68±0.04^{b}	0.69±0.03^{b}	0.75±0.06^{ab}	0.67±0.04^{b}	0.65±0.05^{b}	0.63±0.04^{b}
THR	1.18±0.04^{b}	1.20±0.02^{b}	1.30±0.03^{a}	1.26±0.04^{ab}	1.24±0.03^{ab}	1.29±0.03^{a}	1.27±0.03^{a}	1.26±0.03^{a}
ALA	0.50±0.03^{a}	0.48±0.03^{a}	0.26±0.01^{b}	0.27±0.02^{b}	0.28±0.02^{a}	0.24±0.01^{b}	0.23±0.02^{b}	0.25±0.01^{b}
TYR	0.16±0.02^{a}	0.15±0.02^{a}	0.17±0.02^{a}	0.17±0.01^{a}	0.16±0.02^{a}	0.16±0.02^{a}	0.16±0.01^{a}	0.16±0.01^{a}
CYS	0.14±0.01^{a}	0.15±0.01^{a}	0.12±0.02^{a}	0.13±0.01^{a}	0.13±0.02^{a}	0.11±0.02^{a}	0.12±0.02^{a}	0.12±0.01^{a}
VAL	0.69±0.04^{b}	0.68±0.06^{b}	0.86±0.05^{a}	0.85±0.04^{a}	0.82±0.05^{a}	0.87±0.03^{a}	0.88±0.03^{a}	0.86±0.03^{a}
MET	0.84±0.06^{a}	0.85±0.04^{a}	0.83±0.11^{a}	0.84±0.09^{a}	0.82±0.05^{a}	0.84±0.05^{a}	0.86±0.06^{a}	0.86±.007^{a}
TRP	0.08±0.01^{a}	0.08±0.01^{a}	0.06±0.01^{a}	0.07±0.01^{a}	0.06±0.01^{a}	0.08±0.01^{a}	0.08±0.01^{a}	0.07±0.01^{a}
PHE	0.75±0.04^{a}	0.74±0.05^{a}	0.78±0.09^{a}	0.78±0.06^{a}	0.76±0.05^{a}	0.75±0.05^{a}	0.74±0.03^{a}	0.76±0.05^{a}
ISO	0.84±0.04^{b}	0.87±0.03^{b}	1.02±0.05^{a}	0.98±0.05^{a}	0.99±0.04^{a}	0.99±0.06^{a}	0.96±0.06^{a}	0.97±0.05^{a}
LEU	1.48±0.10^{a}	1.51±0.12^{a}	1.53±0.13^{a}	1.49±0.09^{a}	1.55±0.11^{a}	1.50±0.08^{a}	1.52±0.10^{a}	1.53±0.07^{a}
LYS	1.41±0.11^{a}	1.44±0.09^{a}	1.37±0.12^{a}	1.38±0.09^{a}	1.39±0.09^{a}	1.39±0.11^{a}	1.41±0.13^{a}	1.43±0.06^{a}
TEAA	6.19±0.10^{b}	6.27±0.09^{b}	6.45±0.12^{a}	6.39±0.08^{a}	6.39±0.15^{a}	6.42±0.11^{a}	6.45±0.09^{a}	6.48±0.11^{a}
TAA	14.95±0.13^{a}	15.08±0.21^{a}	14.55±0.16^{b}	14.56±0.21^{a}	14.73±0.20^{ab}	14.53±0.22^{a}	14.41±0.23^{a}	14.50±0.18^{a}

Values are expressed as mean ±SE. Mean values in a row with different superscripts were statistically different (P≤0.05). ASP; aspartic acid, GLU; glutamic acid, ASN; asparagine, SER; serine, GLN; glutamine, HIS; histidine, GLY; glycine, THR; threonine, ALA; alanine, TYR; tyrosine, CYS; cysteine, VAL; valine, MET; methionine; TRP; tryptophan, PHE; phenylalanine, ISO; isoleucine, LEU; leucine, LYS; lysine, TEAA; total essential amino acids, TAA; total amino acids.

Table 5. Fatty acid composition of the Black Sea trout obtained from different conditions (%)

	Wild forms		Culture forms			Filial Generations		
Fatty acids	**Altındere River**	**Çağlayan River**	**Altındere River**	**Çağlayan River**	**Borçka Dam Lake**	**F3 Generation**	**F4 Generation**	**F5 Generation**
C10:0	0.08±0.02^{c}	0.12±0.02^{b}	0.09±0.01^{c}	0.14±0.02^{ab}	0.20±0.02^{a}	0.18±0.01^{a}	0.16±.002^{ab}	0.14±0.02^{ab}
C12:0	0.11±0.02^{b}	0.15±0.02^{b}	0.12±0.02^{b}	0.23±0.03^{a}	0.20±0.01^{a}	0.21±0.02^{a}	0.17±0.01^{ab}	0.17±0.01^{ab}
C14:0	1.83±0.03^{d}	1.90±0.03^{d}	2.79±0.07b^{c}	2.67±0.05^{c}	2.88±0.03^{b}	2.91±0.06^{ab}	3.00±0.04^{a}	3.10±0.06^{a}
C15:0	5.48±0.29^{a}	5.39±0.27^{a}	5.67±0.18^{a}	5.62±0.23^{a}	5.71±0.28^{a}	5.60±0.26^{a}	5.61±0.24^{a}	5.55±0.22^{a}
C16:0	11.20±0.31^{b}	11.25±0.35^{b}	12.81±0.32^{a}	12.89±0.28^{a}	12.88±0.40^{a}	12.61±0.41^{a}	12.56±0.44^{a}	12.54±0.47^{a}
C17:0	1.96±0.11^{b}	2.01±0.12^{ab}	2.27±0.14^{a}	2.16±0.17^{a}	2.28±0.11^{a}	2.17±0.13^{a}	2.15±0.15^{a}	1.91±0.09^{b}
C18:0	3.40±0.22^{a}	3.54±0.24^{a}	3.61±0.29^{a}	3.58±0.22^{a}	3.44±0.25^{a}	3.47±0.27^{a}	3.44±0.22^{a}	3.55±0.18^{a}
C20:0	1.52±0.10^{b}	1.54±0.09^{b}	1.50±0.12^{b}	1.67±0.08^{ab}	1.74±0.11^{a}	1.73±0.08^{a}	1.78±0.13^{a}	1.75±0.13^{a}
C21:0	0.81±0.02^{b}	0.88±0.03^{a}	0.84±0.04^{ab}	0.79±0.02^{b}	0.91±0.03^{a}	0.85±0.02^{ab}	0.88±0.03^{a}	0.84±0.03^{ab}
C22:0	0.96±0.11^{a}	1.03±0.13^{a}	0.67±0.08^{b}	0.68±0.09^{b}	0.60±0.06^{bc}	0.52±0.05^{c}	0.51±0.05^{c}	0.58±0.04^{bc}
C24:0	0.46±0.03^{a}	0.49±0.03^{a}	0.33±0.04^{b}	0.28±0.03^{bc}	0.31±0.03^{b}	0.22±0.03^{c}	0.24±0.03^{c}	0.26±0.03^{bc}
TSFA	27.81±0.33^{c}	28.30±0.30^{c}	30.70±0.32^{b}	30.71±0.26^{ab}	31.15±0.30^{a}	30.47±0.35^{b}	30.52±0.41^{b}	30.40±0.30^{b}
C15:1	0.09±0.01^{a}	0.10±0.01^{a}	0.08±0.01^{a}	0.08±0.01^{a}	0.05±0.01^{b}	0.08±0.01^{a}	0.09±0.01^{a}	0.08±0.01^{a}
C16:1	9.84±0.12^{a}	9.66±0.14^{a}	9.42±0.16^{b}	9.36±0.12^{b}	9.56±0.09^{b}	9.48±0.15^{b}	9.45±0.16^{b}	9.36±0.18^{b}
C17:1	1.12±0.03^{a}	1.13±0.03^{a}	1.02±0.02^{b}	1.13±0.03^{a}	1.10±0.02^{a}	1.12±0.02^{a}	1.08±0.03^{ab}	1.07±0.04^{ab}
C18:1	12.33±0.21^{a}	12.45±0.23^{a}	12.24±0.19^{a}	12.29±0.12^{a}	12.14±0.20^{a}	12.36±0.18^{a}	12.23±0.22^{a}	12.18±0.29^{a}
C20:1	1.30±0.04^{a}	1.33±0.04^{a}	1.20±0.04^{b}	1.15±0.03^{c}	1.24±0.05^{ab}	1.19±0.04^{bc}	1.22±0.03^{b}	1.26±0.03^{ab}
TMUFA	24.68±0.36^{ab}	24.67±0.42^{ab}	24.68±0.51^{ab}	24.56±0.33^{ab}	24.09±0.26^{b}	24.95±0.51^{a}	24.88±0.51^{a}	24.67±0.42^{ab}
C18:2	11.20±0.30^{a}	11.09±0.27^{a}	10.03±0.20^{b}	10.26±0.24^{b}	10.06±0.12^{b}	10.40±0.26^{b}	10.32±0.25^{b}	10.26±0.16^{b}
C18:3	1.36±0.05^{a}	1.35±0.04^{a}	1.20±0.05^{b}	1.20±0.04^{b}	1.23±0.04^{b}	1.23±0.03^{b}	1.18±0.05^{b}	1.27±0.04^{ab}
C20:2	0.62±0.05^{a}	0.63±0.04^{a}	0.70±0.05^{a}	0.68±0.06^{a}	0.65±0.02^{a}	0.64±0.06^{a}	0.64±0.04^{a}	0.66±0.06^{a}
C20:3	0.94±0.05^{a}	0.99±0.06^{a}	0.78±0.06^{b}	0.77±0.04^{b}	0.84±0.04^{ab}	0.82±0.05^{b}	0.86±0.05^{ab}	0.85±0.05^{ab}
C20:4	1.20±0.04^{a}	1.23±0.05^{a}	1.10±0.06^{ab}	1.09±0.07^{b}	1.11±0.04^{ab}	1.04±0.06^{b}	1.06±0.05^{b}	1.06±0.06^{b}
C20:5	5.46±0.18^{a}	5.29±0.11^{a}	4.80±0.25^{b}	4.86±0.19^{b}	5.16±0.09^{ab}	4.99±0.12^{b}	5.02±0.15^{b}	5.10±0.15^{ab}
C22:5	1.42±0.32^{a}	1.49±0.24^{a}	1.36±0.26^{a}	1.38±0.27^{a}	1.50±0.31^{a}	1.42±0.20^{a}	1.40±0.28^{a}	1.39±0.29^{a}
C22:6	25.22±0.31^{a}	24.86±0.25^{a}	24.34±0.24^{b}	24.32±0.21^{b}	24.21±0.23^{b}	24.03±0.41^{b}	24.11±0.34^{b}	24.30±0.29^{b}
TPUFA	47.22±0.36^{a}	46.93±0.34^{a}	44.71±0.29^{b}	44.56±0.044^{b}	44.76±0.41^{b}	44.57±0.50^{b}	44.59±0.32^{b}	44.89±0.41^{b}

Values are expressed as mean ± SE, mean values in a row with different superscripts were statistically different (P <0.05). TSFA; total saturated fatty acids, TMUFA; total monounsaturated fatty acids, TPUFA; total polyunsaturated fatty acids, C10:0; capric acid, C12:0; lauric acid, C14:0; myristic acid, C15:0; pentadecylic acid, C16:0; palmitic acid, C17:0; margaric acid, C18:0; stearic acid, C20:0; arachidic acid, C21:0; heneicosylic acid, C22:0; behenic acid, C24:0; lignoceric acid, C14:1; myristoleic acidC15:1; pentadecenoic acid, C16:1; palmitoleic acid, C17:1; heptadecenoic acid, C18:1; oleic acid, C20:1; eicosenoic acid, C18:2; linoleic acid; C18:3; α-linolenic acid, C20:2; eicosadienoic acid, C20:3; dihomo-γ linolenic acid, C20:4; arachidonic acid, C20:5; eicosapentaenoic acid, C22:5; docosapentaenoic acid, C22:6; docosahexaenoic acid

Amino acid compositions of the Black Sea trout individuals obtained from the different environments were shown in Table 4. According to results, while the total amino acid amount was detected as highest in the wild fish, the total amount of essential amino acids was detected highest in the culture forms (P≤0.05). The most abundant amino acids were found as leucine, glutamic acid, serine, and lysine in all groups, respectively (P≤0.05). Glycine, alanine, glutamic acid, and aspartic acid were found higher in the wild forms, whereas isoleucine, threonine, and valine were found higher in the culture forms (P≤0.05). There are no statistical differences determined between all culture forms, including filial generations (P≥0.05). The eight essential amino acids were detected in all fish groups, including tryptophan, even though it was found as a minimum quantity. While threonine, valine, and isoleucine were found highest in the culture forms (P≤0.05), other essential amino acids were found statistically the same between groups (P≥0.05). Amino acids are essential compounds for nutrition. Essential amino acids are necessary are for many vital tasks in metabolism, such as protein synthesis, gene expression, cell division, and hormone secretion (Wu et al., 2010). Amino acids and proteins need to be taken daily in all diets for healthy eating and long life (Fontana & Partridge, 2015; Mirzaei et al., 2014). For these reasons, it is crucial to determine the amino acid composition of the species, such as the Black Sea trout, whose growth potential is increasing day by day. As well as the amount of amino acid in fish species may differ from species to species (Kaushik & Seiliez, 2010), the species may also vary according to environmental factors and feeding conditions (Ballantyne, 2011). Moreover, amino acid composition and muscle structure of Salmonidae species can be show differences due to the development of myotomal bundles caused by swimming activity between actively swimming species and non-swimming ones, even though in some species (Totland et al., 1987; Videler, 1993). As an anadromous species, Black Sea trout can be migrated between sea and throughout the whole stream in wild forms (Aydın & Yandı, 2002). Thus, crude protein and total amino acid contents of the wild forms were found higher compared to others due to muscle development. All essential amino acids, just as isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine, and tryptophan were detected in all groups. The lowest amino acid determined as tryptophan among all amino acids due to analyzing procedures. In the amino acid analysis, fish meat was treated with extreme conditions such as high temperature and low pH. Tryptophan is instable such extreme conditions (Çankırılıgil et al., 2020), and it can be lost entirely (Cuq & Firedman, 1989). Thus, tryptophan was found lowest.

The fatty acid composition of the Black Sea trout individuals was shown in Table 5. According to results, while the highest total saturated fatty acid (SFA) was detected in culture forms obtained from Borçka Dam Lake, values of wild forms were detected lower compared to other groups (P≤0.05). Filial generations were found more abundant in terms of total monounsaturated fatty acids among groups (P≤0.05). Oleic acid was found highest monounsaturated fatty acid in the Black Sea trout is all individuals and followed by palmitoleic acid. Besides that, these two fatty acids found highest in the wild forms among groups (P≤0.05). Polyunsaturated fatty acids were specified as the highest fatty acid group with the ratios ranges from 44.56±0.04 to 47.22±0.36, and they were found higher in wild forms than culture forms (P≤0.05). Linoleic acid and α-linolenic acid, which are essential for humans, were found in all forms of Black Sea trout. The most abundant polyunsaturated fatty acids were detected as DHA, linoleic acid, and EPA, respectively (P≤0.05). Whereas linoleic acid, α-linolenic acid, dihomo gamma-linolenic acid, arachidonic acid, DHA, and EPA were found highest in wild forms (P≤0.05), there are no statistical differences detected in the eicosadienoic acid and docosapentaenoic acid between groups (P≥0.05). One of the essential quality parameters that makes fish meat nutritious is the content of long-chain fatty acids (Lund, 2013; Sahena et al., 2009). Regular intake of polyunsaturated fatty acids, especially EPA and DHA are recommended for healthy nutrition in humans. It has been reported that fish oil is reducing deaths from such heart diseases and certain types of cancer with its effects on lowering insulin resistance, preventing infections, reducing embolisms, and blood viscosity (Simopoulos, 1991, 2002). According to our results, Black Sea trout rich in terms of beneficial fatty acids, DHA, and EPA, along with essential ones such as linoleic acid and alpha-linolenic acid. Marine fish living in cold waters are more affluent in long-chain fatty acids that are important for human nutrition (Farkas et al., 1980; Innis, 1991). Besides, pelagic fishes of cold marine waters have the highest DHA and EPA contents compared to others (Hossain, 2011). The trout individuals were used in this study were caught in rivers having approximately 11 °C water temperature. The environmental conditions are similar to why the culture forms were obtained from the aquaculture facilities on the same river pending the same period. However, as aforementioned before, wild Black Sea trout migrates between sea and freshwater (Kaushik & Seiliez, 2010) and are exposed to very different salinity and temperature conditions. Conversely, cultured trouts are stocked in a fixed area with a high stock density compared to the trouts living in nature (Mazur & Iwama, 1993). The fishes used in our study are at the same age and close length, yet environmental conditions vary. Besides that, wild trouts feed on crustase, diptera, molluscs, and fish species, which are rich in terms of polyunsaturated fatty acids (Kolanowski et al., 2007; Teixeira & Cortes, 2006). Thus, it

is possible to conclude that the differences in fatty acid composition are caused by environmental conditions as well as the feeding regime. Ultimately, it is crucial to know the fatty acid profile of the Black Sea Trout caught from different environmental conditions.

Conclusion

The Black Sea trout, an endemic species to the Eastern Black Sea, has been widely cultured in recent years and has a high economic return. Although the process of aquaculture of the species has been limited to the last 20 years, scientific studies on the species are extensive. In parallel with the scientific studies and the spread of the aquaculture of the species, consumer demand is increasing day by day. This species, which is preferred by consumers, is rich in terms of meat quality. Although individuals sampled from nature are more abundant in some essential amino acids and unsaturated fatty acids, it has been determined that culture forms values close to individuals from nature. The culture forms obtained from different aquaculture facilities show similar results to different culture lines (F3, F4, F5). With the breeding studies to be carried out on the Black Sea trout, the aquaculture of this nutritious species can be increased.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: All experiments were carried out with approval (ETIK-2017/1) of the Ethical Committee of Animal Experiments of Central Fisheries Research Institute considering the ethical rules of ARRIVE (Animal Research: Reporting of in Vivo Experiments) and European Union directive named as 2010/63/EU.

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ÖZ

Çardak Lagünü'nde (Çanakkale Boğazı) yapılan bu çalışmanın amacı pinterle avlanan Yeşil Yengeç, *Carcinus aestuarii* 'in aylık birim çabadaki av miktarını (BÇAM) belirlemektir. Bu çalışmada yengeç örnekleri Nisan 2015-Mart 2016 arasında pinter aracılığı ile aylık olarak 6 farklı istasyondan toplanmıştır. Çalışma sonucunda toplam 686 dişi, 1755 erkek ve 17 immature birey toplamda 2458 yengeç bireyi örneklenmiştir. En yüksek av verimi Ekim ayında (12.74 birey/gün), en düşük av verimi ise Şubat ayında (2.43 birey/gün) elde edilmiştir. En yüksek BÇAM değeri (10.02 birey/gün) 1. Istasyon için, en düşük (7.02 birey/gün) 6. istasyon için hesaplanmıştır.

Anahtar Kelimeler: Yeşil yengeç, *Carcinus aestuarii*, BÇAM, Çardak Lagünü, Çanakkale boğazı

ABSTRACT

Catch per unit effort (CPUE) of green crab, *Carcinus aestuarii* Nardo, 1847 captured by fyke-nets in Çardak Lagoon

The aim of this study is to determine the catch per unit effort (CPUE) of Green Crab, *Carcinus aestuarii* captured monthly by fyke-nets in Çardak Lagoon (Çanakkale Strait). In the study, the crabs individuals were sampled by means of fyke-nets at 6 different stations between April 2015 and March 2016. A total of 2458 individuals (686 female, 1755 male and 17 juvenile) were captured. The highest number of catch per unit effort (CPUE) value in October, and the lowest value was in February. The CPUE value was recorded from the highest station number 1 and calculated from the lowest station 6.

Keywords: Green crab, *Carcinus aestuarii*, CPUE, Çardak Lagoon, Çanakkale strait

Giriş

Lagünler mevcut fauna ve flora, balıkçılık ve su ürünleri faaliyetleri (akuakültür) açısından önemli ekolojik alanlardır. Lagüner alanlardaki faunal ve floral kompozisyon, meteorolojik koşullar, lagünlerin derinliği, su dolaşımı, besleyici element indeksi ve sıcaklık/tuzluluk değişkenleriyle ilişkilendirilmektedir (Pearce ve Crivelli, 1995). Birçok denizel form için potansiyel üreme alanı olan lagünlerde biyolojik çeşitlilik yüksektir. Ayrıca bu özel ekosistemler canlılara barınak oluşturan ve populasyonun büyümesini sağlayan özel ekotonlardır (Demir, 2008). Dekapod krustaseler denizel ekosistemin ekolojik bileşenlerinden biridir ve besin zincirinin önemli halkalarından biridir (Farina ve ark., 1997). Dekapod krustaselerden Portunid yengeçler bivalv, poliket ve gastropod gibi bentik grupların bolluğunu kontrol edebilen önemli predatörlerdir (Cilenti ve ark, 2014). Lagüner alanlar beslenme ve barınma için oldukça uygun yaşam alanları olmasına karşılık, su derinliği, tuzluluk ve sıcaklık gibi çevresel faktörler sürekli değiştiği için yengeçlerin fizyolojisi negatif olarak etkilenmektedir. Bu yüzden abiyotik faktörlerin etkilerini en aza indirebilecek şekilde sürekli göç yaparlar (Rewitz, 2004). Yeşil yengeç populasyonları büyük değişimler gösteren çevresel koşullara karşı toleranslıdırlar (Abello ve ark., 1997; Aydin, 2013).

Akdeniz Ekosistemi Lagünleri'nde Yeşil yengeç populasyonları yoğundur ve olgun dişilerin lagünlerden kıyı sularına periyodik olarak çıkışı iki ekoton arasında önemli miktarda biyokütle değişimi oluşturmaktadır (Mori ve ark., 1990). Yeşil yengeç bireyleri lagüner ekosistemlerde Ağustos- Eylül ayları arasında üremeye başlar ve sonbahar periyodunda üreme devam eder. Bununla birlikte, Ekim ve Kasım aylarında üreme potansiyeli en yüksek yüzdeye ulaşır ve yumurtalı olgun dişiler popülasyon içerisinde görülmektedir. Lagünlerde olgun dişilerin kıyı sularına göçü genelde Aralık ayında veya Ocak ayının başlangıcında yağışlı mevsim değişkenliğine bağlı olarak başlamaktadır (Mori ve ark., 1990).

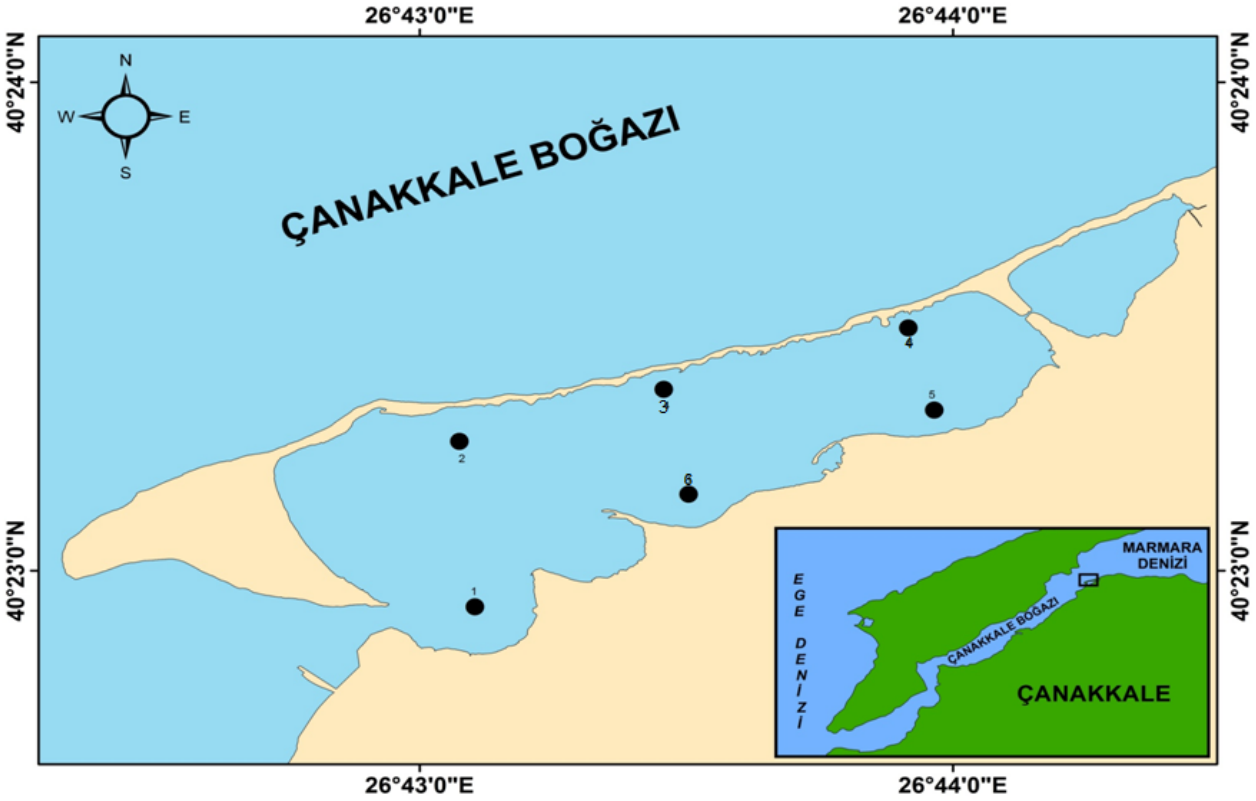
Yapılan bu çalışmada amaç Çanakkale Boğazı kıyısında yer alan ve özel bir ekolojik alan olan Çardak Lagünü'nde geniş dağılım gösteren Yeşil yengeç'in aylara ve istasyonlara göre av verimini belirlemektir.

Materyal ve Metot

Yeşil Yengeç bireyleri Nisan 2015 ile Mart 2016 arasında Çardak Lagünü' nün 6 farklı istasyonundan aylık olarak örneklenmiştir (Şekil 1). Örnekleme zamanları deniz ve hava koşullarına göre önceden belirlenmiş ve örneklemeler belirlenen tarihlerde gerçekleştirilmiştir. Örneklemelerde ticari balıkçı teknesi kullanılmıştır. Örneklemeler 36 mm göz açıklığına sahip, ağız açıklığı 38 cm olan 4 m boyundaki tek girişli kerevit pinterleri ile lagün alanında yaklaşık 1.5 – 2 m derinlikten gerçekleştirilmiştir (Şekil 2). Pinterler suya herhangi bir yemleme işlemi yapılmadan bırakılmıştır. Suya bırakılan pinterler 48 saat sonra toplanmıştır. Yengeç bireyleri gece daha aktif olduklarından yeterli sayıda birey elde etmek amacıyla pinterler 2 gün suda bırakılmıştır. BÇAM = (Σbirey/ Σ4Pn) * Gün formülü kullanılmıştır (birey/gün). Her örnekleme istasyonunda 4 adet pinterle örneklemelerde elde edilen Yeşil yengeç bireyleri için Σbirey yakalanan toplam birey sayısını, Σ4Pn kullanılan toplam pinter sayısı ile günün çarpımını ifade eder. Lagün suyunun fizikokimyasal değişkenleri (Tuzluluk, sıcaklık, pH, doymuş oksijen) anlık olarak arazide YSI 556 model MPS ile ölçülmüştür. Aylara göre av miktarları arasındaki farkları istatistiksel açıdan belirlemek için χ^2 (ki-kare) testi uygulanmıştır. Ayrıca BÇAM ile sıcaklık ve dişi, erkek birey sayısı arasındaki ilişki Pearson korelasyonu ile kontol edilmiştir. Ki-kare (χ^2) testi ve korelasyon testleri Minitab 16 ve SPSS 20 programında yapılmıştır.

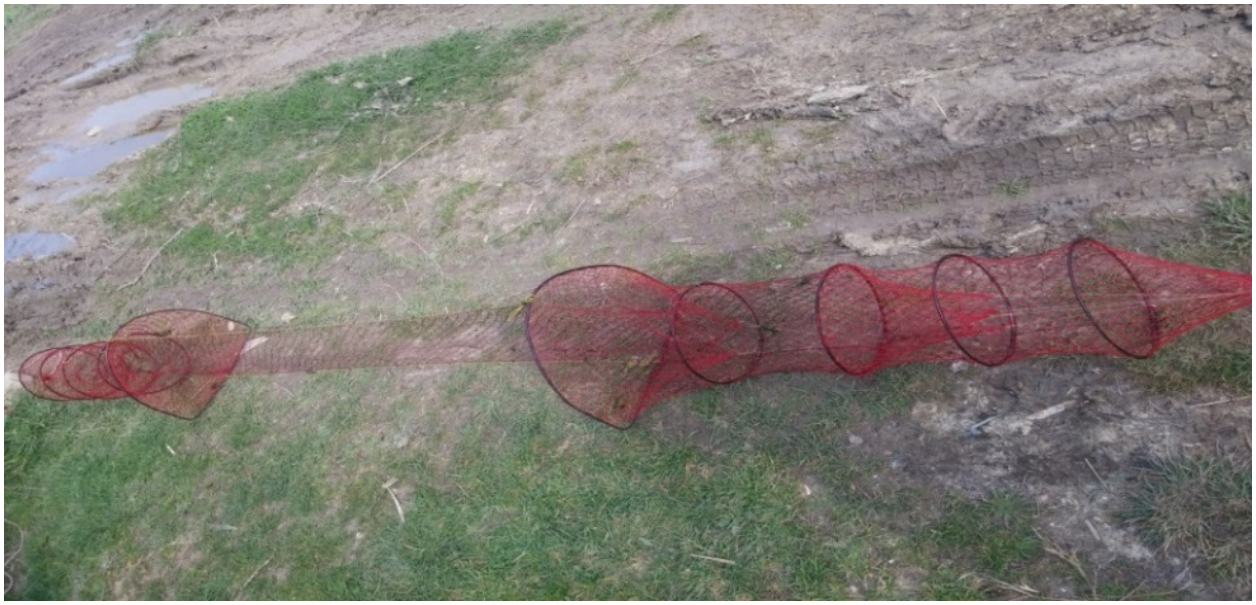
Bulgular ve Tartışma

Çardak Lagünü'nde yapılan çalışmada yakalanan Yeşil yengeç populasyonunun % 27.9'unu (686 birey) dişi ve % 71.39'unu (1755 birey) erkek ve % 0.7'sini (17 birey) olgunlaşmamış (immature, juvenil) bireyler oluşturmaktadır. İstasyonlara göre birey sayılarına bakıldığında Birey sayılarının cinsiyete bağlı farklılıkları ANOVA testiyle istatistiksel olarak analiz edilmiş ve dişi ve erkek birey sayılarının istatistiksel açıdan önemli olduğu görülmüştür ($p=0.000$, $p<0.05$). En fazla birey (239 birey) Kasım ayında en az birey (125 birey) ise Şubat ayında örneklenmiştir. En fazla dişi birey (116 birey) Aralık ayında en az dişi (18 birey) Haziran ayında örneklenirken, erkek bireyler en fazla (192 birey) Eylül ve Mart ayında, en az (86 birey) ise Şubat ayında kaydedilmiştir (Şekil 3). İstasyonlara göre birey sayılarına bakıldığında en fazla erkek birey 5. istasyondan yakalanmıştır, en fazla dişi birey ise 1. Istasyonda örneklenmiştir (Şekil 4). Pinter avcılığı ile lagün içinden levrek *Dicentrarchus labrax* (Linnaeus, 1758), kaya balığı *Neogobius melanostomus* (Pallas, 1814), yengeçler, *Xantho poressa* (Olivi, 1792), *Liocarcinus depurator* (Linnaeus, 1758) gibi farklı balık ve omurgasız türleri de avlanmıştır ancak çalışmada hedef tür Yeşil Yengeç olduğu için bu türler hedef dışı olarak bırakılmıştır.



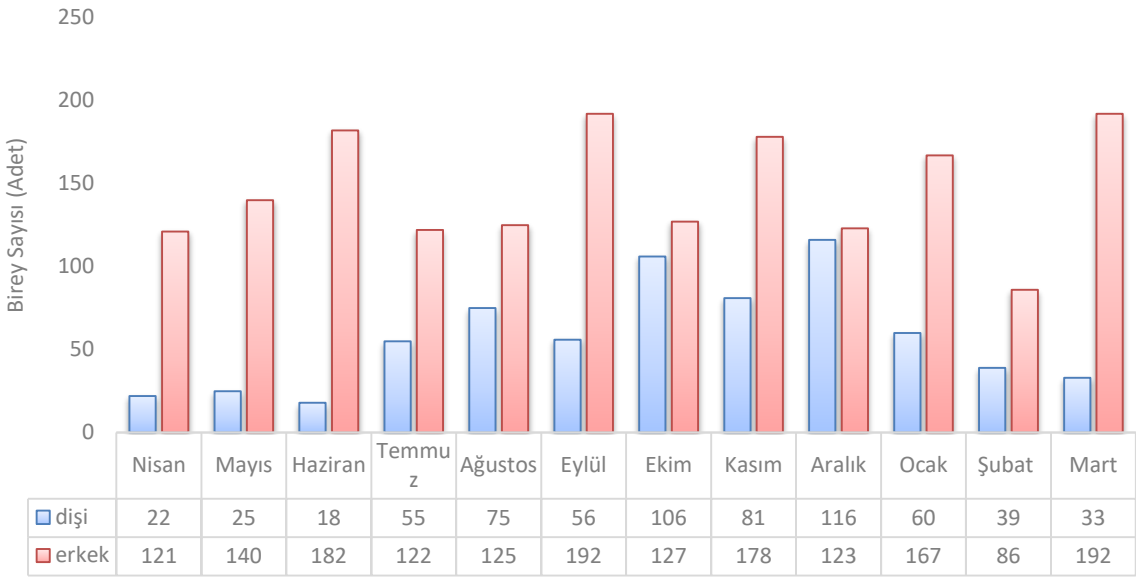
Şekil 1. Çalışma Alanı

Figure 1. Study area



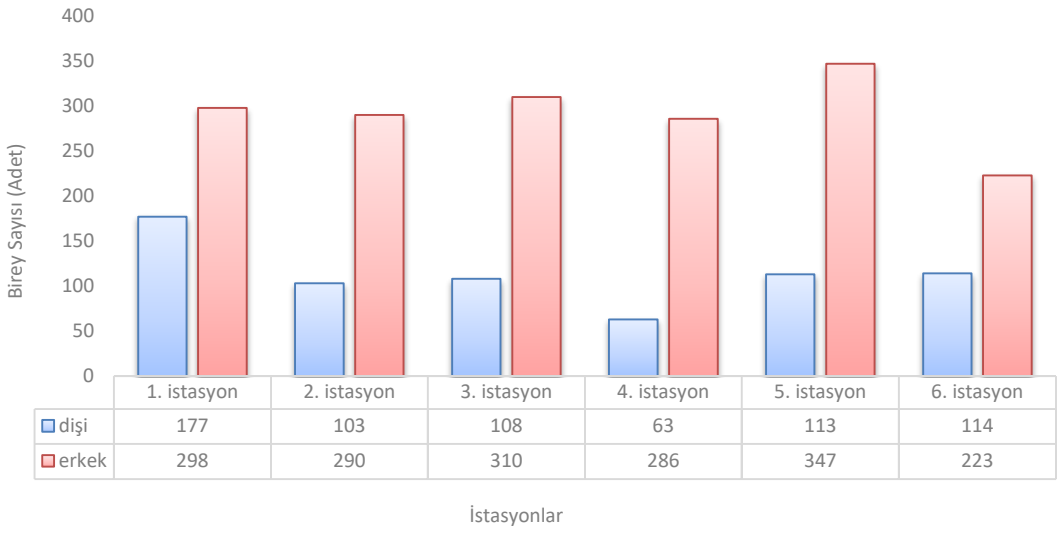
Şekil 2. Yeşil Yengeç avcılığında kullanılan pinter (Orijinal)

Figure 2. Pinter used in catching of green crab (Original)



Şekil 3. Aylara göre dişi ve erkek birey sayısı

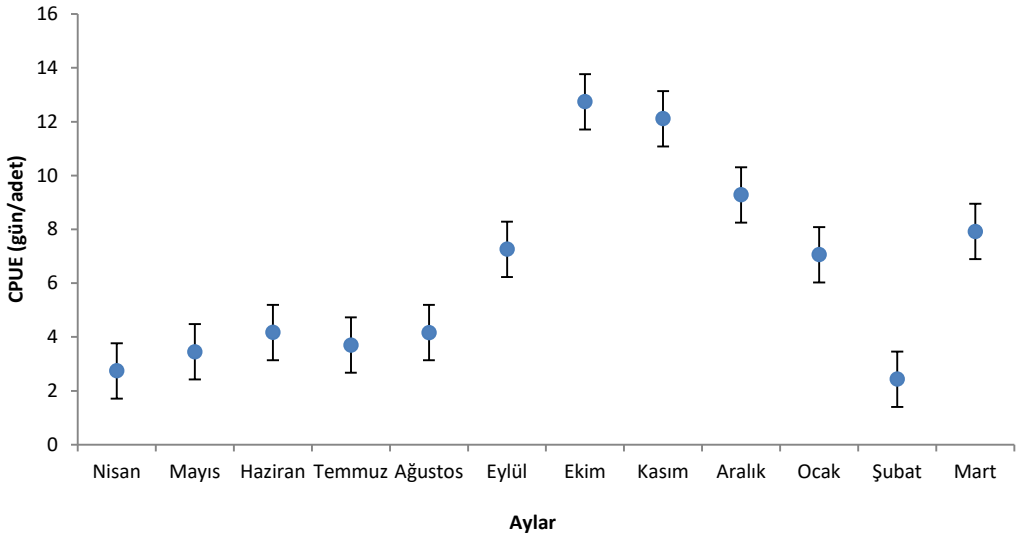
Figure 3. Pinter used in catching of green crab (Original)



Şekil 4. İstasyonlara göre birey sayısı

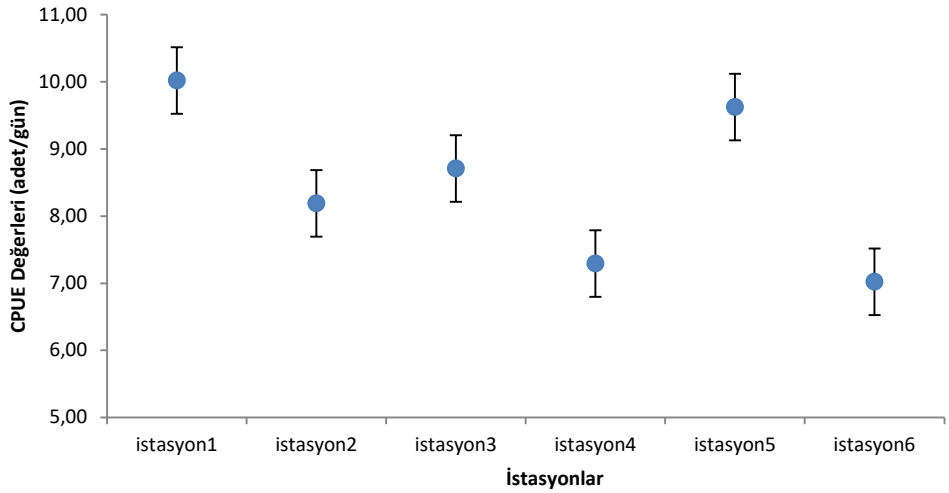
Figure 4. The number of individuals in the sampling stations

Araştırma alanında dağılım gösteren Yeşil Yengeç avcılığında birim çabaya düşen av miktarı aylara ve istasyonlara göre hesaplanmıştır. Aylara göre, en yüksek av miktarı Ekim ayında (ortalama 12.74 birey/gün) ve en düşük av verimi miktarı (ortalama 2.43 birey/gün) ise Şubat ayındadır. İstasyonlara göre ise, en yüksek av verimi (ortalama 10.02 birey/gün) 1. istasyonda kaydedilirken, en düşük verim (ortalama 7.02 birey/gün) ise 6. istasyondadır. En yüksek av verimi (4.88 birey/gün) ise Ekim ayı örneklemesinde 6. istasyonda kaydedilmiştir (Şekil 5). İstasyonlara göre BÇAM değerlerine bakıldığında en yüksek değer 1. istasyondan kaydedilmiştir (Şekil 6). Aylara göre istasyonlardaki BÇAM değerleri arasındaki ilişki χ^2 (ki- kare) testiyle kontrol edilmiştir ve Ekim 2015 ve Şubat 2016'da BÇAM değerleri istatistiksel açıdan önemlidir (χ^2=2.52; df=12; $p<0.05$). Bununla birlikte, genel olarak ortalama BÇAM değeri aylara göre önemlidir ($p<0.05$). İstasyonlara göre BÇAM değerleri istatistiksel açıdan önemli değildir. (χ^2= 3.60; df=5; $p>0.05$). Ancak, % birey sayısı aylara göre istatistiksel açıdan önemlidir ($p<0.05$) (Tablo 1).



Şekil 5. Aylara göre BÇAM değerleri

Figure 5. CPUE values in the months



Şekil 6. İstasyonlara göre BÇAM değerleri

Figure 6. CPUE values in the sampling stations

Tablo 1. Aylara ve istasyonlara göre BÇAM ve %N değerleri

Table 1. Values of CPUE and N% in the months and the sampling stations

	İstasyon 1		İstasyon 2		İstasyon3		İstasyon4		İstasyon5		İstasyon6	
Aylar	**CPUE**	**%N**	**CPUE**	**%N**	**CPUE**	**%N**	**CPUE**	**%N**	**CPUE**	**%N**	**CPUE**	**%N**
Nisan	0.60	1.64	0.10	0.20	0.54	1.07	0.27	0.53	0.75	1.47	0.48	0.94
Mayıs	0.52	1.02	0.42	0.81	0.29	0.57	0.69	1.35	1.13	2.21	0.40	0.78
Haziran	0.35	0.70	0.67	1.31	0.73	1.43	0.50	0.98	1.27	2.50	0.65	1.27
Temmuz	1.81	3.54	0.63	1.22	0.63	1.23	0.00	0.00	0.63	1.23	0.00	0.00
Ağustos	1.04	2.05	1.04	2.05	1.04	2.05	1.04	2.05	0.00	0.00	0.00	0.00
Eylül	1.44	1.75	0.90	1.68	1.10	1.68	0.94	1.76	1.50	1.64	1.38	1.64
Ekim	2.23	1.64	3.27	1.84	0.92	1.72	0.48	0.86	0.96	1.64	4.88	1.84
Kasım	1.40	1.87	0.98	1.63	4.33	1.84	1.90	1.64	2.52	1.64	0.98	1.97
Aralık	1.38	1.64	1.19	1.64	2.60	1.68	0.63	1.23	1.77	1.64	1.71	1.97
Ocak	1.25	1.76	0.63	1.23	2.23	1.68	0.90	1.64	1.40	1.72	0.65	1.27
Şubat	0.21	0.41	0.38	0.90	0.21	0.61	0.31	0.61	0.63	1.23	0.69	1.35
Mart	1.17	1.39	0.79	1.56	0.92	1.80	3.60	1.64	0.98	1.93	0.46	0.90

Tablo 2. Örnekleme noktalarında kaydedilen fizikokimyasal değişken değerleri

Table 2. Values of environmental variables recorded at the sampling points

	Sıcaklık (C⁰)						Tuzluluk (ppt)						Ç.O. (mg/L)						pH					
	İst.1	**İst. 2**	**İst. 3**	**İst. 4**	**İst. 5**	**İst. 6**	**İst.1**	**İst. 2**	**İst. 3**	**İst. 4**	**İst. 5**	**İst. 6**	**İst.1**	**İst. 2**	**İst. 3**	**İst. 4**	**İst. 5**	**İst. 6**	**İst.1**	**İst. 2**	**İst. 3**	**İst. 4**	**İst. 5**	**İst. 6**
Nisan	12.3	14.4	13.8	14.2	12.1	13.6	21.8	21.7	21.7	21.4	21.8	21.6	8.5	8.3	8.4	8.4	8.5	8.5	8.8	8.86	8.9	8.8	8.6	8.7
Mayıs	21.8	22	20.7	22.6	23	21.1	21.2	21.8	21.3	21.9	21.9	21.2	7.88	8.1	7.09	7.21	9.04	7.42	8.73	8.78	8.69	8.82	8.93	8.69
Haziran	22.8	23.3	23.3	23.1	22.9	23.1	20.2	20.8	20.8	20.7	20.4	20.3	7.21	8.97	9.47	8.42	7.86	8.43	8.73	8.88	8.89	8.86	8.84	8.82
Temmuz	27	28.7	28.6	28.7	28.8	28.1	19.3	20.1	20.4	20.7	20.7	19.3	7.94	8.03	8.42	7.33	6.45	7.65	8.8	8.83	9.01	8.86	8.97	9
Ağustos	25.7	25.6	25.5	25.5	25.1	25.7	20.2	20.8	20	20.2	20	20.1	6.6	6.58	6.27	6.48	6.42	6.52	8.83	8.82	8.82	8.86	8.8	8.85
Eylül	23.3	23.4	23.5	23.4	24.4	23.3	20.1	20.1	20.8	20.8	20.8	20.8	7.83	8.65	7.94	7.53	7.8	7.35	8.79	8.84	8.83	8.84	8.89	8.83
Ekim	18.9	18.5	18.6	18.8	18.9	19.1	20.8	21.2	21.1	21.2	20.8	21.1	5.91	6.51	5.84	6.44	5.62	5.31	8.74	8.79	8.85	8.83	8.83	8.79
Kasım	14.9	15.1	13.9	13.9	14.5	14.2	22.4	21.8	22.1	21.2	22	22.1	8.81	9.98	9.98	10.77	9.3	8.91	8.7	8.76	8.82	8.84	8.76	8.74
Aralık	9.6	9.2	9.3	9.3	9	9.9	22.8	23.2	23.4	23.4	23	23.4	7.6	7.29	7.61	6.55	8.68	7.54	8.64	8.64	8.5	8.62	8.61	8.61
Ocak	12	11.9	12.1	12.2	12.4	12.4	22.9	23.1	23	22.6	22.6	23.1	8.99	8.39	8.5	8.25	8.54	8.24	8.66	8.63	8.66	8.63	8.68	8.63
Şubat	10.3	11.7	10.7	10.9	11	11.1	23.6	23.1	23.9	23.7	23.5	23.2	10.91	11.2	12.21	11.68	11.3	11.21	8.7	8.7	8.8	8.8	8.8	8.8
Mart	12.5	13.1	12.8	12.9	13.9	13	22.5	22.6	22.6	22.5	22.5	22.6	10.05	11.44	10.07	10.11	11.71	10.3	8.9	8.9	8.8	8.8	8.8	8.8
Ortalama	17.6	18.1	17.7	18.0	18.0	17.9	21.5	21.7	21.8	21.7	21.7	21.6	8.2	8.6	8.5	8.3	8.4	8.1	8.8	8.8	8.8	8.8	8.8	8.8
std hata	1.83	1.84	1.86	1.88	1.91	1.80	0.40	0.33	0.36	0.33	0.32	0.39	0.40	0.46	0.51	0.50	0.53	0.45	0.02	0.03	0.04	0.02	0.03	0.03

BÇAM değerleri ile sıcaklık arasındaki ilişki korelasyon testiyle kontrol edilmiştir. Av miktarı ile sıcaklık arasındaki ilişki negatif yönde bir ilişki olup, av miktarı arttıkça sıcaklığın azaldığı sonucuna varılmıştır. İlişki istatistiksel olarak önemli değildir (r=-0.28; p=0.384; p>0.05). Tuzluluk ile BÇAM değerleri arasında pozitif yönde zayıf bir ilişki (r=0.18; p=0.716; p>0.05) , O_2 ve pH ile negatif yönde zayıf ilişki vardır (r=-0.19; p=0.545; p>0.05; r=-0.32; p=0.300; p>0.05) (Tablo 2). Dişi ve erkek bireylerin birim çaba başına düşen av miktarı (BÇAM) ile ilişkisi Pearson korelasyonu ile kontrol edilmiştir. Buna göre dişi birey sayısı ile BÇAM arasında istatistiksel açıdan önemli bir pozitif ilişki bulunmuştur (r=0.733; p=0.007; p<0.05). Erkek birey sayısı ile BÇAM arasındaki ilişki önemli olarak bulunmamıştır (r=0.367; p=0.240; p>0.05).

Kuzey Akdeniz Kıyıları lagüner alanlarındaki Yeşil yengeç topluluklarının avlanmasında farklı av araçları ve yöntemleri kullanılmaktadır. Farklı avlama yöntemlerinin birey sayısı ve cinsiyet oranına etkisi yürütülen çalışmalarda belirtilmiştir. Yakın zamanlarda, Cilenti ve ark. (2014) Varona Lagünü (doğu İtalya)'nde yaptıkları çalışmada pinter kullanmışlar ve toplamda Yeşil yengeç bireylerinden 192 erkek, 13 dişi örneklemişlerdir. Baklouti ve ark. (2013) Tunus Kıyıları (güney Akdeniz)'nda fanyalı ağlarla örnekleme yapmışlar ve 518 erkek, 881 dişi Yeşil yengeç bireyi yakalamıştır. Glamuzina ve ark. (2017) Parilla Lagünü (Kuzey Adriyatik)'nde sığ suda yılan balığı pinteri kullanarak örnekleme yapmışlarıdır. Parilla Lagünü'nde yapılan örnekleme sonucunda toplam 1844 erkek ve 2112 dişi birey elde etmişlerdir. Ülkemiz kıyılarında yayılış gösteren ve örihalin bir tür olan *C. aestuarii* toplulukları üzerine birkaç çalışma bulunmaktadır. Bunlardan, Can ve ark., (2004) Çakalburnu Dalyanı (İzmir Körfezi)'nda yaptıkları çalışmada Yeşil yengeç bireylerini örneklemek için algarna çekimi yapmışlardır ve toplamda 1185 erkek ve 991 dişi birey örneklemişlerdir. Özbek ve ark. (2012) pinter, fanyalı ağlar ve ığrıp gibi farklı av araçları kullanarak Homa Lagünü (İzmir Körfezi)'nden toplam 608 erkek ve 559 dişi Yeşil yengeç bireyi bulmuşladır. Aynı lokalitede Özcan ve ark. (2009) da tuzak kullanarak Yeşil yengeç'in toplamda 555 erkek ve 101 dişi bireyini yakalamışlardır. Homa Lagünü'nde Acarlı ve ark., (2009) tarafından yapılan başka bir çalışmada ise farklı avcılık yöntemleri kullanılmış (kuzuluk, uzatma ağları, pinter, kargılı ağlar) ve Yeşil yengeç bireylerinin bütün av araçlarında yakalandığı görülmüştür. Aydın (2013) Türkiye'nin doğu Karadeniz Yeşil yengeç toplulukları üzerine yürüttüğü çalışmada av aracı olarak uzatma ağlarını kullanmış, toplamda 279 dişi ve 286 erkek birey örneklemiştir. Çardak Lagünü'nde yapılan bu çalışmada ise av aracı olarak kerevit pinteri kullanılmıştır. Bu çalışmada toplamda 1744 erkek ve 686 dişi birey yakalanmıştır ve dişi-erkek oranı 0.39 olup 4 katına yakındır. Önceki çalışmalarda farklı av araçları ile örneklenen bireylerde bu oran yaklaşık algarna için 0.83, uzatma ağları için 0.97'dir. Bu bağlamda pinterle avlanan dişi birey oranı diğer av araçlarıyla avlanan oranlara göre daha düşüktür. Ayrıca, erkek Yeşil yengeç bireyleri dişilere oranla daha aktiftir ve av araçlarına daha fazla girmektedir. Kişisel gözlemlerimize göre küçük karapas boyuna sahip dişiler av aracının içerisinden kolaylıkla kaçmaktadır ve sonuçta avlanan dişi sayısı erkek sayısına oranla düşüktür. Muoneke ve ark., (1993)'na göre pasif av araçlarının yakalama etkinliği, türe, habitata, boyut, davranış ve av aracının niteliğine bağlıdır. Çardak Lagünü'nde yapılan bu çalışmada da dişi ve erkek birey sayısı arasındaki farklılıkların av aracının niteliğine bağlı olduğu düşünülmektedir. Yapılan çalışmada tek bir avcılık yöntemi değerlendirilmiştir, birsonraki yapılacak çalışmalarda farklı av araçlarının türün av verimi üzerine etkisi belirlenebilir. Bu çalışmada da lagün alandaki populasyon yoğun olup, özellikle deniz etkisindeki 1. istasyonda en fazla avcılık değeri hesaplanmıştır. Ayrıca 1 numaralı istasyondan en yüksek dişi birey sayısı kaydedilmiştir. Dişilerin özellikle kış aylarında daha az sayıda olması ve yumurtalı dişi bireylerin azlığı, uygun olmayan şartlarda dişilerin lagünler alanla kıyı suları arasındaki değişimini destekler niteliktedir. Ayrıca lagün alanlarda canlıların dağılımlarını ve lagün-deniz göçlerini etkileyen en önemli değişken olan sıcaklık ile av verimi arasında negatif bir ilişkinin olduğu belirlenmiştir. Sıcaklığın giderek düşmeye başladığı Ekim ayından itibaren av veriminin yükseldiği ve ilkbahara doğru tekrar azalmaya başlamıştır. Şubat ayı av verimi açısından en düşük aydır. Özellikle suların soğuması ile dişilerin derin sulara geçişi, yumurtalı bireylerin morfolojik açıdan daha küçük olması av aracından kaçtıklarını düşündürmektedir.

Sonuç

Çardak Lagünü birçok denizel balık ve kuş türü için önemli bir barınma ve beslenme alanıdır. Bu tip lagüner alanlarda özellikle kış aylarında gel-git dönemlerinde, dişi yengeçler deniz ve lagün arasında göç yapmaktadırlar. Bu göçün belli nedenlerinden birinin de sıcaklık ve tuzluluk gibi çevresel değişkenlerin av miktarı üzerindeki etkileri olabileceği düşünülebilir. Ayrıca levrek ve çipura gibi ticari öneme sahip balıkların önemli bir besin bileşenini oluşturan Yeşil yengecin lagün içi avcılığında pinter kullanımı hem gerekli avcılığı sağlaması hem de yengeçlerin canlı ve hasarsız yakalanması açısından önemlidir. Bu çalışmada kullanılan kerevit pinterleri lagünde yengeçlerin yakalanmasında etkilidir. Bu çalışmanın ileride türün avcılığına yönelik yapılacak çalışmalara referans olabileceği düşünülmektedir.

Etik Standart ile Uyumluluk

Çıkar çatışması: Yazarlar herhangi bir çıkar çatışmasının olmadığını beyan eder.

Etik kurul izni: Araştırma niteliği bakımından etik izin gerektirmemektedir.

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Açıklama: Bu çalışma "Çardak Lagünü (Çanakkale, Lapseki)'nde Bulunan Yeşil Yengeç, *Carcinus aestuarii* Nardo, 1847'nin Populasyon Yapısı ve Bazı Biyo-Ekolojik Özellikleri" başlıklı doktora tezinin bir bölümüdür.

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....(Crockatt, 1995).

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Material Type	Reference List/Bibliography
A book in print	**Baxter, C. (1997).** *Race equality in health care and education.* Philadelphia: Ballière Tindall, p. 110-115, ISBN 4546465465
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