# MARINE SCIENCE AND TECHNOLOGY BULLETIN

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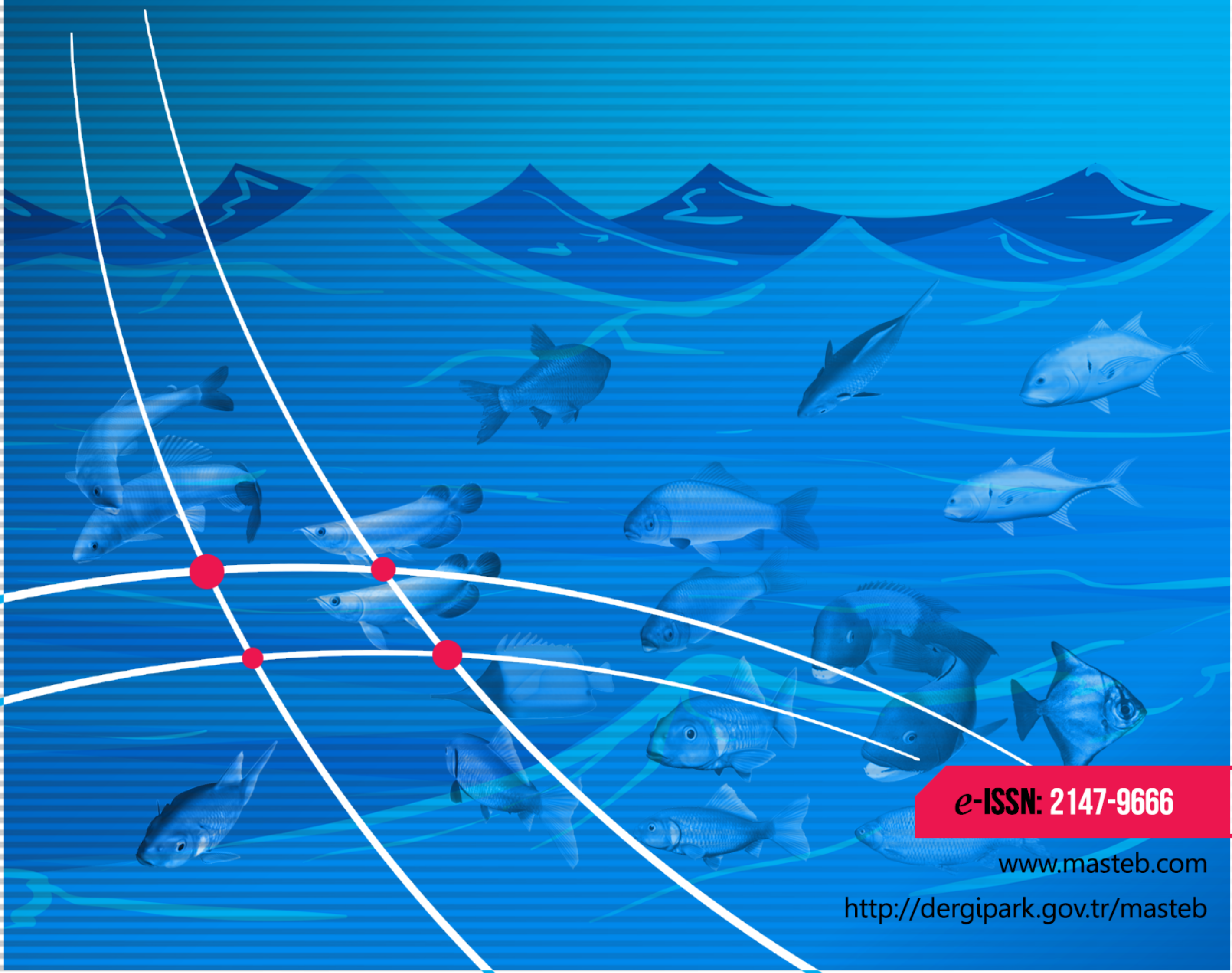

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# MARINE SCIENCE AND TECHNOLOGY BULLETIN

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Conference Proceedings:

Notev, E. & Uzunova, S. (2008). A new biological method for water quality improvement. *Proceedings of the 2nd Conference of Small and Decentralized Water and Wastewater Treatment Plants*, Greece, pp. 487-492.

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## *SHORT COMMUNICATIONS*

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Marine Science and Technology Bulletin

RESEARCH ARTICLE

# Occurrence of the lesser spotted dogfish (*Scyliorhinus canicula* Linnaeus 1758) in the international waters of Mersin Bay, Turkey.

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ABSTRACT

Eighty-five specimens of the lesser spotted dogfish, *Scyliorhinus canicula* Linnaeus, 1758, was caught by a bottom trawl in the international waters of the Mersin Bay in May 2018. Some of the caught individuals were preserved in 4% formalin and was deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (catalogue number: MEUFC-18-11-079). The depth of sampling area is between 274 and 641 m. A total of 13 trawling operations were carried out. The total number of caught individuals was 85 and on average 5 individuals were caught in each operation. The other cartilaginous fishes caught apart from *S. canicula* were *Galeus melastomus* (1 individual), *Squalus acanthias* (4 individuals), *Etmopterus spinax* (11 individuals) and *S. canicula* made up 84.16% of all cartilaginous fishes which were caught.

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Ayas, D., Çiftçi, N. (2018). Occurrence of the lesser spotted dogfish (*Scyliorhinus canicula* Linnaeus 1758) in the international waters of Mersin Bay, Turkey. *Marine Science and Technology Bulletin*, 7(2): 47-50.

## Introduction

*Scyliorhinus canicula* is a small shark species belonging to the family of the Scyliorhinidae of the Carchariniformes order. This shark's second dorsal fin is much smaller than the first. Its body is large, fairly chunky, and its dorsal part is characterized by black spots and sometimes small white spots in different sizes. Its lower jaw has only labial furrows and its small anterior nasal flaps reach the mouth (Compagno, 1984). *S. canicula* and *S. stellaris* cannot be easily identified with the reason that they are very similar to each other. Anterior nasal flaps of *S. stellaris* don't reach the mouth. This is an important morphological difference that is distinctive for the two species.

It has been reported that *S. canicula* is found both in coastal and open waters on rocky bathyal bottoms or corals. Tough *S. canicula* distributes between 10 m and 780 m depth, its distribution is typically 80 to 100 m depth. While it can be found up to 400 m (Muus and Nielsen, 1999) in the Mediterranean Sea, this species inhabits up to 780

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m in the Ionian Sea (Mytilineou et al., 2005). It feeds invertebrates like Crustaceae and Mollusca and demersal bony fish species (Froese and Pauly, 2018). *S. canicula* is consumed by people. This species is consumed as fresh or salted and dried fish by humans, is also converted into fish meal (Froese and Pauly, 2018).

Its maximum total length is reported as 100 cm (Compagno, 1984), the common adult length is 60 cm (Muus and Nielsen 1999), and the average size at first sexual maturity is 57 cm which ranges from 41 to 64 cm (Froese and Pauly, 2018). This is an oviparous species, with a single egg laid at a time per oviduct (Compagno, 1984). It eggs in spring and summer seasons. They also leave their eggs on algae in the subtidal or intertidal zone (Ellis and Shackley, 1997).

*S. canicula* distributes in the Northeast and Eastern Central Atlantic and Mediterranean Sea, and it continues to the Shetland Isles and Southern Norway to the north and Senegal to the south. There is no distribution of this shark species in the Black Sea (Compagno et al., 2005). *S. canicula* was categorized as least concern (LC) in the IUCN Red List of Threatened Species 2009 (Ellis et al., 2009). It is difficult to assess the effects of fisheries on *S. canicula* populations in the Mediterranean Sea due to lack of species specific reports. Besides, this shark species has a high post survival rate as a discard species among the species (Ellis et al., 2009). Overfishing and habitat degradation seem to be the main factors responsible for the reduction of deep-sea demersal species in the Northeastern Mediterranean Sea. In this study, it was determined the distribution and density of *S. canicula* in the international waters of the Mersin Bay, Northeastern Mediterranean Sea.

## Material and Methods

Deep-sea sampling by means of trawl was carried out in the international waters of the Mersin Bay between 14 and 17 May 2018 by a commercial trawl. The depth of sampling area is between 274 and 641 m. Coordinates of the sampled area: 36.24853N-34.36491E, 36.18839N-43.38847E, 36.17065N-34.40686E, 36.07227N-34.53326E (Figure 1). A total of 13 trawling operations were carried out. Each trawl operation lasted approximately 4 hours. During the sampling, eighty-five specimens of the lesser spotted dogfish was caught. Some specimens were preserved in 4% formalin and was deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (catalog no: MEUFC-18-11-079) (Figure 2). Taxonomic identification was based on diagnostic characters provided by Compagno (1984). All morphometric measurements were done to the nearest 0.01 cm using dial calipers (Table 1).

## Results

In the study, 85 individuals of *S. canicula* were caught in 13 trawling operations at a depth of 274-641 m from the open waters of the Mersin Bay (Figure 2). The mean length of the individuals is 32.3 cm and the mean weight is 117.302 g. Some morphometric measurements of the species were done and presented in Table 1.

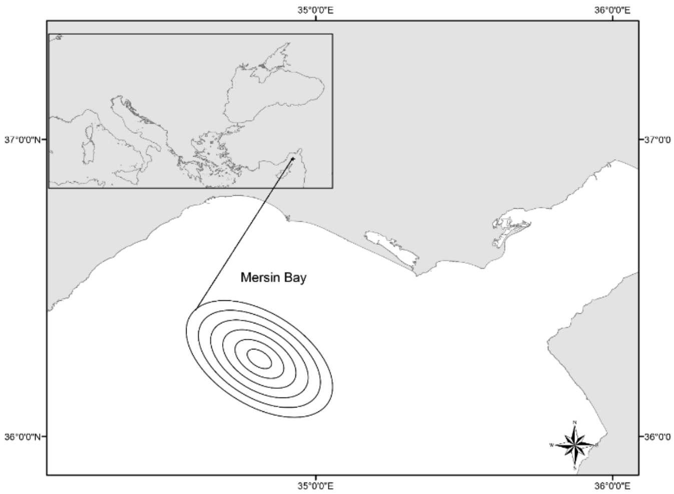


**Figure 1.** The shaded area indicates the locations where the specimens were caught.

**Figure 2.** Specimens of *S. canicula* from the international waters of the Mersin Bay, Turkey.

## Discussion

The mean length of the individuals caught in this study is 32.3 cm which ranges from 30 to 33.5 cm (Table 1). The size at first sexual maturity is 57 cm which ranges from 41 to 64 cm (Froese and Pauly, 2018). This indicates that all the individuals caught in the sampling area are immature.

While it can be found up to 400 m (Muus and Nielsen, 1999) in the Mediterranean Sea, this species inhabits up to 780 m in the Ionian Sea (Mytilineou et al., 2005). According to our findings, the distribution of this species is between 274 and 641 m, and this finding is similar to the literature. In this study, it was also determined that immature individuals of this species may be found at the depth of 641 m in the international waters of Mersin Bay. Baino and Serena (2000) reported that the juvenile individuals of the *S. canicula* are found especially on the upper slopes (~ 200 m). Researchers also reported that nursery ground is located on the seabed at depths of about 200 m. It can distribute at different depths depending on the maturation stages of *S.*

*canicula*. Younger individuals live in deeper areas, while adults are scattered in shallow water. This may indicate that *S. canicula* shows a reproductive migration, depending on depth. Furthermore, distribution of immature individuals in the deep-sea can be explained by overfishing and predator pressure.

**Table 1.** Some biometrical measurements expressed as a percentage of TL in *S. canicula*.

| Parameter | Present study (n=85) Min-max | Moftah et al. 2011 (n=4) |
|---|---|---|
| Pelvic length/TL % | 10.49-11.88 | - |
| Interdorsal space/TL% | 12.65-14.19 | - |
| Mouth width/TL% | 5.29-5.94 | - |
| Mouth length/TL% | 4.52-5.31 | - |
| Interorbital space/TL% | 5.88-7.10 | - |
| Precaudal-fin length/TL% | 77.42-81.19 | 78.69 |
| Predorsal-fin length/TL% | 49.33-52.31 | 49.04 |
| Prepectoral-fin length/TL% | 15.67-20.62 | 15.54 |
| Prepelvic-fin length/TL% | 39.35-41.19 | 38.39 |
| Preanal-fin length/TL% | 58.08-61.49 | 57.73 |
| Body depth/TL% | 8.62-10.33 | 6.82 |
| Head length/TL% | 12.26-14.33 | 16.79 |

We found that some biometric measurements of *S. canicula* in our study were similar to some biometric measurements obtained in the other study (Moftah et al., 2011) except for body depth/TL% and head length/TL% (Table 1). Both studies were conducted on the Eastern Mediterranean Sea population of this species. The researchers obtained individuals of *S. canicula* by catching in the Alexandrian waters of Egypt (Moftah et al., 2011). Besides, the ratios of two biometric measurements are different in both studies. The reason for these measurement ratios being different may be as follows: head length and body depth is not a good biometric measurement point; have less certainty than other biometric measurement points; measurement errors are made for this reason.

It was reported that in the 28% of 6336 trawling operations during the International Bottom Trawl Survey in the Mediterranean (MEDITS) in the 1994-1999 years, *S. canicula* specimens have been caught (Baino et al., 2001). During the Gruppo Nazionale Risorse Demersali (GRUND) project, 22 trawling operations were carried out in Italy between 1985-1998 years (Relini et al., 2000). In these surveys of the GRUND project, *S. canicula* was the 2th species in terms of frequency of occurrence in the obtained species composition. Other sharks, *G. melastomus* and *S. stellaris*, were found in the 1th and 18th ranks, respectively (Relini et al., 2000). Both catching rates for *S. canicula* were high in the MEDITS surveys and GRUND project, and this species also was caught in all 13 trawl operations in the present study. The total number of caught individuals was 85 and on average 5 individuals were caught in each operation. Other cartilaginous fishes caught apart from *S. canicula* were *G. melastomus* (1 specimens), *S. acanthias* (4 specimens) *E. spinax* (11 specimens) and *S. canicula* was made up 84.16% of all cartilaginous fishes. *S. canicula* is widespread in the East Atlantic and Western Mediterranean Sea according to the literature; and it is also determined that its distribution is intense in the international waters of Mersin Bay in the Northeastern Mediterranean.

## Conclusion

Immature individuals of *S. canicula* were only found in this study conducted in open waters of the Mersin Bay. This situation can be explained by the fact that immature is distributed in deep waters in order to avoid the predator and hunting pressure until the maturation period.

## Conflict of Interest

The authors declare that there is no conflict of interest.

## Acknowledgements

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RESEARCH ARTICLE

# Effect of celery (*Apium graveolens*) extract on the growth, haematology, immune response and digestive enzyme activity of common carp (*Cyprinus carpio*).

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ABSTRACT

In this study, the effect of a dietary supplementation of *Apium graveolens* on growth performance, digestive enzyme activities and immune response of juvenile common carp (*Cyprinus carpio*) were evaluated. *C. carpio*, with an average weight at the beginning of the experiment of 6.5 ± 0.07 g, were supplemented with a celery (*Apium graveolens*) aqueous methanolic extract at a dose of 0% (control), 0.1%, 0.5% or 1% over 45 days. Every 15 days, respiratory burst, lysozyme and myeloperoxidase activity were measured, and at the end of the study, haematological responses, growth performance and digestive enzyme activity were investigated. Respiratory burst and myeloperoxidase activity was significantly improved in all treated groups compared with the control group ($P < 0.05$). Lysozyme activity was highest in the 0.1% and 1% extract groups. At the end of the study, the final weight (FW), weight gain (WG) and specific growth rate (SGR) were significantly increased in the 0.1% group compared with the other groups. The feed concentration ratio was decreased in the 0.1% and 1% groups compared with the control ($P < 0.05$). Haematological parameters were affected by *A. graveolens* extract intake ($P < 0.05$). The total white and red blood counts, haemoglobin content and haematocrit value were highest in the 0.1% extract group ($P < 0.05$). However, the mean cell volume and mean cell haemoglobin concentration were decreased in the 0.5% group ($P < 0.05$). Digestive enzyme activity (trypsin, amylase and lipase) in all experimental groups was significantly elevated compared with the control ($P < 0.05$). These results indicated an immunostimulatory and growth-promoting effect and increasing digestive enzyme activity of *C. carpio* supplemented with an *A. graveolens* aqueous methanolic extract.

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## Introduction

Fishes not only play an important role as food for humans; they have also emerged as major model organisms for different biomedical researches. A number of experiments with several drugs have been conducted on fish (Govind et al., 2012). The common carp (*Cyprinus carpio*) is one of the most important fish species in aquaculture (Shirali et al., 2012) and is an economically significant fish species that is cultivated mainly in Asia and Europe. The global production of cultivated *C. carpio* comprised about 6.14% of global aquaculture production (FAO, 2008). It is also cultivated commercially (Cao et al., 2013) in other parts of the world such as Australia and South America because of its fast growth rate, facile cultivation and high feed efficiency ratio (Tokur et al., 2006). *C. carpio* has an important place in Turkey's fishing industry, and the species is widespread throughout Turkey's freshwater ecosystems, such as lakes, ponds and dam lakes (Güner et al., 2014). Compared with other aquaculture species such as shrimp and salmon, carp are considered an eco-friendly fish because most are omnivorous filter feeders and hence consume less fish meal and fish oil than other species (Xu et al., 2014).

Herbs and medicinal plants have a variety of properties, such as an appetite stimulator, growth promoter, antiparasitic, antimicrobial, immunostimulating and antioxidant due to the presence of various active compounds, like flavonoids, alkaloids, phenolics, pigments, steroids, terpenoids and essential oils (Citarasu, 2010). Celery (*Apium graveolens*) belongs to the Apiaceae and is a widely used food item. It is found in North and South America, Southern Europe, Africa and Asia (Sowbhagya, 2014). Many studies have revealed some pharmacological effects of *A. graveolens* extracts that were related to their antioxidant (Li et al., 2014), hepatoprotective (Ahmed et al., 2002), anti-inflammatory (Baananou et al., 2012), anticancer, analgesic, antibacterial and anti-spasmodic properties (Modaresi et al., 2012). Its major active constituents are phenolic compounds, flavonoids and volatile oils that can be extracted from its roots, leaves and seeds (Aydemir and Becerik, 2011; Baananou et al., 2012; Li et al., 2014).

The process of digestion determines the accessibility of nutrients needed for all bodily functions and enzymatic activity, and it is the basic tool used to observe feeding acceptability and its contribution towards fish growth and maintenance (Gisbert et al., 2009). Metabolic adaptations to changing feed ingredients and in turn enzymatic secretions result in better feed utilisation (Caruso et al., 2009). Digestive enzyme activities vary in different fish species, which may be due to differences in digestive potential and feeding habits.

The purpose of this study was to investigate the effect of an *A. graveolens* extract on growth performance, haematological profile, immune response and activity of digestive enzymes for *C. carpio*.

## Material and Methods

### *Fish and Experimental Design*

*C. carpio* with an average initial body weight of 6.5 ± 0.07 g were obtained from a commercial fish farm in Antalya, Turkey. Fish were transported to the Faculty of Fisheries, Kastamonu University, Turkey. A total of 480 fish were used for this study, and they were randomly divided into four main groups with triplicates per group (12 aquariums) and 40 fish in each aquarium. Fish were acclimatised for 2 weeks before the experiment started. During acclimation, fish were fed a commercial diet twice a day. During the experimental period, fish were fed the commercial diet supplemented with *A. graveolens* aqueous methanolic extract at a concentration of 0% (control), 0.1%, 0.5% and 1% for 45 d to satiation twice a day. Fish were maintained under a natural photoperiod (12 h dark/12 h light), and dissolved oxygen ranged from 6.8 to 7.2 mg/L (Hache Lange), pH from 7.7 to 8.5 and water temperature from 25 to 28°C. These parameters were checked daily and were within the accepted range throughout the experimental period.

### *Preparation of A. graveolens Extract*

*A. graveolens* was collected from Kastamonu province in the north of Turkey. Leaves were extracted by using an aqueous methanol extraction method according to Pakravan et al. (2012) with some modification as follows. Leaves were ground to a fine powder in a mechanical grinder, and 50 g samples were added to 1 L of 40% methanol (Sigma-Aldrich). The mixture was allowed to stand at room temperature for 3 day and was shaken every day. After 3 d, *A. graveolens* extract was filtered through filter paper (Whatman filter No 1), and the filtrate was collected and evaporated in a rotary evaporator at 55–65°C to remove the methanol. The final product was dissolved in distilled water and kept in a flask at 4°C for the experimental tests (Bilen et al., 2016). The final extract of *A. graveolens* after the evaporation process was diluted in 50 mL of distilled water and then sprayed on the fish diet at concentrations of 0.1%, 0.5% and 1%. The experimental diets were kept in sealed plastic containers and stored at −20°C until use.

### *Sample Collection*

On days 15, 30 and 45 of the study, three fish from each experimental aquarium were randomly chosen, anaesthetised with 0.30 mL $L^{-1}$ phenoxyethanol, individually weighed and samples were collected. Kidney tissues were collected and transferred individually to 1.5 mL RPMI-1640 medium (Invitrogen, Carlsbad, CA, USA) for direct immunological assays. Blood samples were collected from the caudal vein by heparinised syringes in EDTA tubes to test haematological parameters directly. Blood samples were only collected on day 45 of the feeding trial. Similarly, intestine samples were only collected on day 45 of the feeding trial. These samples were cleaned of waste and all visible fat and stored at −80°C for a digestive enzymes assay.

### *Estimation of Growth Parameters*

Fish were weighed at the beginning and end of the study. Growth performance was calculated following the equations of Tekinay and Davies (2001).

$$WG(\%) = 100 \times \frac{Final\ fish\ weight - Initial\ fish\ weight}{Initial\ fish\ weight}$$

$$SGR = 100 \times \frac{\ln(final\ fish\ weight) - \ln(Initial\ fish\ weight)}{Experimental\ days}$$

$$FCR = \frac{Feed\ Intake\ (g)}{WG\ (g)}$$

$$SR(\%) = 100\ \times \left[\frac{Final\ Number\ of\ Fish}{Initial\ Number\ of\ Fish}\right]$$

In these formulae, WG indicates weight gain, SGR indicates specific growth rate in percent weight for each day, FCR indicates feed conversion ratio, and SR indicates survival rate.

### *Haematological Parameters Analysis*

White blood cell (WBC × $10^7$/mm$^{-3}$) and red blood cell (RBC × $10^6$/mm$^{-3}$) counts and haemoglobin (Hb, g/dL$^{-1}$) and haematocrit (Hct, %) were measured according to methods described by Blaxhall and Daisley (1973). Blood indices included mean cell volume (MCV, fL), mean cell Hb (MCH, pg) and the mean cell Hb concentration (MCHC, %) were calculated according to the formulae of Lewis et al. (2006).

### *Immunological Parameters*

Head kidney cells were isolated from freshly euthanized *C. carpio* according to Kono et al. (2012) with slight modification. Briefly, head kidney tissue was removed carefully and gently pushed through a 100 µm nylon mesh (John Stanier, Whitefield, Manchester, UK) with RPMI-1640 medium supplemented with 5% foetal bovine serum (Invitrogen) and a 1% solution of 10,000 g mL$^{-1}$ streptomycin + 10,000 U mL$^{-1}$ penicillin (Invitrogen) and then pushed again through a 40 µm nylon mesh cell strainer (Becton, Dickinson and Company, Franklin Lakes, NJ, USA). The final homogenised volume of 3 mL was placed in a falcon tube. Head–kidney cell suspensions were pelleted by centrifugation at 1800 rpm for 3 min at 4°C. After centrifugation, the supernatant was collected to measure myeloperoxidase (MPO) by using 3,3,5,5-teteramethylbenzidine hydrochloride (Sigma-Aldrich) as a substrate (Sahoo et al., 2005) and to measure lysozyme by using a lyophilised *Micrococcus lysodeikticus* bacterial cell (Sigma-Aldrich) solution as a substrate (Bilen et al., 2014). The pellet was resuspended with 1 mL of the same medium to assay respiratory burst activity, which was determined by the reduction of nitroblue tetrazolium (Sigma-Aldrich) as a substrate, according to the methods described by Biswas et al. (2013).

### *Digestive Enzymes Activity*

The intestine was homogenised by a Potter Elvenhjem homogeniser in cold double-distilled water (0.1 g/1 mL) and centrifuged at 9000 rpm for 20 min at 4°C. The resultant supernatant was removed and stored at −80°C to test for digestive enzymes activity as follows. Trypsin activity was determined following the method of Erlanger et al. (1961) using benzoyl-dl-arginine-p-nitroanilide (Sigma-Aldrich) as a substrate. Amylase activity was determined by using 2% starch (Sigma-Aldrich) as a substrate according to Worthington (1991). Lipase activity was determined by hydrolysis of 4-nitrophenyl myristate (Sigma-Aldrich) according to the method described by Gawlicka et al. (2000). The protein content was evaluated following the method of Bradford (1976).

### *Statistical analysis*

The result was analysed using SPSS software. One-way ANOVA and Duncan's multiple range tests were used to determine the significant differences between the groups. All results are expressed as mean ± SD, and $P < 0.05$ was considered statistically significant.

## Results

Growth indices of the different groups are presented in Table 1. A significant increase in final weight, WG and SGR was observed for fish supplemented with 0.1% *A. graveolens* extract compared with the control ($P < 0.05$), whereas FCR of the 0.1% and 1% *A. graveolens* extract groups was significantly decreased compared with the control ($P < 0.05$). On the other hand, no significant differences were detected in final weight, WG, SGR and survival in the other treatment groups compared with the control group ($P < 0.05$).

**Table 1.** Growth performance of *Cyprinus carpio* supplemented with different concentrations of *Apium graveolens* extract for 45 days.

| Parameters | Groups | | | |
|---|---|---|---|---|
| | Control | 0.1% | 0.5% | 1% |
| IW (g) | 6.49 ± 0.05$^a$ | 6.54 ± 0.03$^a$ | 6.58 ± 0.02$^a$ | 6.47 ± 0.01$^a$ |
| FW (g) | 9.67 ± 0.45$^a$ | 10.69 ± 0.16$^b$ | 9.69 ± 0.02$^a$ | 9.64 ± 0.49$^a$ |
| WG (%) | 49.07 ± 5.90$^a$ | 63.57 ± 1.82$^b$ | 47.38 ± 0.64$^a$ | 48.91 ± 7.27$^a$ |
| FCR | 2.04 ± 0.03$^a$ | 1.48 ± 0.17$^b$ | 1.98 ± 0.01$^a$ | 1.80 ± 0.05$^c$ |
| SGR (%/day) | 0.89 ± 0.09$^a$ | 1.09 ± 0.02$^b$ | 0.86 ± 0.02$^a$ | 0.88 ± 0.12$^a$ |
| SR (%) | 91.25 ± 3.75$^a$ | 80 ± 6.75$^a$ | 73.75 ± 3.05$^a$ | 88.75 ± 1.77$^a$ |

***Note:*** *Values are means ± SE. Different letters in the same line indicate significant differences among groups (P < 0.05).*

The results indicate that fish supplemented with 0.1% *A. graveolens* extract had a significant increase in WBC, RBC, Hb and Hct and a decrease in MCV, MCH and MCHC compared with the control ($P < 0.05$). Fish supplemented with 0.5% *A. graveolens* extract had a significant decrease in all haematological parameters ($P < 0.05$) except WBC count, which was not significantly different from control fish. Significantly higher WBC count and lower Hct, MCV and MCHC values ($P < 0.05$ were observed in blood samples of fish supplemented with 1% *A. graveolens* extract, whereas no significant differences were observed for RBC, Hb and MCH compared with the control group.

Immunostimulatory effects of *A. graveolens* extract is provided in Tables 3, 4 and 5. Respiratory burst and MPO activities of fish supplemented with different concentrations of *A. graveolens* extract were significantly elevated ($P < 0.05$) on days 15, 30 and 45 compared with the control group. The lysozyme level on day 15 was only significantly decreased ($P < 0.05$) in the 0.5% extract group compared with the control. On day 30, fish supplemented with 0.1% or 1% *A. graveolens* extract showed a significant increase in lysozyme activity (*P < 0.05*). There was no significant difference in lysozyme levels among all groups on day 45.

**Table 2.** Haematological profile of *Cyprinus carpio* supplemented with different concentrations of *Apium graveolens* extract for 45 days.

| Parameters | Groups | | | |
|---|---|---|---|---|
| | Control | 0.1 % | 0.5 % | 1 % |
| WBC (×$10^7$cells $mm^{-3}$) | 32 ± 1.41$^a$ | 54 ± 1.42$^b$ | 33 ± 1.40$^a$ | 48 ± 0.89$^c$ |
| RBC (×$10^6$ cells $mm^{-3}$) | 1.35 ± 0.06$^a$ | 1.63 ± 0.04$^b$ | 1.24 ± 0.02$^c$ | 1.34 ± 0.03$^a$ |
| Hb (g $dl^{-1}$) | 5.48 ± 0.28$^a$ | 6.55 ± 0.19$^b$ | 4.35 ± 0.18$^c$ | 5.25 ± 0.19$^a$ |
| Hct (%) | 19.90 ± 1.25$^a$ | 23.30 ± 1.20$^b$ | 13.62 ± 1.34$^c$ | 18.50 ± 0.39$^d$ |
| MCV (fl) | 152.95 ± 1.79$^a$ | 142.82 ± 1.42$^b$ | 134.45 ± 2.42$^c$ | 145.77 ± 1.51$^d$ |
| MCH (pg) | 42.13 ± 1.69$^a$ | 37.12 ± 1.93$^b$ | 34.07 ± 1.72$^c$ | 42.90 ± 1.81$^a$ |
| MCHC (%) | 286.17 ± 3.43$^a$ | 273.83 ± 2.64$^b$ | 264.33 ± 2.16$^c$ | 276.50 ± 1.87$^b$ |

***Note:*** *Values are means ± SE (n = 9). Different letters in the same line indicate significant differences among groups (P < 0.05).*

**Table 3.** Respiratory burst activity of kidney leucocytes in *Cyprinus carpio* supplemented with different concentrations of *Apium graveolens* extract for 45 days.

| Groups | Study period | | |
|---|---|---|---|
| | 15 day | 30 day | 45 day |
| Control | 1.33 ± 0.02$^a$ | 0.73 ± 0.02$^a$ | 0.86 ± 0.04$^a$ |
| 0.1% | 1.44 ± 0.03$^b$ | 1.64 ± 0.03$^b$ | 1.14 ± 0.07$^b$ |
| 0.5% | 1.54 ± 0.05$^c$ | 1.55 ± 0.03$^c$ | 1.27 ± 0.06$^c$ |
| 1% | 1.47 ± 0.09$^b$ | 1.02 ± 0.02$^d$ | 1.30 ± 0.05$^c$ |

***Note:*** *Values are means ± SE (n = 9). Different letters in the same column indicate significant differences among groups (P < 0.05).*

**Table 4.** Myeloperoxidase activity in kidney leucocytes of *Cyprinus carpio* supplemented with different concentrations of *Apium graveolens* extract for 45 days.

| Groups | Study period | | |
|---|---|---|---|
| | 15 day | 30 day | 45 day |
| Control | 201.20 ± 1.64$^a$ | 203.11 ± 2.67$^a$ | 196.59 ± 2.14$^a$ |
| 0.1% | 213.67 ± 2.83$^b$ | 365.05 ± 3.02$^b$ | 224.18 ± 2.58$^b$ |
| 0.5% | 221.95 ± 1.71$^c$ | 235.11 ± 3.34$^c$ | 202.04 ± 2.69$^c$ |
| 1% | 239.69 ± 0.99$^d$ | 305.18 ± 3.21$^d$ | 237.06 ± 1.97$^d$ |

***Note:*** *Values are means ± SE (n = 9). Different letters in the same column indicate significant differences among groups (P < 0.05).*

**Table 5.** Lysozyme activity of kidney leucocytes in *Cyprinus carpio* supplemented with different concentrations of *Apium graveolens* extract for 45 days.

| Groups | Study period | | |
|---|---|---|---|
| | 15 day | 30 day | 45 day |
| Control | 0.31 ± 0.02$^a$ | 0.31 ± 0.02$^a$ | 0.35 ± 0.05$^a$ |
| 0.1% | 0.31 ± 0.01$^a$ | 0.34 ± 0.01$^b$ | 0.34 ± 0.03$^a$ |
| 0.5% | 0.30 ± 0.01$^b$ | 0.32 ± 0.02$^a$ | 0.33 ± 0.02$^a$ |
| 1% | 0.31 ± 0.01$^a$ | 0.34 ± 0.02$^b$ | 0.35 ± 0.04$^a$ |

***Note:*** *Values are means ± SD (n = 12). Different letters in the same column indicate significant differences among groups (P < 0.05).*

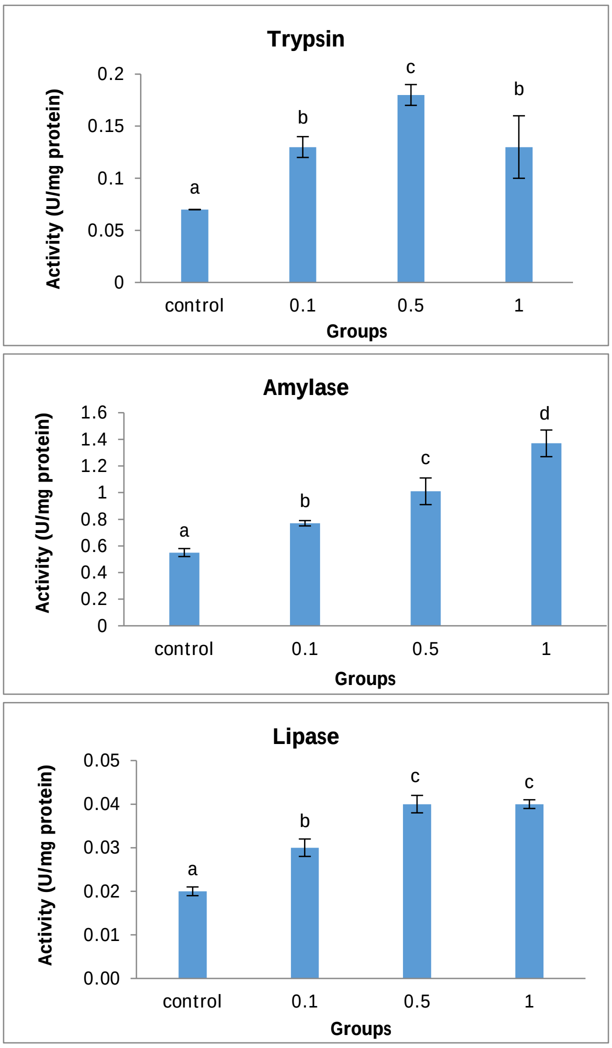


**Figure 1.** Activity of trypsin, amylase and lipase in the intestines of *Cyprinus carpio* fed a basal diet (control) and supplemented with different concentrations of *Apium graveolens* extract. Different superscript letters indicate significant differences among groups ($P < 0.05$).

Digestive enzyme levels are shown in Figure 1. The activity of trypsin, amylase and lipase in fish intestines increased significantly when fish were supplemented with 0.1%, 0.5% or 1% *A. graveolens* extract compared with control group ($P < 0.05$) (Figure 1).

## Discussion

Medicinal plant products are used as a growth promoter, antistress, appetite stimulator, immunostimulant and as a tonic and are said to have aphrodisiac and antimicrobial characteristics in finfish and shrimp larviculture due to the activities of flavonoids, alkaloids, phenolics, pigments, steroids, terpenoids and necessary oils (Sivaram et al., 2004). In this study, supplementation with *A. graveolens* extract changes the growth parameters in *C. carpio* (Table 1). However, the final weight, WG and SGR were elevated and a better FCR was obtained in fish supplemented with 0.1% extract. Similarly, Olvera-Novoa et al. (1990) reported that WG, SGR, nitrogen deposition and feed intake in Mozambique tilapia (*Oreochromis mossambicus*, Peters) were better when supplemented with low levels (i.e. 15–20%) of alfalfa protein. Also, WG was significantly improved when Japanese flounder (*Paralichthys olivaceus*, Temminck & Schlegel) were supplemented with a 0.5% herbal mixture (Seung-Cheol et al., 2007). Most probably, fat was used for energy and protein was used for growth in the herbal supplement diet (Yılmaz et al., 2012). Mostafa et al. (2009) fed Nile tilapia fingerlings a basal diet containing 0, 0.5, 1 and 1.5 g/100 g fenugreek (*Trigonella foenum graecum*) seed meal for 12 weeks and found that the use of 1 g/100 g fenugreek seed meal improved fish performance. According to Farahi et al. (2012), dietary *Aloe vera* supplementation was not efficient in promoting growth performance of rainbow trout (*Oncorhynchus mykiss*). Yilmaz et al. (2012) reported that WG, FCR and SGR of sea bass (*Dicentrarchus labrax*) were not affected by a 1% rosemary (Rosmarinus officinalis) and *T. foenum graecum* supplementation. Also, the growth rate of koi carp (*Cyprinus carpio*) was not affected by a dietary supplementation of tetra (*Cotinus coggygria*) (Bilen et al., 2013). However, some herbs have positive and promoting effects on fish growth (Xie et al., 2008; Mahdavi et al., 2013).

Haematological assays may provide an index of the physiological status of fish. WBC, RBC count, Hb and Hct are particularly recommended as tests that could be performed on a routine basis in fish farms to monitor the health of the stock (Haghighi and Rohani, 2013). The present study indicated that *C. carpio* supplemented with 0.1% *A. graveolens* extract showed an increase in WBC, RBC, Hb and Hct and a decrease in MCV, MCH and MCHC compared with the control group. When supplemented with 0.5% *A. graveolens* extract, a significant decrease in all haematological parameters was observed, except WBC count that showed no significant change compared with the control. De Pedro et al. (2005) indicated that total and differential WBC counts are important indices of non-specific defence activities in fish. Also, they are centrally involved in phagocytic and immune responses to bacterial, viral and parasitic challenges (Houston, 1990). Similarly, *O. mykiss* supplemented with a powdered ginger (*Zingiber officinale*) rhizome for 12 weeks showed an increase WBC, RBC, Hb and Hct values (Haghighi and Rohani, 2013). Also, it was reported that WBC and RBC counts and Hb value were higher in Indian catfish (*Mystus montanus*) fingerlings supplemented with an herbal diet when compared with the control (Kumar et al., 2014). Other investigators reported that there were no significant differences in RBC and Hct in *C. carpio* supplemented with dietary *A. vera* (Alishahi et al., 2010), or RBC and Hb in *O. mykiss* (Farahi et al., 2012) or all haematological parameters in *O. mykiss* (Haghighi et al., 2014).

Phagocytosis and the respiratory burst response by phagocytes in blood and tissues represent a major antibacterial defence mechanism in fish (Secombes, 1996). Respiratory burst activity measured by nitroblue tetrazolium is one of the most important bactericidal mechanisms in fish (Secombes and Fletcher, 1992). In this study, respiratory burst activity of fish supplemented with different concentrations of *A. graveolens* extract were significantly elevated ($P < 0.05$) on days 15, 30 and 45 compared with the control group. A similar result was observed by Bilen et al. (2011) when *O. mykiss* was supplemented with dietary *C. coggygria* leaves. Harikrishnan et al. (2010) reported a significant increase in respiratory bursts at 50 and 100 doses in olive flounder supplemented with three Korean plants. Haghighi and Rohani (2013) reported that respiratory burst activity was significantly high in *O. mykiss* fed a commercial diet containing *Z. officinale*. Also, our results are in agreement with those of some studies of dietary immunostimulants used in various fish species (Yin et al., 2009; Bilen and Bulut, 2010).

Neutrophils contain MPO in their cytoplasmic granules (Rodriguez et al., 2003). MPO is an important enzyme with microbiocidal properties, which utilises an oxidative radical ($H_2O_2$) to produce hypochlorous acid (Dalmo et al., 1997). This process is believed to be important in killing microorganisms (Johnston, 1978). This study revealed an increase in MPO content in all experimental groups. In line with our study, *O. mykiss* supplemented with 1% of quercetin and 1% black cumin seed (*Nigella sativa*) oil showed a significant increase in MPO activity (Awad et al., 2013). Heart-leaved moonseed (*Tinospora cordifolia*) leaves also increased MPO activity in *O. mossambicus* (Alexander et al., 2010). Bilen et al. (2013) also reported similar results with the administration of *C. coggygria* extract.

Lysozyme activity is an important component in the immune system of fish. Lysozyme is an important enzyme in the blood that actively lyses bacterial cell wall peptidoglycans. It is also known to act as an opsonin and activates the complement system and phagocytes (Magnadottir, 2006). In this study, the lysozyme level on day 15 was significantly decreased in the 0.5% extract group. On day 30, fish supplemented with 0.1% or 1% extract showed a significant increase in lysozyme activity, there was no significant difference among the groups on day 45. The observed increasing in lysozyme level is in agreement with several reports on the role of herbal immunostimulants in enhancing lysozyme activity (Rao et al., 2006; Choi et al., 2008; Bilen et al., 2011). Moreover, Tang et al. (2014) recorded an elevation in lysozyme activity in *O. niloticus* supplemented with a Chinese herbal mixture of angelica, astragalus, liquorice root, honeysuckle and hawthorn. On the other hand, Sivaram et al. (2004) noticed no significant change in lysozyme activity in juvenile greasy groupers (*Epinephelus tauvina*) supplemented with *Ocimum sanctum*, *Withania somnifera* and *Myristica fragrans*.

Nutrient digestion begins with the actions of (digestive) enzymes in the stomach and continues in the intestine with enzymes secreted by the pancreas, including trypsin, chymotrypsin, amylase and lipase (Nagase, 1964; Moriarty, 1973). Trypsin activity is considered a nutritional conditional indicator of fish, and its secretion is consistent with the activity of the pancreas (Sunde et al., 2001). During the present study, an increase in trypsin activity in the intestine was in line with the results of Yaghoubi et al. (2016), who reported an increase in trypsin level of silvery-black porgy (*Sparidentex h*asta) juveniles fed a diet containing soy products. Similarly, Kawai and Ikeda (1973) found an increase in the total protease activity of *O. mykiss* fed a high protein diet. It has been reported in several studies that a higher protease activity in the intestine is associated with a higher protein content in the diet (Xiong et al., 2011; Melo et al., 2012).

Amylase is stimulated by glycolytic chains, glycogen, and starch in larval and juvenile fish (Krogdahl et al., 2005). This study observed an enhanced amylase activity in all treatment groups compared with the control. Similar results were reported by Pavasovic et al. (2007) who experimented with animal feeds containing plant-based ingredients and Awad et al. (2012) who reported on *O. mykiss* supplemented with lupin, mango and stinging nettle. Certainly, amylase was found to increase in *O. mykiss* fed diets containing increased amounts of dietary plant protein (Kawai and Ikeda, 1973).

Lipase is mainly secreted by the pancreas and exerts a major role in breaking down of fats, especially triacylglycerols, leading to digestion (Awad, 2010). Generally, the experimental groups had a higher lipase activity compared with the control. This result is in line with those of Lopez-Lopez et al. (2005), who observed significant differences in lipase activity in animals fed a sorghum diet compared with those fed red crab meal and sardine meal, and Al-Saraji and Nasir (2013) who reported an increase in lipase activity of *C. carpio* fed diets containing protein from different sources. In conclusion, the use of *A. graveolens* as an immunostimulant for *C. carpio* resulted in a significant enhancement of innate immunity, specifically respiratory bursts, lysozyme and MPO activities. Haematological results also showed an increase in WBC, RBC, Hct and Hb with plant dietary supplements, and it also resulted in an increase in digestive enzymes, including trypsin, amylase and lipase.

## Conclusion

In the study, Celery has been proved as an effective immunostimulant or antioxidant in higher animals. On the contrary, our results suggest that the methanolic extract of celery has beneficial effects on growth and immune responses when treated at the dose of 0.1%. Further research is needed to examine whether celery methanolic extract is effective for other fish species.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

# Trend analysis of mean monthly, seasonally and annual streamflow of Daday Stream in Kastamonu, Turkey.

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**ABSTRACT**

Water is one of the most important natural resources and assessment of the trends in water has a great importance to estimate the future of water resources. The main purpose of this study is to present a trend analysis of the streamflow of Daday Stream in Kastamonu, Turkey by monthly, seasonally and annual analyses. Monthly streamflow data were obtained from streamflow gauging station on the stream between 1988 and 2007. Trends of monthly, seasonal and annual runoff of Daday Stream were analysed by Trend analysis, non-parametric Mann-Kendall and Spearman tests. The results showed that mean annual streamflow of Daday Stream had a significant tendency to decrease for this period ($p<0.01$). The results of seasonal trend analysis results demonstrated that statistically significant decreasing trends were found for all seasons. Trend analyses for monthly mean streamflow displayed that there were also statistically significant decreasing trends for all month excluding February, March, April, and June. In conclusion, decreasing trends in the streamflow of Daday Stream have been predicted for this period and for the future. The fluctuation in water resources could be affected by some reasons such as decreasing rainfall, rising temperature depending upon climate change.

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## Introduction

Water is one of the most important natural resources and many studies focused on water to investigate the temporal variations or characteristics of water with different purposes around the world. The Intergovernmental Panel on Climate Change (IPCC, 2007) noted that water resources are under pressure and stress by some reasons such as growing population, greenhouse gases, temporal variations, climate change, and other reasons for half a century. Interactions between climatic parameters and topography, vegetation, and soil affecting evaporation, precipitation, and infiltration define the streamflow (Dingman, 2002; Brutsaert, 2005). These processes and the regime of the streamflow are commonly estimated to be affected by the climate change (Zhou et al., 2014; Christensen et al., 2004; Stewart et al., 2004).

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The temporal patterns of streamflow is sensitive to the climate change. The impacts of the climate change on the hydrologic processes in rivers are widely accepted by many authors. A few scientists have investigated the projected effects of climate change on streamflows at a regional scale (Christensen et al., 2004; Stewart et al., 2004; Reidy and Liermann et al., 2012). Current trends of the streamflows should be determined and monitored, and future trends should also be predicted to understand the possible effects of the climate change. Assessment of the trends in water parameters has a great importance to estimate the future of water resources. Therefore, investigations on the trend of water resources and rivers provide valuable contributions to the knowledge for the water resources management and decision-making process.

Several authors have analysed trends in climatic and hydrologic parameters (Kadıoğlu, 1997; Büyükyıldız and Berktay, 2004; Şensoy et al., 2005; Cigizoglu et al., 2005; Yıldırım et al., 2013; Saplıoğlu et al., 2014; Sütgibi, 2015; Yenigün and Ülgen, 2016; Ay and Özyıldırım, 2017; Ercan and Yüce, 2017; Tosunoğlu, 2017; Tosunoglu and Kisi, 2017). Also numerous studies determined trends in water parameters by using different methods (Sen, 1968; Hirsch et al., 1982; Helsel and Hirsch, 2002; Şen, 2012). In Turkey, trend analysis for water parameters were firstly carried out by İçağa (1994). Afterwards, many authors conducted studies to estimate the trends in water parameter (İçağa and Harmancıoğlu, 1995; Kalayci and Kahya, 1998; Albek, 2002; Kişi and Ay, 2014; Doğan Demir et al., 2016; Ejder et al., 2016a, 2016b; Kale et al., 2016a, 2016b; Kişi et al., 2018; Kale et al., 2018). Unfortunately, there is no study on determining and monitoring trends of the streamflow of Daday Stream. Therefore, the main purpose of this study is to present a trend analysis of the streamflow of Daday Stream in Kastamonu, Turkey.

## Material and Methods

### *Study Area*

Daday Stream arises from Çamlıbel village and runs through the villages of Akılçalman, Örencik, Akpınar, Bolatlar, Tüfekçi, Sarıçam, Yazıcameydan, İnciğez, Kızılörencik, Eymir, Hacımuharrem, Talipler, Çiğil, Dokuzkat, Göcen, Subaşı, Numanlar, Gölköy, Emirler, Sarıömer, Koruköy, Hocaköy, Mollaköy, Kurtgömeç, Hasköy, Kurusaray, Emirli, Hatipköy, Eşenköy and the city centre of Daday district and Kastamonu province (Figure 1). It merges with Karasu Stream in Bükköy as tributaries of Gökırmak Stream. The climate of the region is typical continental climate with snowy winters, warm summers in drier conditions, and spring and autumn seasons that are often sharp cold and frost which is unfavourable for agriculture and production of vegetables and fruits. Daday Stream rises from 1217 km and its length is calculated 72.3 km.

Streamflow data were obtained from streamflow gauging station at Hasköy (D15A225) of the General Directorate of State Hydraulic Works (DSİ). Analyses were carried out for each of mean monthly, seasonal, and annual data.

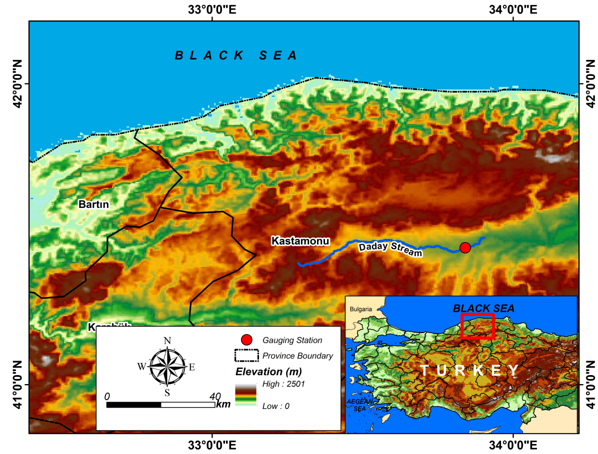


**Figure 1.** The location of Daday Stream.

### *Change Point Analysis*

Pettitt's change-point analysis (Pettitt, 1979) was used to detect the change time of the streamflow data. This non-parametric test was modified from the Mann-Whitney statistic and detects significant changes in the averages of time series. Pettitt's change-point analysis was performed in R statistical software (R Core Team, 2017). The formulae as follow:

$$U_{t,T} = \sum_{i=1}^{t} \sum_{j=t+1}^{T} sgn(x_i - x_j) \text{ for } t = 2, \ldots\ldots, T$$

$$K_T = max|U_{t,T}|,$$

The null hypothesis of the change-point test is the absence of change point. The statistic of null hypothesis is $K_T$. $U_{t,T}$, confirms whether two examples ($x_1, \ldots\ldots, x_t$ and $x_t+1, \ldots\ldots, x_T$) are in the same population or not. Associated probability ($p$) is used for computing the significance.

### *Trend Analysis*

Trend analysis is commonly used method to determine the tendency in a hydrological time series. Box-Jenkins technique (Box and Jenkins, 1976) and the auto regressive integrated moving average model were applied to understand the trend of streamflow. In ARIMA model ($p$, $d$, $q$), $p$ shows the number of auto regressive terms, $q$ shows the number of moving average terms and $d$ shows the differencing order. The ARIMA model used in the study as follow:

$$X_t = c + \Phi_1 X_{t-1} + \cdots + \Phi_p X_{t-p} + \theta_1 e_{t-1} + \theta_q e_{t-q} + e_t$$

In this equation, $X_t$ is the variable will be described in $t$ time, $c$ is the constant, $\Phi$ is coefficient of per $p$ parameter, $\theta$ is the coefficient of per $q$ parameter, and $e_t$ is the error in $t$ time.

### *Mann-Kendall Test*

Mann-Kendall test (Kendall, 1955; Mann, 1945) is a widely used test to explore the trends in a time series. Non-parametric Mann-Kendall test and Spearman's rho test offer more trustworthy results than parametric tests. One advantage of this non-parametric test is that the data do not require to track any specific distribution. The formulae for this test are as follows:

$$S = \sum_{i=1}^{n-1} \sum_{k=i+1}^{n} sgn(x_k - x_i)$$

In this equation, the time series $x_i$ is from $i$ = 1, 2, …, $n$-1, and $x_k$ from $k$ =$i$ + 1, …, $n$.

$$sgn(\theta) = \begin{cases} +1, & \theta > 0 \\ 0, & \theta = 0 \\ -1, & \theta = 0 \end{cases}$$

Normalized test statistic is computed by the follow equation:

$$Z_c = \begin{cases} \dfrac{S-1}{\sqrt{var(S)}}, & S > 0 \\ S+1 & S = 0 \\ \dfrac{}{\sqrt{var(S)}}, & S < 0 \end{cases}$$

$Z_c$ is the test statistic and when $|Z_c| > Z_{1-\alpha/2}$, in which $Z_{1-\alpha/2}$ are the standard normal variables and α is the significance level for the test, $H_0$ will be rejected. The magnitude of the trend is given as follow:

$$\beta = \text{Median}\left(\frac{x_i - x_j}{i-j}\right), \forall_j < i, \text{ where } 1 < j < i < n.$$

A negative value of $\beta$ shows a decreasing trend, while a positive value of $\beta$ shows an increasing trend.

## Results

The descriptive statistics of the runoff data including mean with standard deviation, coefficient of variation (CV), coefficient of skewness, maximum and minimum values and range are listed in Table 1.

The results of change point analysis indicated that the change point for mean annual runoff was 1993. As a result of the trend analysis, a decreasing trend was found for mean annual runoff (Figure 2).

For mean seasonal runoff, change points were detected 1993, 1993, 1999, and 2002 for spring, summer, autumn, and winter, respectively. The results of trend analyses showed that runoff has decreasing trends for all seasons (Figure 3).

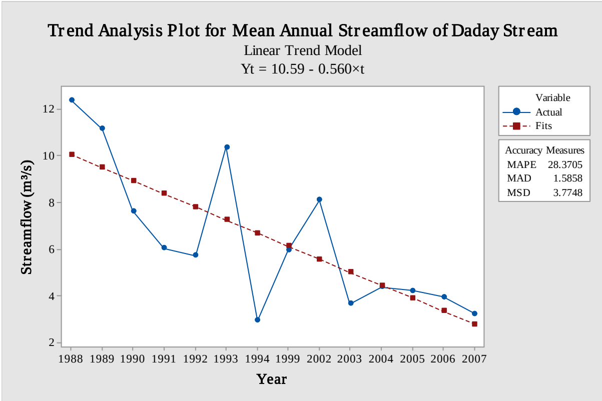


**Figure 2.** Trend analysis result of mean annual streamflow.

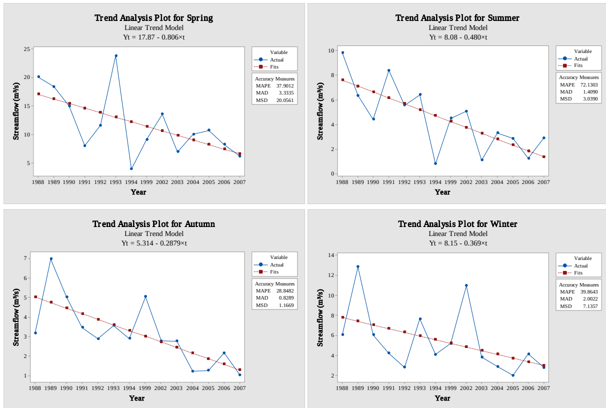


**Figure 3.** Trend analysis results of mean seasonal streamflow.

Change point analysis results detected the change point years for mean monthly runoff as 1999, 2002, 1993, 2004, 1993, 1993, 2002, 2002, 2002, 1999, 1999, and 2002 for the months from January to December, respectively. Trend analysis results showed that mean monthly runoff have decreasing trends for all months (Figure 4).

Results of Mann-Kendall trend tests pointed out that there is a statistically significant decreasing trend in the series of mean annual runoff (p<0.01). Also statistically significant decreasing trends were found for mean seasonal runoff for all seasons. Moreover, there were statistically significant decreasing trends for mean monthly runoff for all months excluding February, March, April, and June (Table 2).

**Table 1.** Basic statistics of streamflow data.

| Mean Streamflow | Average | Standard deviation | Coefficient of variation | Coefficient of skewness | Maximum value | Minimum value | Range |
|---|---|---|---|---|---|---|---|
| Annual | 6.40 | 3.09 | 0.48 | 0.56 | 12.38 | 2.91 | 9.47 |
| Spring | 11.83 | 5.74 | 0.49 | 0.77 | 23.87 | 3.91 | 19.96 |
| Summer | 4.48 | 2.70 | 0.60 | 0.04 | 9.84 | 0.78 | 9.06 |
| Autumn | 3.16 | 1.65 | 0.52 | 0.49 | 6.97 | 1.03 | 5.94 |
| Winter | 5.38 | 3.17 | 0.59 | 1.15 | 12.83 | 1.99 | 10.84 |

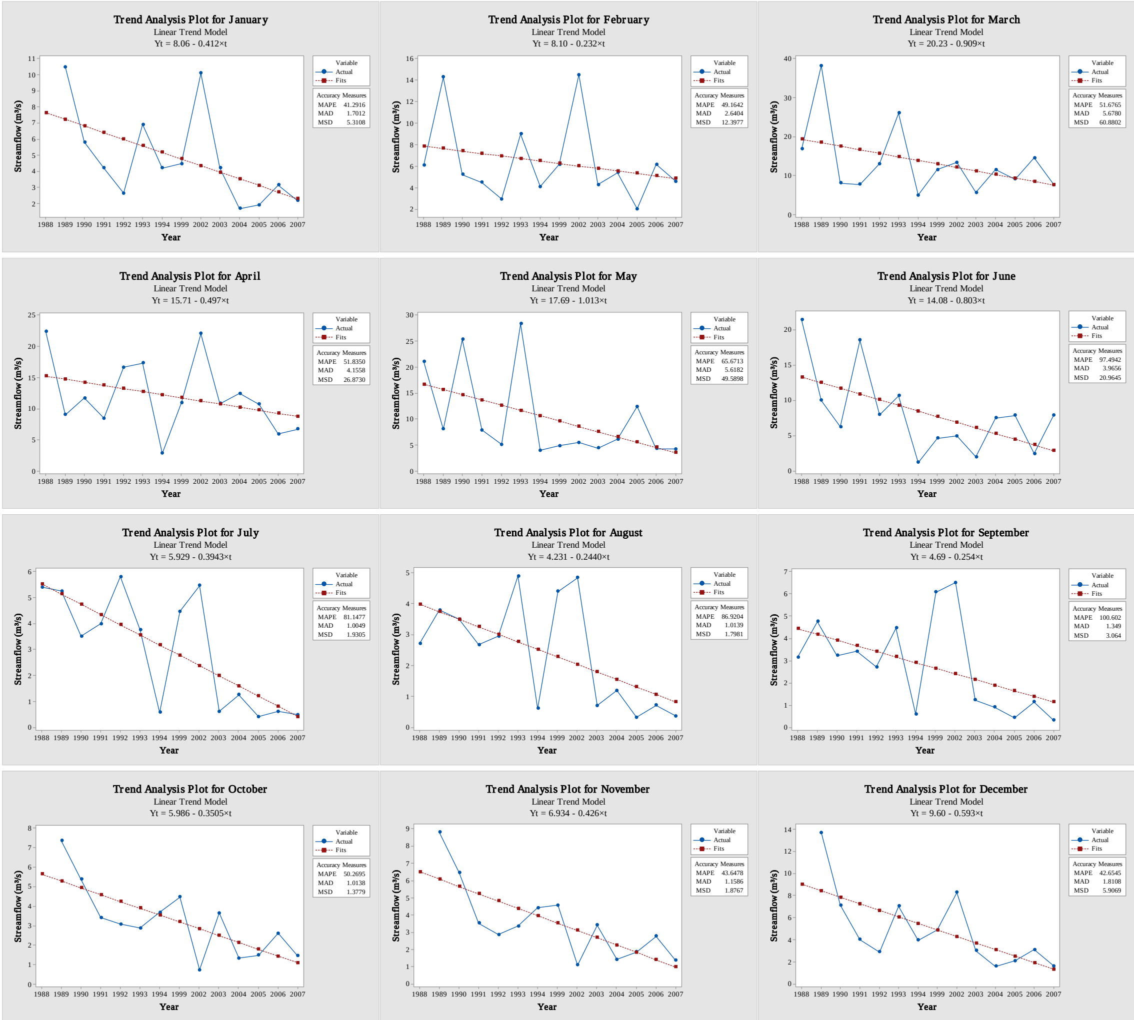


**Figure 4.** Trend analysis results of mean monthly streamflow.

**Table 2.** Non-parametric tests values and trend status.

| Period | Streamflow | Kendall's tau | *p* | Trend | Spearman's rho | *p* | Trend |
|---|---|---|---|---|---|---|---|
| | *Annual* | -0.604 | 0.003 | ▼ | -0.741 | 0.002 | ▼ |
| *Seasonally* | Spring | -0.429 | 0.033 | ▼ | -0.578 | 0.030 | ▼ |
| | Summer | -0.516 | 0.010 | ▼ | -0.710 | 0.004 | ▼ |
| | Autumn | -0.648 | 0.001 | ▼ | -0.815 | 0.000 | ▼ |
| | Winter | -0.473 | 0.019 | ▼ | -0.631 | 0.016 | ▼ |
| *Monthly* | January | -0.452 | 0.032 | ▼ | -0.644 | 0.018 | ▼ |
| | February | -0.143 | 0.477 | | -0.178 | 0.543 | |
| | March | -0.221 | 0.273 | | -0.339 | 0.236 | |
| | April | -0.275 | 0.171 | | -0.376 | 0.185 | |
| | May | -0.407 | 0.043 | ▼ | -0.569 | 0.034 | ▼ |
| | June | -0.319 | 0.112 | | -0.516 | 0.059 | |
| | July | -0.486 | 0.016 | ▼ | -0.664 | 0.010 | ▼ |
| | August | -0.363 | 0.071 | ▼ | -0.552 | 0.041 | ▼ |
| | September | -0.385 | 0.055 | ▼ | -0.569 | 0.034 | ▼ |
| | October | -0.513 | 0.015 | ▼ | -0.709 | 0.007 | ▼ |
| | November | -0.538 | 0.010 | ▼ | -0.753 | 0.003 | ▼ |
| | December | -0.513 | 0.015 | ▼ | -0.687 | 0.010 | ▼ |

*Note:* ▼ indicates statistically significant trends.

## Discussion

Water resources are limited in the worldwide and several countries will face serious water shortages and/or scarcities on limited resources due to the impacts of global warming and climate change (Hisar et al., 2015). Therefore, investigations on the trend of water resources and rivers provide valuable contributions to the knowledge for the water resources management and decision-making process.

There are many studies about trend analysis on climatic parameters such as temperature (Türkeş et al., 1996; Han et al., 2012; Limjirakan and Limsakul, 2012; Doğan Demir and Demir, 2016; Demir et al., 2008; Duman and Kara, 2017; Kale, 2017a), evaporation (Tebakari et al., 2005; Jaswal et al., 2008; Kale, 2017b; Bacanlı and Tanrıkulu, 2017), and precipitation (Partal and Kahya, 2006; Aslantaş Bostan and Akyürek, 2007, 2010; Kızılelma et al., 2015; Doğan Demir and Demir, 2017; Yavuz and Erdoğan 2012; Bacanlı and Tanrıkulu, 2016; Bacanli, 2017; Taylan and Aydın, 2018). Trend analyses were also carried out to determine the trends in the streamflow. Numerous authors have reported decreasing trends in the streamflow of rivers. Durdu (2010) reported decreasing trend in Büyük Menderes River basin. Zhou et al. (2015) informed that there was a decrease in Huangfuchuan River streamflow. Herawati et al. (2015) found decreasing trend in streamflow of rivers in Indonesia. Pumo et al. (2016) stated that streamflow presented a significantly decreasing trend in non-perennial small rivers in Italy. Ozkul (2009) and Ozkul et al. (2008) informed about decreasing trends in the streamflow of Gediz and Büyük Menderes rivers. Türkeş and Acar Deniz (2011) described decreasing trend in the streamflow of the southern Marmara rivers. Bahadir (2011), Kahya and Kalaycı (2004), Koçman and Sütgibi (2012) reported that streamflow of rivers tended to decrease. Ejder et al. (2016a) described a decreasing trend in Sarıçay streamflow while Ejder et al. (2016b) documented a decreasing trend in the streamflow of Kocabaş Stream. Kale et al. (2016a) and Kale et al. (2016b) informed that decreasing trends were found in the streamflow of Karamenderes and Bakırçay rivers, respectively. Kişi et al. (2018) described decreasing and increasing trends in monthly streamflow of three different basins in Turkey. Kale et al. (2018) recently documented decreasing trends in rivers in western Turkey. Kale and Sönmez (2018) also reported decreasing trends in the streamflow of Akkaya Stream in Turkey and highlighted that decreasing trends were found statistically significant for mean annual, seasonal and monthly streamflow. Authors claimed that decreasing trend in the streamflow of Akkaya Stream could be attributed to decrease in rainfall and snowmelt, tremendously increase in temperature of air and water and other causes resulted from the climate change.

In this paper statistically significant decreasing trends were found for mean annual, seasonal, and monthly (excluding February, March, April, and June) streamflow. The findings of the present study are related to other reported trend analyses researches on hydrologic parameters. These decreasing trends could be related to the climate change especially rainfall and temperature. Changes in the climate such as rising temperature and decreasing rainfall may affect the streamflow and availability of water resources. On the other hand, Bates et al. (2008) stated that trends in streamflow were not always related to the variations in the precipitation. Some authors noticed that agricultural activities (Durdu, 2010; Dügel and Kazanci, 2004; Kaçan et al., 2007; Yercan et al., 2004), hydraulic structures (Ozkul et al., 2008) and human activities (Gao et al., 2011; Jackson et al., 2011; Zhou et al., 2015) had effects on the river streamflow along with the effects of the climate change.

## Conclusion

Trends of monthly, seasonal and annual streamflow of Daday Stream were analysed. Statistically significant decreasing trends were found for mean annual, seasonal, and monthly streamflow excluding the months of February, March, April, and June. This study is the first study on determining and monitoring trends of the streamflow of Daday Stream. So, this paper provides significant information about past, current and future trends of the streamflow of Daday Stream. The amount of streamflow and water resources could be affected by some reasons such as decreasing rainfall, rising temperature depending upon climate change. In future period, it is predicted that decreasing trend will continue for Daday Stream. Therefore, available water resources should be effectively and efficiently managed. Sustainable use of water resources should be ensured to maintain the sustainability of natural resources.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

# Monitoring of weekly catch per unit effort (CPUE) and some biological features of bluefish (*Pomatomus saltatrix* Linnaeus, 1766) captured from southern Black Sea coasts of Turkey.

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**ABSTRACT**

In this study, changing of catch per unit effort (CPUE) and length composition of bluefish (*Pomatomus saltatrix* Linnaeus, 1766) caught in the southern Black Sea was monitored during the period of 8 weeks in October and November 2012. A total of 2255 kg bluefish was captured by pelagic trawl at the end of 32 hauls. The length-weight relationship of bluefish was established as $W=0.0037L^{3.3067}$ (positive allometric growth). The catch per unit effort (CPUE) and mean length were fixed as 14.43 $kgh^{-1}$ and 17.5±0.03 cm, respectively. Differences between CPUE values of each week were found statistically significant ($P<0.05$). The highest and lowest mean total lengths of bluefishes were determined 18.9±0.08 cm (October) and 16.2±0.10 cm (November), respectively. It is determined that changing in size composition of the caught fishes is depending on time. Also, it can be expressed that fishing period affects catch per unit effort in bluefish fisheries.

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## Introduction

Bluefish, *Pomatomus saltatrix*, are distributed worldwide seas (Salerno et al., 2001). Bluefish is a migratory pelagic species that appear in temperate and tropical waters on the continental shelf and in estuarine habitats around much of the world (Wilk, 1977). Bluefish is one of the important pelagic fish species caught in Turkey's seas (Akyol and Ceyhan, 2007). Bluefish production is at 6th place, among all pelagic species, with 1936 tons in fisheries production of Turkey (TUIK, 2018). Bluefishes have been mainly caught by active fishing gear such as purse seine, midwater trawl and demersal trawl also by passive fishing gears such as set nets and hand-lining (Ceyhan et al., 2005).

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Dominant species are whiting and red mullet in the Black Sea demersal trawl fisheries (Erdem, 2000; Erdem et al., 2007). However, many species are captured as bycatch in the demersal trawl fisheries (Aksu, 2012; Yıldız and Karakulak, 2018). Bluefish is one of the fish species captured as bycatch by the demersal trawl nets in September, October and November in the Black Sea (Özdemir et al., 2006; Özdemir et al., 2009a). But, bluefish is target species in the pelagic trawl fisheries. Bluefishes have been captured intensively by the midwater pair trawl, an effective and have excellent selectivity fishing gear, during October and November in the Black Sea coasts (Erdem and Özdemir, 2008; Özdemir et al., 2010).

Bluefish were given different names for certain size group only in Turkish waters. These names are defne yaprağı (≤ 10 cm), çinekop (10-18 cm), sarıkanat (18-25 cm), lüfer (25-35 cm) and kofana (≥ 35 cm) (Akşiray, 1987). The biggest size group, called as kofana, have been rarely found in the seas of Turkey anymore, but recently çinekop and sarıkanat size groups are the most exploited groups in Turkish fisheries. When minimum landing size (MLS) was 20 cm for the bluefish 2012-2016 fishing periods, MLS was determined as 18 cm in the Notification to Regulate Commercial and Recreational Fisheries for between 2016-2020 fishing seasons (Anonymous, 2016). It was a wrong decision taken in terms of the sustainability and maximum yield of the bluefish.

Coasts of Kızılırmak and Yeşilırmak deltas are preferred by trawl fishermen, which are important crossing points for bluefish and horse mackerel (Figure 1). Pelagic species can migrate for feeding during the day or seasonally owing to reproduction behavior (Ivanov and Beverton, 1985). The migrations affect abundance and size composition of fish schools in the transition fields. Size composition of the fishes varies with participation or separation of the fishes in different size groups from shoals in the area. It is indicated that size composition of the caught bluefish is affected by fishing area and used fishing gears (Özdemir et al., 2009b).

Most of the studies on bluefish has been carried out in the Marmara Sea and Aegean Sea. Some of them is about age, growth, maturity, fishing gear selectivity of bluefish (Ceyhan and Akyol, 2006; Akyol and Ceyhan, 2007; Ceyhan et al., 2007; Acarlı et al., 2013, Öztekin et al., 2018; Bal et al., 2018; İlkyaz, 2018). However, there are only few studies on bluefish in the Black Sea. Gillnet selectivity (36 mm, 40 mm and 44 mm) for the bluefish were determined in the Sinop Coasts of Black Sea by Sümer et al. (2010). Özdemir et al. (2014) tested codend selectivity (square mesh panel and diamond mesh) for the bluefish of demersal trawl used on the Black Sea coasts. Samsun (2017) examined meat yield and chemical composition of bluefish captured Black Sea coasts.

The subject of the present study is to determine weekly CPUE data and some biological characteristic of bluefish from southern Black Sea coasts of Turkey. In this study, changes in size composition and CPUE of bluefishes captured in October and November (during 8 weeks) were monitored. Additionally, length-weight relationship of bluefish were estimated. It was determined that how to changing of school structure and size composition of bluefish as depending on time.

## Material and Methods

The study was carried out in the Samsun shores of the Black Sea throughout 8 weeks period of fishing season between October and November 2012. The sampling area is east and west coasts of Kızılırmak and Yeşilırmak estuary. The region is an important migration and stopover state of pelagic and demersal school fishes (Figure 1).

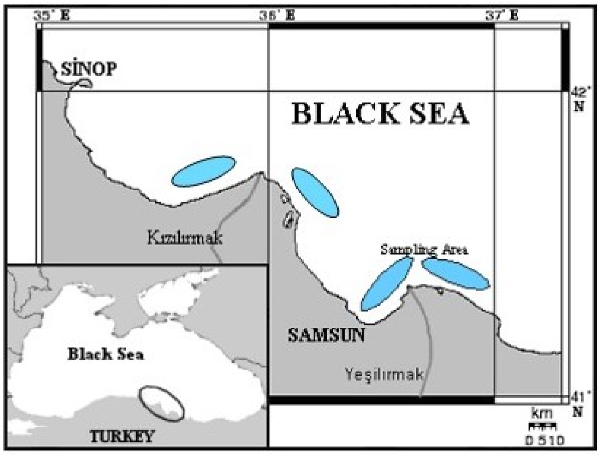


**Figure 1.** Survey areas of the study

A total 32 trawl surveys (4 days per week) was conducted during the experiment. Data were obtained from fishing operation of commercial midwater pair trawling boats in the region. The net has 600 mesh sizes in mouth and 18 mm mesh size in codend with a PE netting. The codend had 600 meshes around the circumference and a 27 m stretched length (Figure 2).

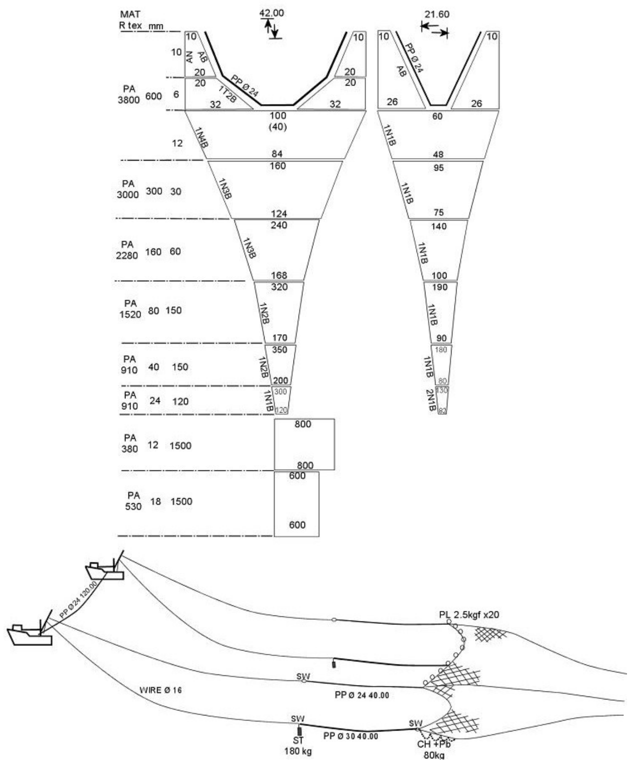


**Figure 2.** Technical plan of commercial midwater pair trawl

The amount of catch per unit effort (CPUE) for each net haul was calculated using the following formula by (Gulland, 1983):

$$U = \frac{\sum C}{\sum f}$$

In which; $U$ is catch per unit effort, $C$ is catch and $f$ is effort.

The catch expressed in kg fish, the effort as sea time and the CPUE expressed in kg per unit of time spent at sea (Hoof and Salz, 2001). Duration of the net hauls were calculated in hours and it refers to 60-minutes net hauling. The total length (TL) and weight (W) of each fish were measured to the nearest 0.1 cm and 0.01 g (Figure 3).

**Figure 3.** Length measurement of bluefish

The relationships between length and weight is expressed by $W = a \times L^b$ which was converted to linear form as $\ln a + b \ln L$ where $W$ is total body weight (g), $L$ is the total length (cm), $a$ is intercept and $b$ is slope regression coefficients.

The b value for each species was tested with a t-test at the 0.05 level of significance to verify whether it was significantly different from the predicted values for isometric growth (Morey et al., 2003). Besides, t-test for two groups and One-way analysis of variance (ANOVA) for more than two groups was used in the statistical analysis of the size composition and CPUE data.

## Results and Discussion

A total of 2255 kg bluefish was caught in the 32 midwater trawls hauls during the study period. Mean CPUE for all hauls was determined as 14.43 kg $h^{-1}$ at the end of the study. The lowest and highest mean CPUE were established 5.53 kg $h^{-1}$ and 28.46 kg $h^{-1}$ in October. Mean CPUE was 13.38 kg $h^{-1}$ for November and 15.48 kg $h^{-1}$ for October.

In this study total length and wet weight of 3190 bluefish individuals were measured. Observed maximum, minimum length and calculated mean total length were 27.3 cm, 9.2 cm and 17.5±0.03 cm, respectively. Maximum, minimum and mean weight of bluefish were fixed 199.2 g, 7.7 g and 47.3±0.48 g respectively.

The most of fishes were captured in the çinekop size group. Few fishes were caught in the lüfer group. There is no kofana group in the all of the samples. Length frequency distributions (Figure 4) at çinekop group, sarıanat group and lüfer group showed major peaks of 17 cm, 18 cm, 22.5 cm in October, 16.5 cm, 18 cm, 27 cm in November and 17 cm, 18 cm, 26.5 cm in general.

Akyol and Ceyhan (2007) reported mean fork length 16.9±0.01 cm (8.4 – 45.3) for bluefish and also intensively captured çinekop and sarıkanat size groups in October and November in the Marmara Sea. The most of the lüfer size group only were determined in June. Özdemir et al. (2010) fixed mean total length of bluefish 17.52±0.09 cm (9.7 – 23.1) in the Black Sea coasts. Ceyhan (2005) determined mean fork length for bluefish 16.86±0.01 cm (8.4 – 45.3) in Marmara Sea and north Aegean Sea of Turkey. Bal et al. (2015) established mean total length of bluefish 20.57±0.17 cm (12.3 – 43.7) in Marmara Sea. İlkyaz (2018) reported mean total length 23.25±0.03 cm (16.5 – 35.3) for bluefish in Aegean Sea. Of all the study results show that bluefish (*Pomatomus saltatrix*) has been captured at çinekop and sarıkanat groups (juvenile size) in commercial fisheries of Turkish waters.

Length-weight relationship (LWR) of bluefish was determined as $W=0.0037L^{3.3067}$ (positive allometric growth, $p<0.05$). In the present study, the $b$-value was estimated to be 3.3067 for bluefish. It was identified that $b$ values of bluefish varied from 2.5287 to 3.460 by other authors (Table 1). The variations in $b$-values may be ascribed to one or more factors: the seasons and effects of different areas, differences in salinity, temperature and pollution of aquatic environment, gender, nutrient quality and availability, differences in the quantity of fish analyzed, as well as in the observed size ranges of the sampled species (Goncalves et al., 1997; Froese et al., 2012).

For bluefish, six of fourteen studies had significantly different $b$-values, which reported negative allometric growth (Kalaycı et al, 2007; Bök et al., 2011) and isometric growth (Kasapoğlu and Düzgüneş, 2014; Bal et al., 2015, 2018; İlkyaz, 2018). Nevertheless, bluefish in the present study showed the $b$-values to be generally in agreement with similar results (positive allometric) in other studies (Table 1).

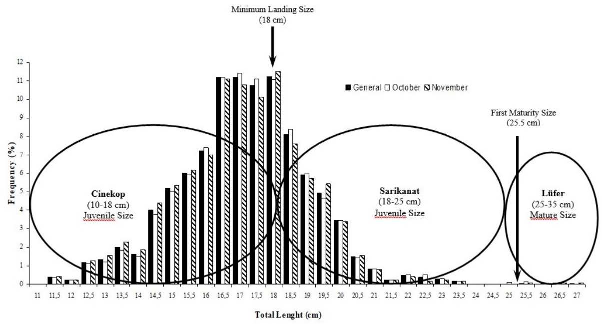


**Figure 4.** Frequency distribution of bluefish size groups for October and November 2012

Differences between mean lengths calculated from caught fishes at each trawl haul were found statistically significant ($p<0.05$). Mean lengths were determined by weekly performed sampling 4 times for both months in October and November. For October, the highest mean length was calculated as 18.9±0.08 cm at 2nd week and the lowest was 17.5±0.06 cm at 4th week. The highest and lowest values of mean length were determined for November 17.8±0.09 cm (2nd week), 16.2±0.10 cm (in 5th week), respectively. Additionally, it is determined that CPUE values and mean length values calculated in the same week showed a reverse relationship. Mean CPUE and total lengths established from weekly performed sampling for each month were given in Figure 5.

**Table 1.** Studies on some biological features and length-weight relationship of bluefish (*Pomatomus saltatrix*) in Turkish Seas

| Authors | Region | Length (cm) (min-max) | Weight (g) (min-max) | n | a | b | R | Growth |
|---|---|---|---|---|---|---|---|---|
| Ceyhan (2005) | Aegean-Marmara Sea | 8.4* – 45.3* | 7.0 – 996.7 | 2817 | 0.0063 | 3.4600 | 0.98 | +Allometric |
| Kalaycı et al. (2007) | Middle Black Sea | 13.2 – 21.7 | 23.2 – 88.2 | 143 | 0.0130 | 2.8600 | 0.96 | -Allometric |
| Ak et al. (2009) | Eastern Black Sea | 11.6 – 21.2 | 12.0 – 131.0 | 14 | 0.0030 | 3.3400 | 0.98 | +Allometric |
| Özdemir et al. (2009a) | Middle Black Sea | 9.2 – 23.4 | 10.1 – 135.5 | 820 | 0.0037 | 3.3270 | 0.99 | +Allometric |
| Özdemir et al. (2009c) | Middle Black Sea | - | - | 628 | 0.0060 | 3.1950 | 0.98 | +Allometric |
| Özdemir et al. (2010) | Middle Black Sea | 9.7 – 23.1 | 9.8 – 126.9 | 529 | 0.0030 | 3.3990 | 0.99 | +Allometric |
| Bök et al. (2011) | Marmara Sea | 10.6 – 24.0 | 12.1 – 107.6 | 290 | 0.0325 | 2.5287 | 0.93 | -Allometric |
| Özdemir and Duyar (2013) | Middle Black Sea | 12.2 – 24.0 | 15.4 – 127.2 | 207 | 0.0050 | 3.2500 | 0.94 | +Allometric |
| Kasapoğlu and Düzgüneş (2014) | Eastern Black Sea | 12.5 – 20.2 | 16.0 – 75.2 | 25 | 0.0092 | 3.0050 | 0.93 | Isometric |
| Bal et al. (2015) | Marmara Sea | 12.3 – 43.7 | 18.9 – 794.1 | 1230 | 0.0107 | 2.9574 | 0.98 | Isometric |
| Özpiçak et al. (2017) | Middle Black Sea | 13.5 – 23.6 | 22.0 – 161.2 | 125 | 0.0080 | 3.1200 | 0.98 | +Allometric |
| Samsun et al. (2017) | Western Black Sea | 16.1 – 27.5 | 32.5 – 227.9 | 820 | 0.0050 | 3.2500 | 0.97 | +Allometric |
| Bal et al. (2018) | Marmara Sea | 12.3 – 47.3 | 18.7 – 794.1 | 1023 | 0.0107 | 2.9574 | 0.97 | Isometric |
| İlkyaz (2018) | Aegean Sea | 16.5 – 35.3 | - | 136 | 0.0103 | 2.9700 | 0.99 | Isometric |
| *Present study (2018)* | Middle Black Sea | 9.2 – 27.3 | 7.7 – 199.2 | 3190 | 0.0037 | 3.3067 | 0.99 | +Allometric |

*Note:* In this table, *n* indicates number of fish, *a* indicates condition factor, *b* indicates coefficient of chunky, *R* indicates correlation coefficient, * indicates the fork length.

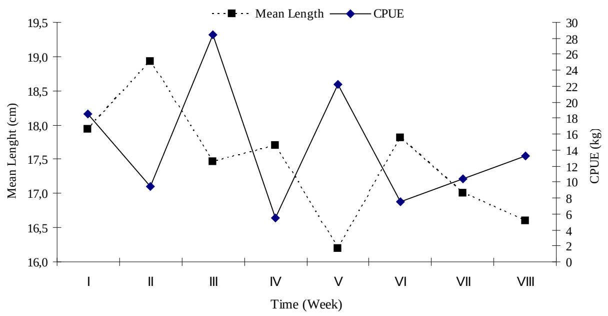


**Figure 5.** Weekly catch per unit effort (CPUE) and mean length of bluefish

Passive fishing gears (set nets and hand-lines) have optimum catch length (OCL) more than active fishing gears (purse seine and trawl) for bluefish. OCL for captured bluefish by hand-line with hooks number 1, 1/0, 2/0, 3/0 and 4/0 were reported as 19.18 cm, 21.88 cm, 24.14 cm, 27.02 cm and 28.19 cm (Öztekin et al., 2018). Acarlı et al. (2013) estimated that OCL of the gillnets with 22 mm, 23 mm, 25 mm, and 28 mm mesh size were 22.24 cm, 23.25 cm, 25.27 cm and 28.30 cm, respectively. Determined lengths for bluefish are higher than MLS (18 cm) but some lengths is lower than fist maturity size (25 cm) of bluefish.

Commercial catches were dominated by fish between 11 and 23 cm fork lengths for the purse-seine fleets and by fish >23 cm for gill netters and hand-lines in Turkish waters (Akyol and Ceyhan, 2007). Also, length of bluefish captured by pelagic and demersal trawls were determined in the range 9-24 cm in the Black Sea coasts (Özdemir et al., 2009a).

While catch per unit effort (CPUE) of bluefish was increasing, mean length of bluefish were decreased in the study. Table 2 shows that the highest CPUE (3$^{rd}$ week) and mean length (2$^{nd}$ week) of bluefish is in October. Mean length of bluefish is just more than minimum landing size (18 cm) in the 2$^{nd}$ week haul. Mean length of bluefish is less than minimum landing size for all hauls except 2$^{nd}$ week haul. But average length of bluefish is 18.0 cm and limit of minimum landing size in October. Mean length of fishes is under of minimum landing size (MLS) in November. Differences among CPUE and mean total length of bluefish are significant for all weeks ($p<0.05$). According to results, it can be expressed that fishing period affects catch per unit effort in bluefish fisheries.

**Table 2.** Fishing time, mean total length (cm) and CPUE (kgh$^{-1}$) for bluefish

| Months | Weeks | Mean total length | General | CPUE | General |
|---|---|---|---|---|---|
| October | 1 | 17.9±0.10$^{a}$ | 18.0±0.08$^{a}$ | 18.48$^{a}$ | 15.48$^{a}$ |
| | 2 | 18.9±0.08$^{b}$ | | 9.45$^{b}$ | |
| | 3 | 17.5±0.06$^{a}$ | | 28.46$^{c}$ | |
| | 4 | 17.7±0.09$^{a}$ | | 5.53$^{d}$ | |
| November | 5 | 16.2±0.10$^{c}$ | 16.9±0.10$^{b}$ | 22.28$^{c}$ | 13.38$^{a}$ |
| | 6 | 17.8±0.09$^{a}$ | | 7.57$^{bd}$ | |
| | 7 | 17.0±0.09$^{d}$ | | 10.40$^{bd}$ | |
| | 8 | 16.6±0.15$^{cd}$ | | 13.25$^{b}$ | |

*Note:* Test for total length and CPUE: a, b, c, d (↓). Differences between groups showed with different letter is significant ($p<0.05$)

Lucena et al. (2002) reported that adult individuals of bluefishes were fished excessively and young individuals are not successful in ensuring the continuity of the stock. Salerno et al. (2001) were determined >34 cm (1+ and 2 age) first maturity size of bluefish in northern coasts of the USA. The bluefish has varied growth ratios between sexes, with females tending to be larger. The first maturity size of bluefish ranges from 25 cm to 43 cm in Brazil coasts (Cumplido et al., 2018). Furthermore, Ceyhan (2005) informed that the average fork length of bluefishes which are caught from the Aegean and Marmara Sea of Turkey is 16.9 cm, first maturity length is 25.4 cm for females and fishing pressure on the species is excessive. On the other hand, Bal (2015) determined that the reproduction of bluefish occurred between in July and August, also the first maturity of length is 25.5 cm and 25.0 cm for females and males were established.

Bluefish were generally exploited by purse seines, pelagic trawls and set nets in the Black Sea coasts. The landings are from juvenile individuals. There is over fishing pressure on bluefish in the Black Sea (Figure 4). The high exploitation ratio (0.62 and 0.66) and heavy fishing pressure for bluefish were demonstrated by Akyol and Ceyhan (2007) and Bal (2015). Thus, authors recommend that minimum landing size (MLS) of bluefish has to be re-assessed for sustainable bluefish fishery.

## Conclusion

The present study supplies utility data on CPUE of fishing gears, LWR, biology of fish in the other seas and ocean regions in terms of the some parameters estimation for the bluefish captured from the Black Sea coasts. Besides, this important data and results are usually used in the management of fish stocks, fisheries biology institution and scientists. Therefore, the relevant studies on CPUE, LWR, population dynamics and biological characteristic of fishes captured in the Mediterranean basin should be improved and appraised in the near future.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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SHORT COMMUNICATION

# Additional record of *Trypauchen vagina* (Bloch & Schneider, 1801) from Mersin Bay, Turkey.

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ABSTRACT

Two mature individuals of *Trypauchen vagina* were caught by trawl fishing at 30 m depth in the Mersin coastal areas in September 2018. Meristic and morphometric measurements of the individuals were done and compared with its measurements reported in other studies. In previous studies; one record from Mersin Bay and in totally three records of *T. vagina* in the Northeastern Mediterranean Sea were reported. In this study, the second record of *T. vagina* was reported from Mersin Bay.

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## Introduction

*Trypauchen vagina* (Bloch and Schneider, 1801) is an amphidromous fish belonging to the family Gobidae and is tropical and Indo-Pacific origin, living in muddy bottoms from sea to brackish waters (Rainboth, 1996; Riede, 2004). Records of the species from the Pacific are as follows: China (Herre, 1927), various regions of Indonesia (Bleeker, 1860; Kottelat et al., 1993), Philippines (Herre, 1953), Caledonia (Kulbicki et al., 1993), Taiwan (Chen and Fang, 1999), the Mekong Delta (Rainboth, 1996; Dinh, 2018a) and the Hau River (Dinh, 2018b). Records of the species from the Indian Ocean are as follows: India (Hora, 1924), the Bombay coasts (Acharya and Dwivedi, 1984), South Africa (Kottelat et al., 1993), Persian Gulf (Alavi-Yeganeh et al., 2015), the marine waters of Iraq (Al-Daraji et al., 2017), the Narmada River (Thakkar et al., 2018), between the Indian and Pacific waters of Thailand (Fowler, 1935; Smith, 1945), and Singapore (Larson and Lim, 2005). Records of the species from the Mediterranean Sea are as follows: Iskenderun Bay (Akamca et al., 2011), Israel coasts (Salameh et al., 2010) and Mersin Bay (Yaglioglu et al., 2013). According to the reports, all individuals observed in the Mediterranean Sea were found in the northeastern part of sea. This species has only distribution in the Northeastern Mediterranean Sea.

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There is no record of the species from the Red Sea. According to some researchers, this species has been transported to the Northeastern Mediterranean Sea by ballast waters (Golani, 2004; Goren et al., 2009; Salameh et al., 2010).

The burrowing goby is located at the depths of 20-90 m in the coastal waters (Murdy, 2006; Salameh et al., 2010; Akamca et al., 2011; Yaglioglu et al., 2013). It reaches to the maximum total length of 22 cm (Talwar and Jhingran, 1991). Their body shape is flattened and elongated, with red-pink color and their fins except pectoral fin are transparent whitish. Their dorsal and anal fins are combined with caudal fin. The meristic measurements of this species are D, 50-58, A, 43-50, P, 15-20. The number of scale on the lateral line ranges from 69 to 98. The number of caudal vertebrae is 23-24. The morphometric characters were as follows: SL/TL: 0.815-0.938, HL/SL: 0.161-0.179, predorsal length/SL: 0.188-0.218, prepelvic length/SL: 0.157-0.175, preanal length/SL: 0.308-0.362. Their eyes are almost completely blind as they are covered with skin (Bauchot et al., 1989). There are 8-13 teeth in the lower jaw and 4-16 teeth in the upper jaw. They are carnivores. They usually feed on small invertebrates and crustaceans (Rainboth, 1996; Murdy, 2006).

The aim of this study is to report the presence of adults' specimen *T. vagina* from the Northeastern Mediterranean Sea and to determine current status of this species in the Levantine basin.

## Material and Methods

Two individuals of *T. vagina* were caught by trawl fishing at a depth of 30 m on 18 September 2018 in Mersin Bay (Northeastern Mediterranean Sea) (coordinate: 36°37'54.4" N, 34°50'27.4" E). These specimens were preserved in 4% formalin and were deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (catalogue number: MEUFC-18-11-080). Morphometric and meristic characteristics of these individuals were measured (Table 1) and sampling point of the species in the Mediterranean Sea is presented in the map in Figure 1. Photograph of one of the individuals is shown in Figure 2.

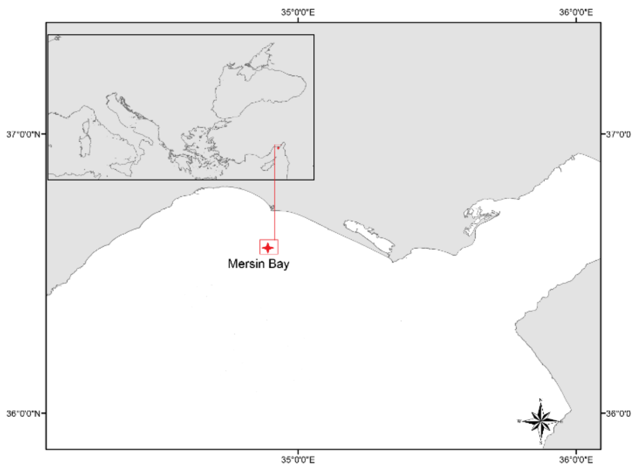


**Figure 1.** Sampling area (The red mark indicates the location where the specimens were caught)

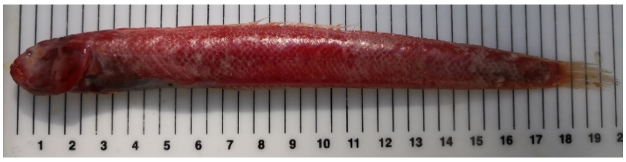

**Figure 2.** An individual of *T. vagina* caught from Mersin Bay (Photographed by Deniz AYAS)

## Results

Two individuals of *T. vagina* were caught using trawl fishing at 30 m depth in Mersin Bay in September 2018. In this study, the second record from Mersin Bay and third record from Mediterranean Sea of *T. vagina* was reported. Meristic and morphometric measurements of the individuals were done. The total lengths of individuals were recorded as 202 and 185 mm, respectively. The sampled individuals are close to the reported maximum total length of the species.

## Discussion

When the measurements of individuals caught from Mersin Bay are compared with those in previous studies, it can be seen that meristic and morphometric measurements of individuals in the present study are compatible with each other (Table 1). This situation was caused by close total lengths of individuals in all studies.

The color of the individuals caught from Mersin Bay was red, pink and the fins outside the pectoral fin were transparent, almost white. The dorsal and anal fins were combined with the caudal fin. Their eyes are almost completely blind as they are covered with skin.

It has been reported that the distribution depth of *T. vagina* in the literature is between 20-90 m (Murdy, 2006; Salameh et al., 2010; Akamca et al., 2011; Yaglioglu et al., 2013). However, it was caught at depths of 4-4.6 m on the coast of India (Thakkar et al., 2018). In this study, individuals from 30 meters were caught and this depth was consistent with the distribution depth of individuals reported in the Northeast Mediterranean Sea.

The maximum length of the species in the literature is 22 cm (Talwar and Jhingran, 1991). The lengths of individuals reported in the Northeast Mediterranean Sea (Akamca et al., 2011; Yaglioglu et al., 2013) and individuals caught in this study are similar to its maximum length. In this case, all individuals reported in the Northeast Mediterranean Sea were adults.

It is reported that the species has no record in the Red Sea and that it has been transported to the Mediterranean Sea by ballast waters (Golani, 2004; Goren et al., 2009; Salameh et al., 2010). The frequency of recording of this species is increasing in the Northeastern Mediterranean Sea day by day. If this species did not come from the Red Sea with the Lessepsian migration, this may suggest that the species has formed a population in the Northeastern Mediterranean Sea. If one species has formed a population in a region, it should also be possible to observe immature individuals in the region.

**Table 1.** The comparison of meristic and morphometric measurements of *T. vagina*

| Parameters | Mersin Bay – NE Mediterranean Sea (Present study) | | | Iranian Coast –Persian Gulf (Alavi-Yeganeh et al., 2015) | Mediterranean Sea (Murdy, 2006) | NE Mediterranean Sea (Akamca et al., 2011) |
|---|---|---|---|---|---|---|
| | *First Individual* | *Second Individual* | *Mean* | | | |
| TL | 202 | 185 | 193.5 | – | – | 210-217 |
| SL | 185 | 165 | 175 | – | – | 189-196 |
| SL/TL | 0.92 | 0.89 | 0.90 | 0.89 | 0.855 | 0.90-0.93 |
| HL/SL | 0.14 | 0.15 | 0.14 | 0.153 | 0.169 | 0.147-0.148 |
| PEL/SL | 0.06 | 0.06 | 0.06 | 0.054 | 0.060 | 0.046-0.049 |
| PEL/HL | 0.42 | 0.40 | 0.41 | 0.352 | 0.354 | 0.312-0.329 |
| PEC/SL | 0.05 | 0.06 | 0.05 | 0.046 | 0.053 | 0.043-0.051 |
| PEC/HL | 0.36 | 0.40 | 0.38 | 0.301 | 0.315 | 0.294-0.346 |
| PEC/PEL | 0.86 | 1.00 | 0.93 | 0.873 | 0.921 | 0.943-0.1051 |
| Snout length/SL | 0.05 | 0.03 | 0.04 | 0.040 | 0.048 | – |
| Interorbital length/SL | 0.03 | 0.03 | 0.03 | 0.026 | 0.027 | – |
| Body depth/SL | 0.10 | 0.10 | 0.10 | 0.107 | 0.107 | 0.106-0.109 |
| Predorsal length/SL | 0.18 | 0.21 | 0.19 | 0.206 | 0.202 | 0.195-0.205 |
| Prepelvic length/SL | 0.19 | 0.21 | 0.20 | 0.158 | 0.165 | 0.163-0.165 |
| Preanal length/SL | 0.32 | 0.32 | 0.32 | 0.348 | 0.345 | 0.341-0.352 |
| D | 55 | – | 55 | 54-57 | 50-58 | 57-58 |
| A | 44 | – | 44 | 43-47 | 43-50 | 45-48 |
| Pec | 17 | – | 17 | 16-17 | 15-20 | – |

*Note: TL* indicates total length, *SL* indicates standard length, *HL* indicates head length, *PEL* indicates pelvic fin, *PEC* indicates pectoral fin, *D* indicates dorsal fin, *A* indicates anal fin, and *Pec* indicates pectoral fin soft rays. Also, the units for parameters are measured in nearest mm.

Until now, the presence of only adult individuals in the records made so far have weakened the idea that *T. vagina* form a population in the Northeastern Mediterranean Sea. Besides, it is not clear whether the individuals which were caught in every new record from the region came with ballast waters. Therefore, the species is likely to be located in the Red Sea and a more detailed research in the region is required.

## Conclusion

Since there is no record of the species in the Red Sea, it has been reported by some researchers that sea transport has a role in its presence in the Northeastern Mediterranean Sea. However, the recordings of *T. vagina* in the Northeastern Mediterranean Sea, which is influenced by Lessepsian migration, strengthen the view that the species could have passed from the Red Sea to the Northeastern Mediterranean Sea. The absence of this species in the Red Sea does not mean that this species is not distributing in the Red Sea. The fact that the captured individuals were close to its maximum length indicates that the Lessepsian migration continues. Furthermore, the absence of immature individuals in the region indicates that the species has not yet been able to form a population in the Northeast Mediterranean Sea. In this case, there is a high probability that there is a distribution of this species in the Red Sea. This paper contributes to the literature by providing the recent knowledge on the presence, bathymetric distribution, morphometric and meristic characteristics of *T. vagina* in the coastal waters of Mersin Bay in the north-eastern part of the Mediterranean Sea.

## Conflict of Interest

The authors declare that there is no conflict of interest.


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