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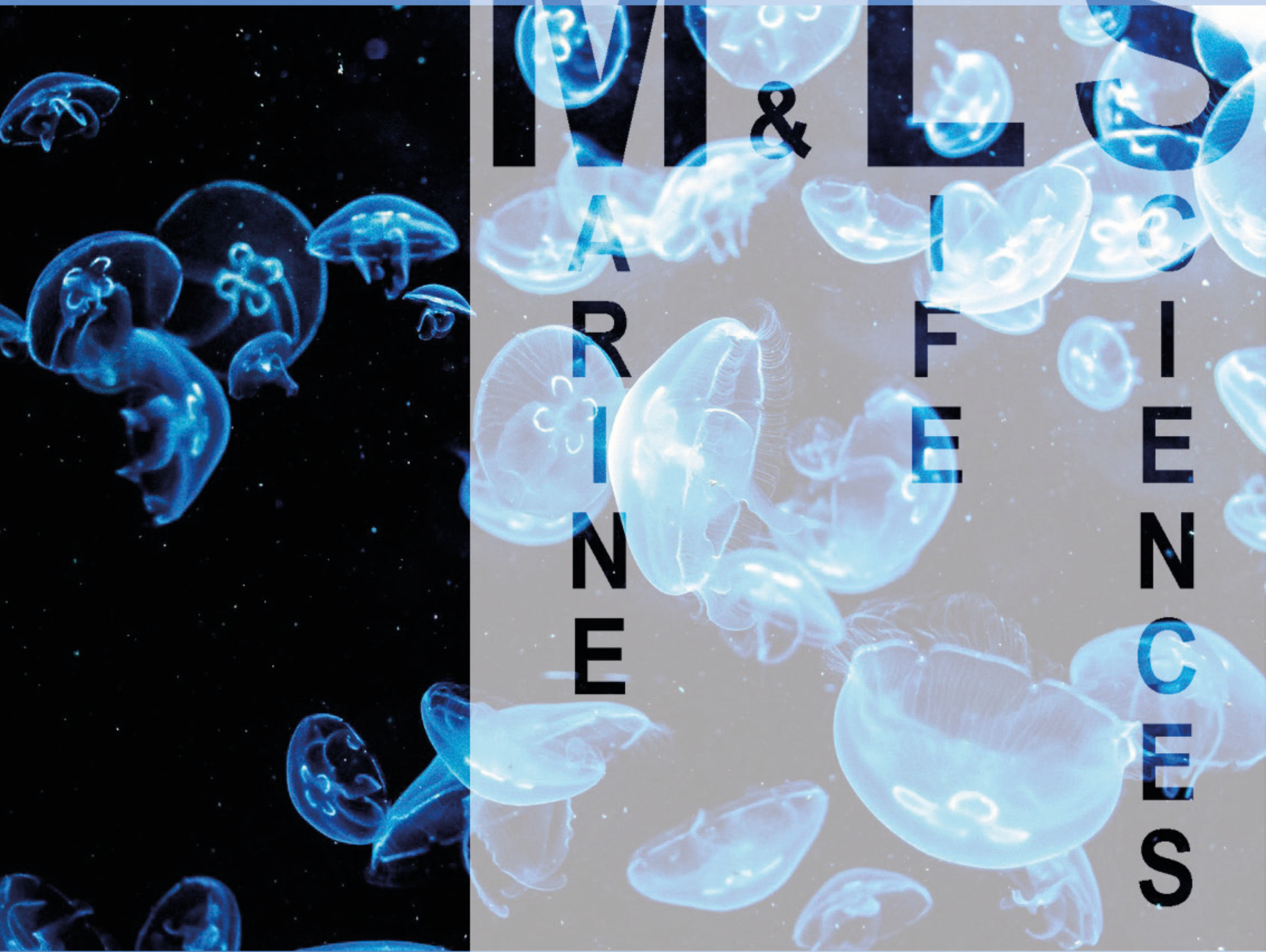

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Research Article

Diversification of narrow-clawed crayfish (*Pontastacus leptodactylus* Eschscholtz, 1823) populations from different parts of Turkey

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Keywords
Diversification
Length-weight relationship
Hepatopancreas moisture content
Narrow-clawed crayfish
Pontastacus leptodactylus

ABSTRACT

The present study was to evaluate diversification of crayfish populations based on length and weight measurements. Crayfish were collected from natural stock with fyke-net at five different populations of Turkey in the lakes Iznik (IL), Egirdir (EL) and Sera (SL) as well as Hirfanlı Dam Lake (HD) and Keban Dam Lake (KL) from June to July, 2008. The mean length, weight and hepatopancreas moisture content (HM, %) of the individuals sampled from different regions were found in order from largest to smallest as EL>HD>KL>IL>SL, EL>HD>KL>SL>IL and IL>KL>HD>KL>SL, respectively. In this study the median value of b coefficient, describing growth type from length-weight relationship, of five populations was 3.08, and fifty percent of the values were fell between 2.72 and 3.75. The growth types in these populations were determined as isometric, except in Keban Dam Lake (positive allometric). DFA (Discriminant Function Analysis) showed that there were no significant differences among the populations, meanwhile 53.06 % dissimilarities between populations was driven by length and HP with the contribution of 60.18% and 39.82% (based on SIMPER analysis), respectively. Although results from b coefficients, HM values and DF analysis of populations may reveal that their environmental conditions and growth types were similar in a certain extent, many more data taken from at least one-year sampling period is highly recommended for better understanding on factors that influenced the growth of its crayfish structure.

Introduction

Recent research has shown that there are more than 640 species of freshwater crayfish known worldwide (Crandall and De Grave, 2017). Crayfish belong to three taxonomic families: Parastacidae in the Southern Hemisphere with 175 species, and Astacidae and Cambaridae in the Northern Hemisphere wit 39 species and 426 species, respectively (Hobbs, 1989). Freshwater crayfish are favored as model organisms in several disciplines such as ecology, biology, genetics, evolution, physiology and population. Because of their ability to survive in different habitats and climatic conditions, body shape and other morphological characteristics may be quite different in this species (Hossain et al., 2018). Moreover, high adaptability, morphological differences caused by environmental conditions, and hybrid formation of some species make taxonomy of crayfish difficult (Benzie, 2005).

Crayfish has been considered as one of the most valuable fishery sources in Turkey. Until 1984, crayfish has a great demand in Europe market. However, after 1986, natural stocks of crayfish declined rapidly in most lakes and dams as a result of over fishing, habitat loss and disease. Especially crayfish plague (*Aphanomyces*

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astaci) infected in Turkish inland water resources and had been causing large scale mortalities and severe damage on crayfish populations. All of these inevitably have been led to massive economic losses in crayfish harvest industry. Even in some attempts like supplemental stocking of *Pontastacus leptodactylus* only has increased the harvest up to 3%. (Mazlum et al., 2017).

Growth in crayfish is not as continuous as in fish, but is based on the periodic increase in body length. As in all arthropods, crayfish have to change their exoskeleton to grow. For molting, crayfish terminate to feed and decrease activity. In addition, biochemical composition of crayfish changes depending on environmental conditions and reproduction period (Dutra et al., 2008). Food, stress, overcrowding and disease or reproductive cycle can affect morphometric variation of crayfish. Therefore, growth measurement in crustaceans is complex because of molting, sexual dimorphism and the growth increment can vary in different ontogenetic stages in crustaceans (Lindqvist and Lathi, 1983; Aiken and Waddy, 1987).

Total length and weight are the most commonly used measurements to measure growth in crayfish biometric studies (Mazlum et al., 2007). Relationships between these two measurements, commonly called as length-weight relationships, are very suitable for fisheries studies such as stock assessment (Valset et al., 2007; Demirci et al., 2018), growth and development (da Rocha et al., 2015; Vasileva et al., 2017), biomass, condition factor, sexual maturity (Waiho et al., 2016), age structure (Stevenson and Woods, 2006; Demirci et al., 2016), biology and ecology (Mazlum, 2003; Kumar et al., 2018) and life cycle (Goncalves et al., 1996, Froese, 2006; Moutopoulos and Stergiou, 2002; Anastasiadou et al., 2008).

Crayfish store large amounts of energy (lipid) in the hepatopancreas for reproduction (Harrison, 1990; Moore et al., 2000; Rosa and Nunes, 2003), larval development (Rosa et al., 2005) and survival (Eversole and Mazlum, 2002; Mazlum and Eversole, 2004). The relative moisture content of the hepatopancreas has been suggested as an indicator of crayfish physiological conditions (Huner et al., 1985, 1990). Previous studies have shown that there are inversely a linear relationship between moisture and energy content in the hepatopancreas (HM) (Jussila and Mannonen, 1997). In addition, high moisture in the hepatopancreas indicates insufficient food intake in crayfish (McClain, 1995).

In this study, the following measurements were evaluated i) the length-weight relationships of five different *P. leptodactylus* populations, and ii) diversification of these population based on their length and HM values (%).

Materials and Methods

Sample collection

Crayfish *(P. leptodactylus)* were collected from natural stock with fyke-net at five different locations of Turkey; Iznik lake (40°27'06.2"N 29°32'04.3"E), Hırfanlı dam lake (39°12'10.8"N 33°32'48.0"E), Sera lake (40°59'00.1"N 39°36'46.3"E), Keban Dam lake (38°38'14.3"N 39°28'58.7"E) and Egirdir lake (37°59'33.4"N 30°52'03.4"E) on June and July 8, 2008 (Fig. 1). Each location consists of 10 samples for analysis. Crayfish shipped by bus and arrived at University Aquaculture research facilities. The total length (TL) of each crayfish was measured from the tip of the rostrum to the end of the telson to the nearest mm with a measuring board. Whole frozen crayfish were placed on filter paper for several minutes to remove excess water then wet weight (W) was measured to the nearest 0.01 g. The hepatopancreas from each individual was removed and weighed to the nearest 0.01 g after blotting (Hww) and dried in a convection oven (80ºC) to a constant dry weight Hdw). Hepatopancreas moisture content (HM) was calculated using following formula (Eversole and Mazlum, 2002).

$$HM = \frac{(Hww - Hdw)}{Hww} * 100$$

Data analysis

Length-weight relationship

All data were checked out for outliers. Freshwater crayfish has a nonlinear relationship between length and weight, as in fishes, the weight may be considered as the function of length therefore more satisfactory formula for the expression of the relationship is $WT = a\ TL^b$, where, WT=wet weight in g, TL=total length in mm. Parameters a and b were estimated by using the non-linear fitting approach. Confidant limits of the b with 95 % values were calculated to determine the growth type as b = 3 represents an isometric growth, b< 3 represents a negative allometric growth, and b> 3 represents a positive allometric growth.

Discriminant Function Analysis (DFA)

Discriminant Function Analysis was used to determine which combinations of variables (distances) discriminated the best among populations and detected which populations were the most different (Ruiz-Campos et al., 2003). Total weight was not considered in DFA due to having high variable nature. Before conducting DFA, the variables (total length and HM) were standardized by logarithmic transformation-log(x). In addition to DFA, SIMPER (Similarity Percentage) was used for assessing which variables are primarily responsible for an observed difference between populations (Clarke, 1993). All computations and statistical analyses were carried out by using Microsoft Excel and Past software (V. 3.23) (Hammer et al., 2001).

Results and Discussion

Freshwater crayfish can easily survive in lakes, ponds, dams and rivers that are exposed to various environmental factors. Geographical and environmental factors affect population density, growth and life cycle of species. Temperature, pH and dissolved oxygen values in the life cycle of crayfish known as highly effective environmental factors (Erol et al., 2017). In addition, these factors are affecting the diversity of the population of some species. Systematic and taxonomic studies have shown that crustaceans display a high degree of variation, which includes variability in size and proportion of major body parts.

The descriptive statistics of three variables (total length, total weight and HM %) according to the populations were given in Table 1. The mean length, weight and HM values of the individuals sampled from different regions were given in order from largest to smallest as EL>HD>KL>IL>SL, EL>HD>KL>SL>IL and IL>KL>HD>KL>SL, respectively.

It is well known that the male and female crayfish are different in size have been well documented in the crayfish literature since the work of Huxley (1881). Mazlum et al. (2007) analyzed the weight–length relationship of Procambarus acutus acutus and they were revealed that males gained weight with increasing length faster than female specimens during the growth period, showing the common nature of sexual dimorphism in freshwater crayfish (Balık et al., 2005; Güner, 2006). Having a sexual dimorphism in any animal population requires evaluating of sexes separately. But in this study, sexual dimorphism was not evaluated for each population due to a small number of samples. However, there was also no significant difference between the mean length and HM percent values of the populations ($p > 0.05$). Also, based on the coefficients of variations (CV, %), variation in length (IL: 8.35, HD: 13.02, EL: 11.56, SL: 16.39 and KL: 7.59) and hepotopancreas moisture content (HM, %), (IL: 14.42, HD: 10.98, EL: 12.56, SL: 15.96 and KL: 7.44) were almost similar. Therefore, sexual dimorphism related errors in calculating both length-weight relationships, DA, and simper analysis somehow may be considered as not significant. The variable “crayfish weight” is not as stable as length and hepatopancreas moisture, because of the even the nutrients taken during the day affect the weight of the crayfish

Crayfish store large amount of lipid as an energy in their hepatopancreas for growth, survival and reproduction (Harrison, 1990). For this reason, moisture content of the hepatopancreas has been used to describe the feeding condition of crayfish (Mannonen and Henttonen, 1995; McClain, 1995). Generally, as organic reserves are depleted from the hepatopancreas tissues, moisture level in the tissues increases. In this study, non-significant differences were present among the mean HM of the populations reveals that the factors affecting the condition of the different populations are almost same.

Populations	TL mean ±sd (min-max)	W mean ±sd (min-max)	HM (%) mean ±sd (min-max)
İznik Lake (IL)	9.45±0.79	19.76±4.86	73.54±10.61
	(8.1-10.5)	(11.87-26.21)	(56.01-86.44)
Hirfanlı Dam Lake (HD)	10.06±1.31	31.42±13.11	66.44±7.30
	(7.9-12.1)	(12.95-51.50)	(57.05-82.16)
Eğridir Lake (EL)	11.85±1.37	47.34±16.56	64.29±8.08
	(9.9-14.5)	(28.77-85.48)	(55.88-82.24)
Sera Lake (SL)	8.72±1.43	21.19±10.38	62.37±9.96
	(6.6-10.6)	(8.36-40.12)	(48.93-79.77)
Keban Dam Lake (KL)	9.74 ± 0.74	27.14±8.81	66.99±4.99
	(8.1-10.5)	(12.33-40.26)	(63.08-76.30)

Table 1. Mean (±sd) and range (min-max) of total length (TL), weight (W) and hepatopancreas moisture (HM %) of *P. leptodactylus* used in this study from various populations of Turkey.

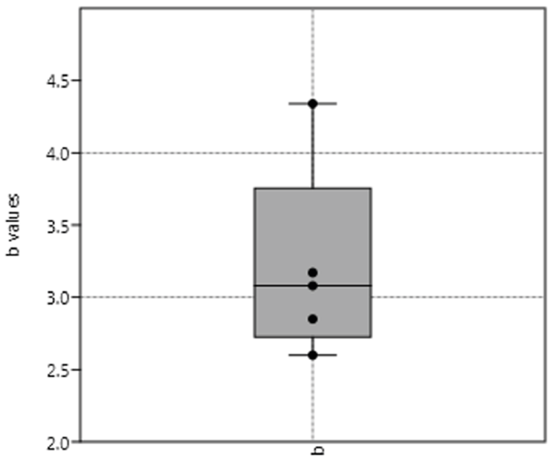
The coefficient b in the length-weight relationships of crayfish individuals obtained from different populations varied between 2.85 and 4.34. The growth types in these populations were determined as isometric, except in Keban Lake (positive allometric) (Table 2).

Figure 1 shows the Box-jitter plot of b coefficient with some descriptive statistics of five populations. In our study the median value of b coefficient of these five populations was 3.08, and fifty percent of the values were fall between 2.72 and 3.75 (Figure 1). The median of b values of reviewed studies was 3.00 and fifty percent of the b values fall between 2.85 and 3.11 (Figure 2). These results showed that our findings were almost consistent with the previous studies. However, our b values tend to be positive allometric growth (Skewness = 1.62) with the range of 1.74 (4.34-2.60), other studies tend to be negative allometric growth (Skewness = -2.26) with the range of 1.12 (3.22-2.10) (Table 3, Figure 2). The two values of b, namely 4.34 (this study) and 2.10 (previous studies) were out of the general tendency.

Population	a	b	R-square	CL of b (95 %)	Growth Type
IL	0.035	2.85	0.79	(1.65-3.95)	I
HD	0.019	3.17	0.91	(2.36-3.98)	I
EL	0.072	2.60	0.89	(1.80-3.40)	I
SL	0.024	3.08	0.96	(2.59-3.36)	I
KL	0.001	4.34	0.93	(3.39-5.28)	(+) A

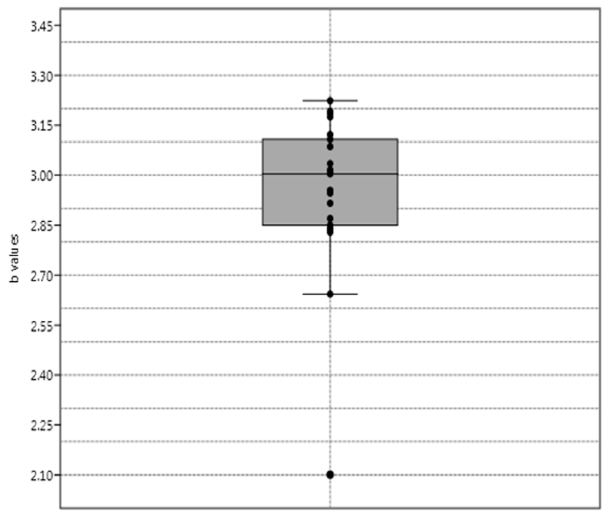
I: isometric growth, (+) A : positive allometric growth

Table 2. Length-weight parameters with R-square and growth type of *P. leptodactylus* from various populations of Turkey.



	b
N	5
Min	2.60
Max	4.34
Mean	3.20
SD	0.67
Median	3.08
25 prcntil	2.72
75 prcntil	3.75
Skewness	1.62
C. var	20.89

Figure 1. Box-jitter plot of b coefficient with some descriptive statistics of *P. leptodactylus* from five populations.



	b
N	23
Min	2.10
Max	3.22
Mean	2.95
SD	0.23
Median	3.00
25 prcntil	2.85
75 prcntil	3.11
Skewness	-2.26
C. var	7.93

Figure 2. Box-jitter plot of b coefficient with some descriptive statistics of *P. leptodactylus* in the reviewed literatures.

Location	b	r^2	Literature
Iznik Lake	3.035	0.95	Aydın et al. (2015)
Sera Lake	3.122	0.97	Erkbay (2004)
Keban Dam Lake	2.643	0.92	Harlıoğlu (1999)
Eğirdir Lake	2.829	0.96	Bolat (2001)
Apolyant Lake	2.955	0.96	Berber and Balık (2009)
Mogan Lake	3.086	-	Tüzün (1987)
Ayrancı Dam Lake	3.015	-	Erdem and Erdem (1994)
İznik Lake	3.004	-	Erdem et al. (2001)
Mogan Lake	2.101	0.99	Benzer et al. (2015)
Thrace region reservoirs	3.224	0.92	Deniz Bök et al. (2010)
Demirköprü Dam Lake	3.1685	0.97	Balık et al. (2005)
Yeniçağa Lake	2.836	0.99	Gencay (2019)
Sapanca Lake	3.186	0.91	Baltacı (2018)
Bafra Lake	2.916	0.91	Uzun (2013)
Keban Dam Lake	2.946	0.83	Yüksel (2007)
Keban Dam Lake	2.946	0.83	Yüksel and Duman (2012)
Mogan Lake	3.086	-	Karabatak and Tüzün (1989)
Aktaş Lake	3.016	0.97	Aksu and Kurt Kaya (2017)
Eğirdir Lake	2.870	0.90	Bolat and Kaya (2016)
Seven inland waters	2.07	0.99	Deniz et al. (2013)
Apolyont Lake	3.008	-	Berber and Balık (2009)
Terkos Lake	2.842	0.91	Güner (2006)
Eğirdir Lake	2.850	0.95	Balık et al. (2005)

Table 3. Literatures on length-weight relationship [log(W) = log a + b log (L)] of *P. leptodactylus* in different populations from Turkey (b : slope of the equation, r-square: coefficient of determination)

Previous study and our knowledge indicate that there are several factors that could contribute to the variations in allometry of decapod crustaceans such as age, sex, differences in diet, foraging behavior, availability and quality of food, environmental conditions with abiotic factors which consist of season, temperature, salinity and rainfall (Taddei et al., 2017). In crustaceans, the body growth occurs by continuous molts dependent upon physiological aspects regulated by abiotic factors, such as photoperiod, temperature, and availability and quality of food (Hartnoll, 1982; Mazlum and Eversole, 2005). In the morphometric relationship of length and weight of crustaceans, study of total length, carapace length and abdominal length in the length-weight relationships are prevalent as these parameters are less variables and more easily measured in the field. As such, the use of these measurements in aquaculture are extremely suggested because there are the most accurate and simple alternative of analyzing growth pattern of animal (Lalrinsanga et al., 2012). In habitat with more food availability and higher temperature, crayfish tend to have higher growth rates (Eversole et al., 2006). The differences in the values of the b parameter between the study species probably results of differences in feeding, sex, breeding behavior and greater capacity of obtaining, converting and storing energy according to living conditions.

Discriminant analysis (DFA) was used to determine the differentiation among the populations. Four functions were identified with DFA, but only first two were explained the 99.51% of total variance as 79.09% and 20.42%, respectively. The specimens were correctly classified into populations with 53.06 % using Jackknife estimation procedure from DFA results (Table 4).

Although DFA showed that there were no significant differences among the populations (Figure 3, Figure 4), SIMPER analyses showed that the 53.06 % dissimilarities between populations was driven by Length and HM with the contribution of 60.18 % and 39.82%, respectively. Recall, precision and F-measure of populations calculated from confusion matrix implied that the diversification for the populations in descending order (based on F-measure) as; EL>SL>IL>KL>HD. So, from that point of view we can conclude that the EL (Eğridir Lake) population with 70 % ratio is much more diverged from then other populations, while HD (Hirfanlı Dam Lake) population is only 20 % (Table 5).

Populations	IL	HD	EL	SL	KL	Total
IL	6	1	0	2	1	10
HD	2	2	3	2	1	10
EL	0	2	7	0	0	9
SL	1	2	0	7	0	10
KL	2	3	0	1	4	10
Total	11	10	10	12	6	49

Table 4. Confusion matrix with Jackknifed classifications from DFA

Table 5. Recall, precision and F-measure of populations calculated from confusion matrix

Populations	Recall (%)	Precision (%)	F-measure
IL	60	54.55	57.14
HD	20	20.00	20.00
EL	70	70.00	70.00
SL	70	58.33	63.64
KL	40	66.67	50.00

The pikeperch is a piscivorous species whose natural role is top predator in a complex of fish species. The lake Egirdir was known for 11 local species until it was stocked in *Stizostedion lucioperca*. However, after 1955, the number of local species decreased by 3-4. Lake Eğirdir nowadays pollution, excessive vegetative development, entering new species and the extinction of natural species is under the pressure of many environmental impacts resulting from changes in the water structure (Campbell, 1992). For this reason, 70 % differentiation is thought to be caused by the pressure of environmental impact of this lake. Hirfanlı is one of Turkey's

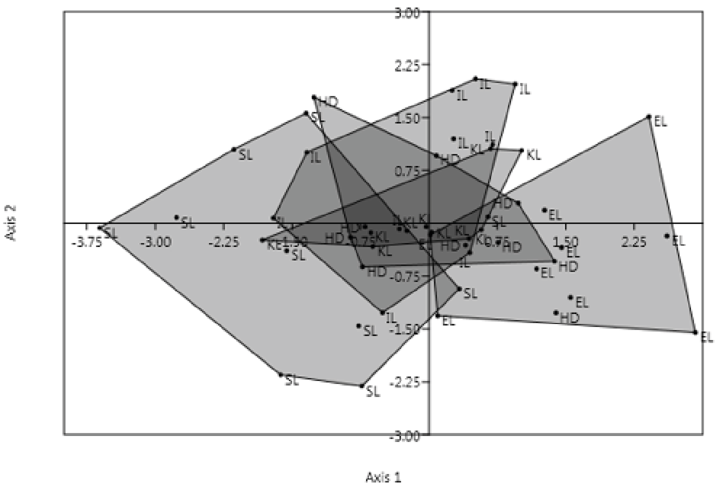


Figure 3. DFA results with convex hulls for *P. leptodactylus*

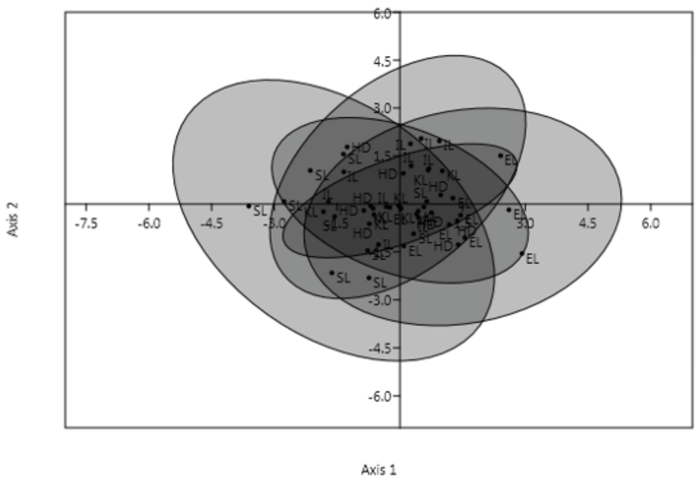


Figure 4. DFA results with 95 % Confidant limits for *P. leptodactylus*.

largest dam. There are many small islands in the reservoir. Tinca tinca was the dominant fish species in Hirfanlı dam lake. The dam, which was built for electricity generation, is also used for irrigation.

In current study, the main reason of why the length and HM did not differ among the populations in terms of parameters (length and HM) it may be due to the low number of samples, and not to evaluating the populations separately as male and female. It may be suggested that, sex discrimination should be made by taking sample data of at least 1 year. Moreover, the generality of our results can be evaluated by investigating the properties of the sample populations including physico-chemical parameters, nutrient status, and competition, etc.

Conclusion

The present study provided some knowledge on length-weight relationships and diversification of five crayfish populations from different regions of Turkey. Although results from b coefficients, HM values and DF analysis of populations may reveal that their environmental conditions and growth types are similar in a certain extent, many more data taken from at least one-year sampling period is highly recommended for better understanding on factors that influenced the growth of its crayfish structure.

Acknowledgement

Authors wish to acknowledge that there is no conflict of interest.

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Research Article

Assessment of magnesium content of three fish species from three bays in Northeastern Mediterranean Sea

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ABSTRACT

Magnesium (Mg) is crucial for all cells of all known living organism. In this study, the accumulation of the magnesium in the tissues (muscle-M, skin-S, liver-L, and intestine-I) of three selected fish species (*Siganus rivulatus, Mullus barbatus, Solea solea*) from the three bays (İskenderun, Mersin, and Antalya) located in the Northeastern Mediterranean Sea was examined in a comparative context. The minimum and maximum values of the Mg accumulation (in µg g-1 w.wt) in the tissues of fish were found as 150-390 for *S. rivulatus*, 80-130 for *M. barbatus*, and 170-180 for *S. solea*. The distribution of the mean Mg accumulation among the organs of *M. barbatus* and *S. solea* from İskenderun and Mersin Bays was the same in the order of I>L>S>M, while the values for *M. barbatus* (I>S>M>L) and *S. solea* (L>I>M>S) from Antalya Bay were different. For *S. rivulatus,* the pattern was almost same in three bays as I>S>M>L. Based on the results of the Discriminant Analysis (DFA) and SIMPER (Similarity Percentage) analysis, overall average dissimilarities among the fish species and bays concerning Mg accumulations were found to be 47.37% and 44.4%, respectively. Results showed that intestines had the most dissimilarities while muscles had the lowest. From the point of view of human nutrition, Mg accumulation in muscle as an edible part of fish was found to be not significantly important among the three fish species and three bays.

Introduction

Magnesium (Mg) is such a key mineral that over 300 enzymes require the presence of magnesium ions for their catalytic action. Therefore, it is crucial for all cells of all known living organisms (Durlach and Bara, 2000; Seelig, 2001; Laires et al., 2004; Brucha-Jastrzebska and Kawcuga, 2011). Also, high solubility of magnesium ions in water helps ensure that it is the third most abundant elements dissolved in seawater (Brucha-Jastrzebska and Kawcuga, 2011).

Fisheries products are key part of human diet due to not only their protein and unsaturated fatty acid content but also vitamins and minerals.

A number of studies have been conducted on Mg accumulation in aquatic organisms. In the framework of a national project, the Mg concentrations (mg) in 100 g edible part of some fish species were reported with their means and ranges (minimum and maximum) from Turkey (www.turkomp.gov.tr). Brucha-Jastrzebska and Kawcuga (2011) studied the Mg concentrations in some freshwater fish and they found that the variations in the concentration of Mg are due to the differences of individual species and the concentration in the analyzed organs of freshwater fish varied significantly. Also, Uysal and Emre (2011) and Yılmaz et al. (2010) investigated the

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Mg content in the different organs of some marine fish species from Antalya and İskenderun Bay, respectively.

The aim of this study was to contribute to the knowledge on Mg accumulation in aquatic organisms. Therefore, it was aimed to evaluate, in a comparative context, the accumulation of the magnesium in the organs (muscle, skin, liver, and intestine) of three selected fish species (*Solea solea, Mullus barbatus, Siganus rivulatus*) from three bays (İskenderun, Mersin, and Antalya) located in North-Eastern Mediterranean Sea.

Material and Methods

Fish species

Common sole (*Solea solea*), Red mullet (*Mullus barbatus*) and Marbled spine foot (*Siganus rivulatus*) were studied for Magnesium (mg) accumulation in their organs (muscle, skin, liver, and intestine). Fish species were confirmed according to Froese and Pauly (2018). Common sole is a demersal marine fish which lives on sandy or muddy bottoms ranging from near shore to 200 m of depth. Adults feed mainly on polychaete worms, molluscs and small crustaceans. Red mullet is a benthic fish and its main habitat is muddy bottoms of the continental shelf between 5 and 300 m feeding on benthic invertebrates (crustaceans, worms, molluscs). Marbled spine foot lives in shallow waters over substrates clothed with algae including rocky and sandy areas as well as the places where algae grows among sea grass beds at depths of less than 15 m. They are herbivorous feeding mainly on algae.

Studied areas

Fish samples were taken from fishermen in the Iskenderun (36°36’20.53”N, 36°10’16.47”E), Mersin (36°46’45.38”N, 34°41’0.35”E) and Antalya (36°52’35.46”N, 30°41’35.08”E) bays in the North-Eastern Mediterranean Sea. These bays are in an interaction with each other through current systems (Hamad et al., 2005).

Sample Collection, Preparation and Analysis

TThe samples were brought to the laboratory on ice immediately and then frozen at -25°C until dissection. Total fish length and weight were measured to the nearest millimeter (mm) and gram (g) before dissection. The mean length and weight of the S. solea, M. barbatus, and S. rivulatus were 25.22±2.20 cm and 135.90±43.11 g, 19.64±4.07 cm and 158.31±123.61 g and 17.29±2.08 cm and 108.34±72.52 g, respectively. The mean body length of each species from three bays were not significantly different ($p>0.05$).

Fish samples were dissected to get organ samples (epaxial muscle, intestine, skin and liver). All chemicals used in the study were of analytical reagent grade. Double distilled water was used throughout the study. Calibration standard solutions were prepared by stepwise dilution of the stock solution. Samples were weighted, digested in HNO3/HCl (1:3 v/v), filtered with 0.45 µm micropore membrane filter, diluted and then analyzed for Mg content in accordance with Yılmaz (2003).

Analysis was carried out in triplicate using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) (Perkin Elmer Nexion 350 X). Metal concentrations were calculated in microgram per gram wet weight (µg metal g^{-1}w.wt.).

Statistical analyses

Discriminant Analysis (DFA) was used to determine which combinations of variables (distances) discriminated the groups and detected which groups were the most different (Ruiz-Campos et al., 2003). Before conducting DFA, the variables were standardized by logarithmic transformation (log(x)). In addition to DFA, SIMPER (Similarity Percentage) analysis was used to assess which variables are primarily responsible for an observed difference between groups (Clarke, 1993).

All computations and statistical analyses were carried out using Microsoft Excel and PAST software (v. 3.23) (Hammer et al., 2001).

Results and Discussion

Table 1 and Figure 1 show mean Magnesium (Mg) concentration (in µg g^{-1}w.wt) with standard deviation and range (minimum, maximum) values in different organs of *S. solea, M. barbatus, S. rivulatus* with respect to the three studied bays, respectively.

Mg concentration in the muscle of *S. rivulatus* changed from 149.50 to 168.69 µg g^{-1} w.wt in İskenderun Bay, 146.22 to 407.22 µg g^{-1} w.wt in Mersin Bay and 124.19 to 188.75 µg g^{-1} w.wt in Antalya Bay. Similarly, Mg concentration of *M. barbatus* varied between 174.32-263.19 µg g^{-1} w.wt in İskenderun Bay, 117.23-263.19 µg g^{-1} w.wt in Mersin Bay, and 68.55-336.79 µg g^{-1} w.wt in Antalya Bay. Finally, Mg concentration in the muscle of *S. solea* in İskenderun, Mersin and Antalya Bays was found to be between 117.22-263.19 µg g^{-1} w.wt, 150.28-204.41 µg g^{-1} w.wt

Table 1. Mean Mg concentrations with standard deviations (µg metal g^{-1} wet weight [w.wt.]) in the organs of *S. solea, M. barbatus, S. rivulatus* with respect to studied bays

Bay	Species	Muscle (M) (mean± sd)	Skin (S) (mean± sd)	Liver (L) (mean± sd)	Intestine (I) (mean± sd)
Iskenderun	*S. rivulatus*	158.16 ±8.86	403.29± 114.58	135.07±26.59	617.62±219.95
		149.50-168.69	248.61-534.16	108.63 - 166.61	421.52-874.85
	M. barbatus	197.54±24.43	225.09± 89.98	292.70±6.17	848.21±752.12
		174.32 - 263.19	100.89-315.61	288.34-297.06	249.74-1654.56
	S. solea	181.75±73.31	198± 87.54	214.66±34.44	561.31±305.85
		117.22-263.19	125.59-321.59	177.22-251.06	290.16-859.753
Mersin	*S. rivulatus*	266.41 ±120.70	187.38± 41.21	117.20±27.01	451.27±252.20
		146.22 - 407.22	137.43-237.17	97.86 to 155.70	100.73-672.48
	M. barbatus	181.75±73.31	198.07± 87.54	214.66±34.44	561.31±305.85
		117.23-263.19	128.53-236.68	177.22-251.06	290.16-859.75
	S. solea	176.73±27.09	186.29± 40.31	268.30±212.01	660.37±193.14
		150.28-204.41	128.53-236.68	134.16-584.75	448.45-849.95
Antalya	*S. rivulatus*	160.60 ±27.88	174.70± 52.32	143.29±69.39	319.13±206.79
		124.19 -188.75	122.31-231.49	101.59 - 266.03	194.53-557.83
	M. barbatus	194.33±111.01	681.74± 313.68	178.42±4.62	1531.98±751.32
		68.55-336.79	100.90-217.21	175.15-181.68	527.48-2345.22
	S. solea	170.01±105.87	153.61± 58.99	283.59±146.67	270.25±214.30
			100.90-217.21	134.16-584.75	131.01-583.41

and 101.21-327.06 µg g^{-1} w.wt, respectively. The highest concentration was observed in *S. rivulatus* from Mersin Bay and the lowest concentration was observed in *M. barbatus* in Antalya Bay (Figure 1).

Mg accumulation level in the skin was found to be 248.61-534.16, 137.43-237.17, 122.31-231.49 µg g^{-1} w.wt for *S. rivulatus*; 100.89-315.61, 125.59- 321.58, 376.08-1108.59 µg g^{-1} w.wt for *M. barbatus* and 125.59-321.59, 128.53-236.68, 100.90-217.21 µg g^{-1}w.wt for *S. solea* in İskenderun, Mersin and Antalya bays, respectively (Figure 1).

Mg concentration in the liver of *S. rivulatus* was found to have changed from 108.63 to 166.61 µg g^{-1}w.wt in Iskenderun Bay, 97.86 to 155.70 µg g^{-1}w.wt in Mersin Bay and 101.59 to 266.03 µg g^{-1}w.wt in Antalya Bay. Similarly, Mg concentration of *M. barbatus* varied between 288.34-297.06 µg g^{-1} w.wt in İskenderun Bay, 177.22-251.06 µg g^{-1} w.wt in Mersin Bay, and 175.15-181.68 µg g^{-1} w.wt in Antalya Bay. Lastly, Mg concentration in the liver of *S. solea* was found between 177.22-251.06 µg g^{-1} w.wt in İskenderun Bay, 134.16-584.75 µg g^{-1} w.wt in Mersin Bay and 156.70-429.11 µg g^{-1} w.wt in Antalya Bay (Figure 1).

Highest Mg accumulation levels were observed in the intestine tissue and the values varied between 421.52-874.85, 100.73-672.48, 194.53-557.83 µg g^{-1} w.wt in Iskenderun, Mersin and Antalya bays for *S. rivulatus*, respectively. The same ranking was observed as 249.74-1654.56, 290.16-859.75, and 527.48-2345.22 µg g^{-1} w.wt for *M. barbatus* in İskenderun, Mersin and Antalya Bays, respectively. Lastly, it varied between 290.16-859.753, 448.45-849.95, and 131.01-583.41 µg g^{-1} w.wt for *S. solea* in İskenderun, Mersin and Antalya bays, respectively. The highest and lowest accumulation values were observed in *M. barbatus* and *S. solea*, respectively, from the Antalya Bay.

The pattern of the mean Mg accumulation among the organs for *M. barbatus* and *S. solea* from İskenderun and Mersin Bays was the same as I>L>S>M while the patterns for *M. barbatus* (I>S>M>L) and *S. solea* (L>I>M>S) from Antalya Bay were different. For *S. rivulatus,* the pattern was almost same in three bays as I>S>M>L (Table 1).

According to Uysal et al. (2008), the rank of Mg bioaccumulation in the different organs of *Lithognathus mormyrus, Liza aurata, Chelon labrasus, Mugil cephalus, Sparus aurata, Liza ramada* was found as Gill (G) >Muscle (M) >Skin

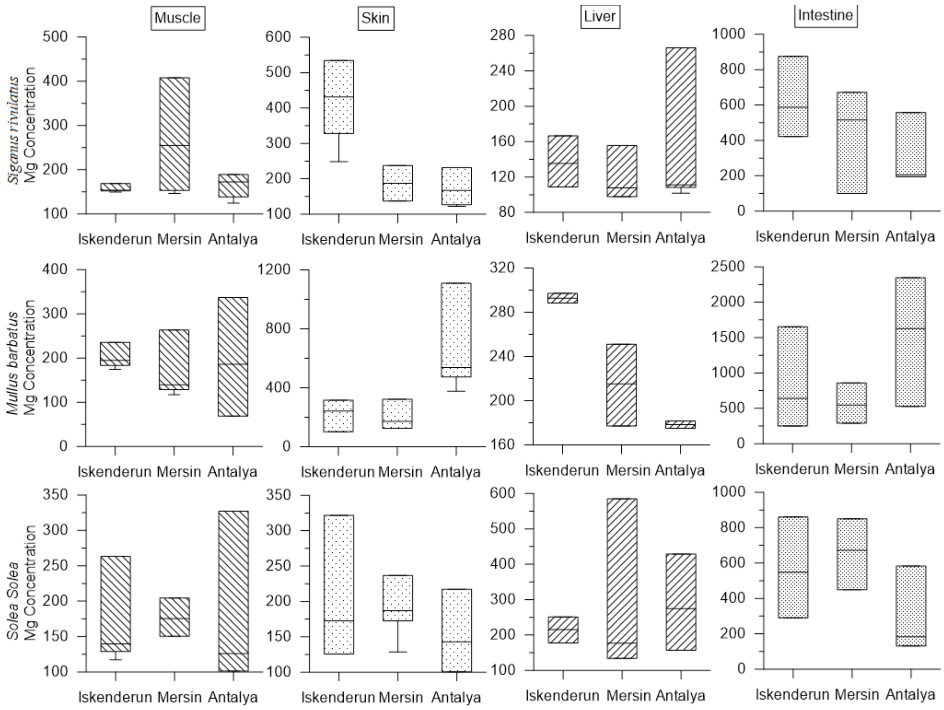

Figure. 1. Box and whisker plots of Mg concentrations (μg g^{-1} w.wt) in the different organs of *S. rivulatus, M. barbatus* and *S. solea* with respect to studied bays

(S). They also reported the Mg accumulation (mg/kg w.wt.) in the different organs of several species including *L. mormyrus* (M: 304.20 ± 22.9, S: 215.60 ± 11.7, G: 659.16±12.8), *L. aurata* (M: 278.60 ± 5.2, S: 173.06 ± 8.6, G: 560.50±4.7), *C. labrasus* (M: 323.40 ± 9.9, S: 168.73 ± 3.7, G: 451.80±20.2), *M. cephalus* (M: 295.70 ± 4.3, S: 188.23 ± 9.8, G: 486.73±4.1), *S. aurata* (M: 332.56 ± 10.5, S: 211.56 ± 28.4, G: 545.93±13.4), and *L. ramada* as (M: 262.53±15.1, S: 233.56±36.5, G: 617.23±4.7).

Uysal and Emre (2011) investigated the Mg content in the different tissues of *Diplodus sargus, S. rivulatus, L. mormyrus, L. aurata, C.* labrasus from Antalya Bay. They reported that Mg level varied from 204.33 to 784.30 μg g^{-1} w.wt depending on

Table 2. The magnesium concentrations (mg) of 100 g edible part of some fish species from Turkish Food Composition Database (URL).

Name	Scientific name	Mean	Min	Max	Reference
Marbled spinefood	*Siganus rivulatus* (Forsskål & Niebuhr, 1775)	20	15	39	This study*
Red Mullet	*Mullus barbatus* (Linnae, 1758)	19	8	31	
Common Sole	*Solea solea* (Linnaeus, 1758)	18	7	28	
Rainbow trout	*Oncorhynchus mykiss*	38	33	44	Turkomp (2019)
Red mullet	*Mullus barbatus* (Linnae, 1758)	33	26	39	
European hake	*Merluccius merluccius* (Linnaeus, 1758)	30	21	40	
European anchovy	*Engraulis encrasicholus* (Linnae, 1758)	30	28	34	
Atlantic and Mediterranean horse mackerel	*Trachurus trachurus* (Linnaeus, 1758) and *Trachurus mediterraneus* (Steindachner, 1868)”	36	31	45	
Turbot	*Scophthalmus maximus* (Linnaeus, 1758)	34	21	39	
Golden mullet	*Mugil auratus* (Linnaeus, 1761)	29	23	37	
Whiting	*Merlangius merlangus euxinus* (Nordmann, 1840)	27	21	30	
Atlantic bonito	*Sarda sarda* (Bloch, 1793)	34	32	37	

**Results of this study were converted to mg/100 g*

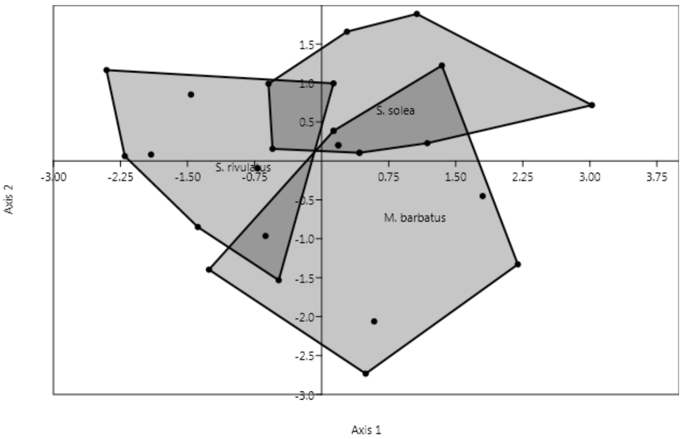

Figure 2. Result of Discriminant Analysis (DFA) on three fish species with convex hulls.

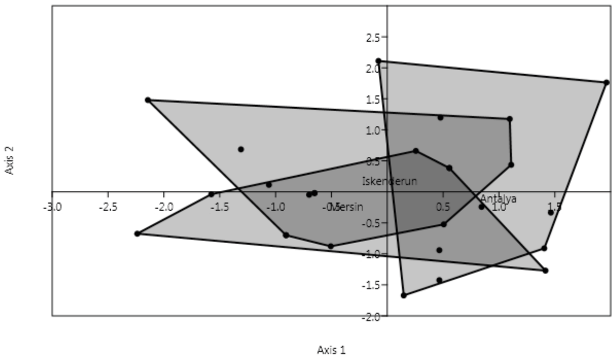

Figure 3. Result of Discriminant Analysis (DFA) on three bays with convex hulls.

species and tissue. The Mg content ranking of *S. rivulatus* was reported to be skin>gill>muscle.

Yılmaz et al. (2010) reported the mean Mg content (as µg metal g^{-1} w.wt.) in the *Triglia lucerna, Lophius budegassa, Solea lascais* collected from İskenderun Bay as 21.7±5.57, 16.6±8.34, 9.05±3.28 µg g^{-1} w.wt in liver, 19.2±1.93, 16.4±3.28, 12.9±7 µg g^{-1} w.wt in skin, and 17.9±4.34, 7.34±3.22, 23.3±12.3 µg g^{-1} w.wt in muscle, respectively.

Brucha-Jastrzebska and Kawczuga (2011) studied the Mg content (mg.kg-1 w.wt.) of muscle tissue of some freshwater species namely Common carp, Rainbow throut, Siberian sturgeon, Northern pike and Grass carp and they found the concentrations as 85.4±24.1, 87.2±33.5, 63.6±16.2, 125.7±32.7 and 72.4±24.3 mg.kg^{-1} w.wt, respectively.

Comparison of our findings with the previous studies revealed that even though Mg bioaccumulation levels are different among species, accumulation level ranking is similar. Liver and intestine had the highest bioaccumulation concentration compared to other organs. Intestines accumulate a lot of heavy metal since it is related with the digestive system. Similarly, liver acts as a target organ in heavy metal accumulation since it is metabolically active organ (Romeo et al., 1999; Yılmaz et al., 2010). Therefore, the present study proves that even though Mg is not a heavy metal, it acts like a heavy metal in terms of bioaccumulation.

The magnesium (Mg) concentrations (mg) of 100 g edible part of some fish species from TurKomp database were given in Table 2.

It is difficult to generalize a mineral content of fish species due to the variations occurring based on several internal and external factors such as mineral type, specimen, sex, biological cycle, location, climate, nutrient availability, temperature, salinity etc. (Martinez et al., 1998; Martinez-Valverde et al., 2000; Yılmaz et al., 2010). For that reason, wide variations in the Mg level were observed depending on fish species, location (bay), and fish tissue (Table 1). However, in a general point of view, our results are consistent with the previous literature and the ministry database.

Discriminant Analysis (DFA) carried out both on species and bays yielded two functions that are accounted the total variance as (70.5% and 29.5% for fish species) and (92.09% and 7.90% for bays), respectively (Figure 2 and Figure 3).

The variations of Mg consternations in organs by the three fish species and the three bays with contribution to dissimilarities based on DFA and SIMPER analyses were shown in Table 2 and Table 3, respectively. Overall average dissimilarities among the fish species and bays concerning the Mg accumulations were 47.37% and 44.4%, respectively. On the other hand, their similarities were 52.63% and 55.60%, respectively.

Table 3. Contribution rates (%) of organs on dissimilarities among the species

Organs	Contribution %	Cumulative %	Pattern
Intestine	43.84	43.84	*M. barbatus>S.solea>S.rivilatus*
Skin	27.49	71.33	*M. barbatus>S.rivilatus> S.solea*
Liver	17	88.33	*S.solea>M. barbatus>S.rivilatus*
Muscle	11.67	100	*M. barbatus>S.solea>S.rivilatus*

Results indicate that differences depending on the three fish species arise from intestine, skin, liver and muscle tissue (Table 3). Patterns showed that intestine with *M. barbatus* interactions produced the most dissimilarities while muscle with *S. rivulatus* had the lowest. Similarly, differences in the Mg accumulation levels depending on the three bays arise from intestine, skin, liver and muscle with the contribution rate of 0.19, 0.13, 0.07 and 0.06, respectively (Table 4). The patterns for contribution rates (%) of organs on dissimilarities among the bays showed that intestine with İskenderun bay interactions

Table 4. Contribution rates (%) of organs on dissimilarities among the bays

Organs	Contribution %	Cumulative %	Pattern
Intestine	0.19	43.83	İskenderun>Antalya>Mersin
Skin	0.13	28.24	Antalya>İskenderun>Mersin
Liver	0.07	15.26	İskenderun >Antalya>Mersin
Muscle	0.06	12.67	Mersin>İskenderun>Antalya

Conclusion

In this study, the accumulations of magnesium (In this study, the accumulations of magnesium (Mg) in the organs (muscle, skin, liver, and intestine) of three selected fish species (*Solea solea, Mullus barbatus, Siganus rivulatus*) from three bays (İskenderun, Mersin, and Antalya) located in Northeastern Mediterranean Sea were examined in a comparative context. Key findings and conclusions of the study are given below:

1. The pattern of the mean Mg accumulation among the organs of *M. barbatus* and *S. solea* from İskenderun and Mersin bays was the same in the order of I>L>S>M while it was different for *M. barbatus* (I>S>M>L) and *S. solea* (L>I>M>S) from Antalya bay. For *S. rivulatus*, the pattern was almost same in all three bays as I>S>M>L.

2. Overall average dissimilarities among the three fish species and the three bays concerning Mg accumulations were 47.37% and 44.4%, respectively. On the other hand, their similarities were 52.63% and 55.60%, respectively.

3. Patterns showed that intestine with *M. barbatus* interactions produced the most dissimilarities while muscle with *S. rivulatus* had the lowest. The patterns for contribution rates (%) of organs on dissimilarities among the three bays showed that intestine with İskenderun bay interactions produced the most dissimilarities while muscle with Antalya Bay had the lowest.

4. From the point of view of human nutrition, it was found that Mg accumulations in muscles as an edible part of fish were not significantly different both among the three fish species and three bays included in the study.

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Research Article

Can brush parks aggregate species in lagoon systems? A case of Homa Lagoon, Aegean Sea, Turkey

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Keywords
Fisheries management
Lagoon fisheries
Brush park fisheries
Fish attractive devices (FADs)

ABSTRACT

This study aimed to investigate the species aggregating performance of brush parks in Homa Lagoon, Aegean Sea, Turkey. The study was conducted in 100 m^2 area between June 2004 and January 2005 in Homa Lagoon. Alternative fishing gears (produced from Polyvinyl chloride (PVC) and sacks filled with bush bundles) were investigated for the first time by the present study besides commonly used fishing gears (fyke net, basket trap, and circled lift net) in traditional fisheries in lagoon systems in Turkey. The species composition was determined for each fishing gears for brush park fisheries. A total of 1855 individuals were caught and the highest yield was obtained from the basket traps (1018 individuals) followed by the sacks filled with bush bundles traps (324 individuals), PVC materials (313 individuals), and the circled lift nets (200 individuals). This study revealed that brush park fisheries can attract the species in lagoon systems. Therefore, socioeconomic assessment and appropriate fisheries management approaches for brush park fisheries and lagoon fisheries should be carried out and applied for sustainable use of fisheries resources in lagoon systems.

Introduction

Fish aggregating (or attracting) devices (FADs) as the form of man-made floating objects have been used worldwide by commercial, artisanal and recreational fishers for catching mainly pelagic fish species (Dempster and Taquet, 2004). FADs increase the catchability of fish species with regard to free swimming fish species (Guillotreaua et al., 2011). Moreover, they increase recruitment, sustainability and habitat of fish species (Kingsford, 1999). Brush park is a kind of FADs which make possible the aggregation and attraction of fish. Brush parks are underwater constructions made up of wooden materials that are usually fixed to the bottom of a shallow water body (COFAD, 2002). Brush parks provide substrate for the growth of periphyton and suitable habitats and shelter areas for several fish species. Therefore, brush parks have high level of nutrients (Welcomme, 2005). They also significantly increase the efficacy of fishing operations (Béné and Obirih-Opareh, 2009). Brush parks are commonly used in western part of Africa (Benin, Ghana, Ivory Coast, Nigeria, and Togo) where they are known as acadjas (Lalèyè, 2000), samrah in Cambodia (Ho, 1999), and katha in Bangladesh (Ahmed and Akther, 2008; Uddin et al., 2015).

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Homa Lagoon is one of the most significant lagoons in the coasts of Aegean Sea of Turkey and it is a biodiversity hotspot (Çolak-Sabancı, 2012). Homa Lagoon was included within the list of wetlands of international importance (Ramsar Site) in Gediz Delta Ramsar Site. Homa Lagoon serves as a natural habitat and provides living space, protection from predators for many aquatic species that have high economic value and more than 200 bird species (Acarlı, 2007). Fish and birds prefer these areas for breeding, feeding, living, nursery, and growth (Alpbaz, 1990; Akyol, 1999; Elbek et al., 2003; Deveciyan, 2006; Acarlı, 2007).

Some studies have been carried out in Homa Lagoon. These studies include different aspects, for instance, limnologic characteristics such as physicochemical characteristics (Ünsal et al., 2000), zooplankton (Pulat and Özel, 2003), algology (Çolak Sabancı and Koray, 2010; Çolak Sabancı et al., 2011; Çolak Sabancı, 2012), growth and survival rates of *Tapes decussatus* (Serdar et al., 2007) *Anadara inaequivalvis* (Acarlı et al., 2012), *Ostrea edulis* (Lok et al., 2005), reproductive activity of *O. edulis* (Acarlı et al., 2015), catch efficiency and catch composition of species (Acarlı et al., 2009), length-weight relationships of fish species (Acarlı et al., 2014) of Homa Lagoon. Heavy metal and pesticide concentrations in fish, molluscs, polychaete species were also studied by some authors (Atılgan and Egemen, 2001; Taş et al., 2009; Bilgin and Uluturhan Suzer, 2015, 2017; Sevgi and Uluturhan Suzer, 2019; Uluturhan et al., 2019). Moreover, fisheries management (Tosunoğlu and Ünal, 2012; Tosunoğlu et al., 2013) and some socioeconomic aspects of fisheries in Homa Lagoon were examined (Köken et al., 2019).

Traditional fishing gears such as fences trap, trammel net, veranda net, and fyke net are commonly used in Homa Lagoon where the most caught species have been Mugilid species including *Mugil cephalus, Liza saliens, Liza ramada, Liza aurata, Chelon labrosus*. Apart from these species, fishing efforts are also performing for *Sparus aurata, Dicentrarchus labrax, Solea solea,* and *Anguilla anguilla* species.

Several fishing gears are used in the lagoon fisheries. However, there is no study on the assessment of fish aggregating performance of brush parks in Homa Lagoon. In addition, there is a lack of information on the utilization of polyvinyl chloride (PVC) pipe materials as alternative fishing gears for brush park fisheries in Homa Lagoon. Therefore, the aim of this study was to investigate the species aggregating potential of brush parks in Homa Lagoon. PVC pipe materials and sacks filled with bush bundles were used for the first time as fishing gears in the present study.

Material and Methods

Homa Lagoon (Figure 1) covers 1852 ha area (Acarlı, 2007) and maximum depth of the lagoon is 1.8 m while average depth ranges between 0.5 m and 1.0 m (Acarlı, 2007). The study area is an active lagoon and spawning season for fish species is between June and October in this lagoon (Acarlı, 2007). At the end of the spawning period, fence traps are closed and fish are introduced into the lagoon voluntarily but prevented from leaving. In autumn season, high salinity is observed due to rainfall and evaporation (Çolak Sabancı, 2012).

Figure 1. The location of the study area in Homa Lagoon

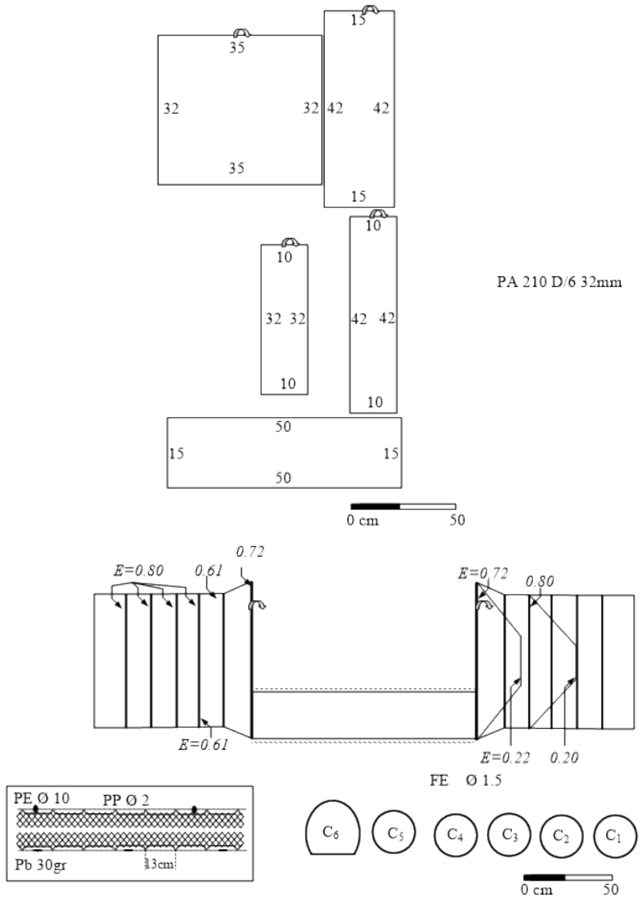

Figure 2. Technical measurements and characteristics of fyke nets (modified from Acarli, 2007)

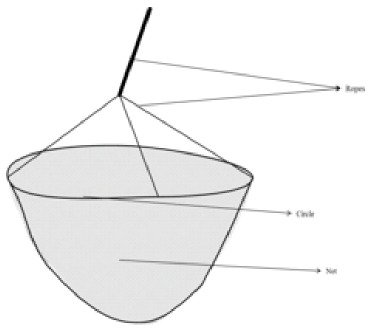

Figure 3. Circled lift nets (modified from Acarlı, 2007)

Brush parks were established on 100 m^2 area in the Homa Lagoon. Piles having 10m×10m and 8m×8m were fixed in the lagoon. FAO (2007) reported that many species live around these traps. Similarly, several authors also documented that these traps attracted animals (Buffe, 1958; Costa and Wijeyaratne, 1994; Welcomme, 2002). Hence, fyke nets, basket traps and polyvinyl chloride (PVC) materials were used and placed around brush parks. Two types of PVC materials were investigated in the study. The first one had 100 cm length and 8 cm diameter (named as PVC 100) while the other one had 300 cm length and 11 cm diameter (named as PVC 300). One of the entries of PVC materials was covered by nets. In addition, PVC materials were interconnected with each other by No.5 surface rope such as longline. The technical measurements and characteristics of fyke nets are given in Figure 2 while the characteristics of basket traps are presented in Table 1. Four different basket traps models were used in the study. The model#1 had blue colour and foldable characteristic in the shape of rectangular prism while model#2 was circle and foldable. The model#3 and model#4 had circular shape whereas the length of the model#3 was higher than model#4. The characteristics of basket traps are also summarized in Table 1. The sacks filled with bush bundles were used for the first time by the present study to investigate the fish attracting performance in the lagoon systems. The circled lift nets were placed around the brush parks. European pilchard (*Sardina pilchardus*) and the Mediterranean mussel (*Mytilus galloprovincialis*) were used as baits for the circled lift nets. The diameter was 50 cm and mesh size was 12 mm (210D/18N) for the circle of the lift net (Figure 3).

Results

Four different fishing traps were placed around the brush parks and 1855 individuals were caught by brush park fisheries. The highest yield was obtained with the model#1 basket trap. The most caught species was *Carcinus aestuarii* (741 individuals). In addition, 157 gastropod individuals (belonging to

15 different species including *Cerithium vulgatum, Nassarius incrassatus, Turritella communis, Epitonium commune, Osilinus sp., Pirenella conica, Nassarius mutabilis, Nassarius pygmaeus, Gibbula albida, Nassarius reticulatus, Bittium reticulatum, Gibbula adensonii adensonii, Cyclope neritea, Bolinus brandaris, Hexaplex trunculus*; Crustacean species *Paguristes syrtensis, Paguristes eremita, Diogenes pugilator, Pagurus forbesi, Pagurus cuanensis*), 107 *Palaemon sp. (P. serratus, P. adspersus, P. elegans)* specimens, 7 *Gobius niger*, 5 *Sepia officinalis,* 1 *Eriphia vericosa*, 1 *Solea solea* were captured by the traps. It was observed that model#2 basket trap caught mostly Solea solea while model#4 basket trap caught Sepia officinalis whereas model#1 basket trap intensely caught Carcinus aestuarii.

Table 1. The characteristics of the basket traps used in the study

Traps	Height (cm)	Width (cm)	Length (cm)	Entry Diameter (cm)
Model#1	65	36	116	7
Model#2	40	70	193	10
Model#3	30	70	225	15
Model#4	25	55	169	11

PVC materials caught 313 individuals belonging to 21 different species. PVC 100 aggregated *Palaemon sp.* (71 specimens), gastropods (63 specimens), *Carcinus aesturaii* (32 specimens), and *G. niger* while PVC 300 intensely collected *Palaemon sp.* (119 specimens) beside gastropods (15 specimens), *C. aestuarii* (2 specimens), *Blennius ocellaris* (7 specimens) and *G. niger* (2 specimens).

The sacks filled with bush bundle traps attracted commonly *Palaemon sp.* (324 individuals) in addition to Crustacean species *C. aestuarii* (87 individuals).

The circled lift nets were used for the first time in Homa Lagoon in the present study and they caught 200 individuals belong to 20 different species including gastropods (186 individuals from 15 different species), *Palaemon sp.* (11 individuals) and *Zosterisessor ophiocephalus* (2 individuals) and *G. niger* (1 individual).

Discussion

The lagoon fishery production have several activities: traditional fishing on lagoon canals and water areas, valley fishing; farm fishing (aquaculture) mussel farming and clam fishing (Rosetto, 2001). Brush parks in lagoon systems can improve fisheries production considerably although their small areas compared with the total surface areas of water bodies where they are hosted (Béné and Obirih-Opareh, 2009). Sugunan et al. (2007) indicated that well-managed brush parks can even be equivalent to intensive or semi-intensive aquaculture operations with regard to annual per-unit-area harvesting rates. Therefore, brush park fisheries can considerably contribute to the increase of water productivity.

Welcomme (2002) indicated that the detrimental or beneficial status of brush parks for natural fish stocks depends to a great range on the ecology of the fish species existing in the water body. Some fish species are attracted for their shelter and food needs while others for reproduction (Anis et al., 2015). If brush parks were used by fish species for breeding, they could serve as a shelter for young fish species and improve the growth and survival of the species. Thus, brush parks have a positive impact on the growth and survival rate of the natural fish stocks. Furthermore, opportunistic predators are attracted to brush parks as stated by Malone et al. (2011). Gammanpila et al. (2017) have revealed that ecomorphology of the fish species in the brush parks is associated with diet. Knowledge on feeding ecology of the fish species in a fish assemblage makes the understanding of trophic interactions possible (Gammanpila et al., 2019a). The understanding of these interactions has a great importance for fisheries managers to decide on ecosystem based management (Pikitch et al., 2004).

In Turkey, lagoon fishermen have been using fishing materials and methods such as trammel nets, fyke nets, longlines, nets (seine or etc.) and fences since many years (Deveciyan, 2006). The fences traps (“kuzuluk” in Turkish) are the most basic fishing gear types for the whole operational lagoons in the coasts of Aegean Sea (Kaykaç and Tosunoğlu, 2015). On the other hand, despite brush parks were used in numerous countries such as Bangladesh (Kapetsky, 1979; Wahab and Kibria, 1994; Ahmed and Hambrey, 1999; Ahmed and Akther, 2008; Uddin et al., 2014, 2015), Benin (Buffe, 1958; Lalèyè 2000; Niyonkuru and Lalèyè 2010), Cambodia (Fily, 1966; Ho, 1999; Lamberts, 2001; Baran, 2005), Cameroon (Stauch, 1966, 1976), China and Mexico (FAO, 1962), Egypt (Ben-Tuvia, 1979), Ghana (Mensah, 1979; Béné and Obirih-Opareh, 2009), India (Mann and Aftabuddin, 2009), Madagascar (Kiener, 1960), Nigeria (Kapetsky, 1981), Sri Lanka (Senanayake, 1981; Costa and Wijeyaratne, 1995; Amarasinghe et al., 2002; Rupasinghe and Asanthi, 2007; Anis et al., 2015; Gammanpila et al., 2016a, 2016b, 2019a, 2019b), and Togo (Welcomme, 1971; Everett, 1976), they were used for the first time in Turkey in this present study. Therefore, this paper provides the first findings for the species aggregating performance of brush parks in lagoon systems in Turkey.

An investigation of brush park fishing in Lagos lagoon of Nigeria has been carried out by Solarin and Udolisa (1993). Positive correlations were found between the fish caught in the brush park and the period of establishment (Solarin, 1998) and between the fish and density of establishment (Solarin and Kusemiju, 2003). Abdul et al. (2004) reported that brush park fisheries presented a respectable catch to the fisherman in Iwopin Lagoon area, Nigeria. In addition, brush park fishing was found profitable and it had supported to development of fisheries and had reduced the poverty among the Nigerian rural inhabitants. Gammanpila et al. (2016b) reported that the optimal time period for fishing was about 30 days after the establishment to reach maximum yield in brush park fisheries.

Atar et al. (2002) have investigated the catching efficiency and catch rates of three different traps in Beymelek Lagoon of Turkey. They reported that traps were particularly effective in crustacean fisheries and that the most caught species was Carcinus aestuarii. In addition, they documented that Lyngbya majuscuta, blue-green algae, caused the closure of traps and circled lift net meshes. Thus, it allows the intensive fishing of crustacean and gastropod species. The results of the present study are similar to the findings of Atar et al. (2002).

Different species have been observed around the brush parks. The adherence of macroalgae to the piles by the currents might be possible providing a feeding and sheltering area for species. Hence, animals were attracted to the piles. Moreover, thigmotropism behaviour of animals (the attraction of animals to a solid object) was efficiently and effectively monitored in brush park fisheries. Therefore, fish behaviour mechanisms should also be investigated for species observed in lagoon system in future researches.

Brush parks have been accepted to be a comparatively effective fishing method to improve the productivity of fisheries. They could efficiently contribute to the improved food productivity in the rural areas where they are established. Thus, brush parks can play an important role in fisheries productivity ensuring the food availability, rural development, and poverty alleviation.

An appropriate management of brush park fisheries can be used as a potential tool to ensure the sustainability of fisheries resources in lagoon systems. Establishment of brush parks may possibly help to develop biodiversity and habitats in Homa Lagoon. Fish population can get benefits of food and shelter in the brush parks throughout the dry season. Furthermore, the fish population can gain sexual maturity for spawning in the next breeding season which is clearly vital for the sustainability of fisheries resources to the next generations.

Conclusion

The present study revealed that brush park can aggregate and attract species in lagoon systems. Brush park fisheries contribute to sustainable fisheries and ecosystem approach to fisheries management by using less harmful fishing gears for habitat and fish stock.

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Research Article

Distribution on the nets of bycatch fishes caught by multifilament and monofilament trammel nets

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ABSTRACT

In this study, the distribution on the nets of by-catch fish species caught by the trammel nets was determined between 01 January 2002 and 31 December 2002 in the Sinop province shores of Black Sea. Nets have multifilament (Fml) and monofilament (Fmn) material with inner mesh size of 36 mm and outer mesh size of 200 mm, were used in the study. The number (7 meshes) of the outer at the height of the net for vertical position of fish was considered. Buoyancy rope of equipped net was divided 10 equal parts for horizontal position. A total of 286 by-catch fish (*Scorpeana porcus, Gaidropsarus mediterraneus, Solea spp., Gobius spp.* and *Labrus spp.,* species) were caught in the study. Fml and Fmn were captured 188 and 98 specimens, respectively. For both nets, the fishes showed capture distribution in the bottom parts (1 and 2 no outer net) 76.1% and 77.6% respectively. Fishes with demersal characteristics lower were caught in the middle (3, 4 and 5 no outer net) and upper parts (6 and 7 no outer net) of the nets. It is thought that the results may contribute to the modification and improvement studies in the reduction of none target species in and achieving species selectivity in the trammel net fisheries.

Keywords
Trammel net
By-catch species
Fish distribution
Black Sea

Multifilament ve monofilament fanyalı uzatma ağları ile avlanan hedef dışı balıkların ağlar üzerindeki dağılımları

ÖZET

Bu araştırmada Karadeniz'in Sinop kıyılarında 1 Ocak 2002 ve 31 Aralık 2002 tarihleri arasında fanyalı uzatma ağları ile avlanan hedef dışı balık türlerinin ağlar üzerindeki dağılımları tespit edilmiştir. Çalışmada multifilament (Fml) ve monofilament (Fmn) materyale sahip, tor ağ göz açıklığı 36 mm, fanya göz açıklığı 200 mm olan uzatma ağları kullanılmıştır. Balıkların dikey yöndeki konum tespiti için yükseklikteki fanya göz sayısı (7 göz), dikkate alınmıştır. Yatay yöndeki konum için donatılmış ağın mantar yakası 10 eşit parçaya ayrılarak işaretleme yapılmıştır. Araştırmada toplam 286 adet hedef dışı balık (*Scorpeana porcus, Gaidropsarus mediterraneus, Solea spp., Gobius spp.* ve *Labrus spp.*) yakalanmıştır. Balıkların 188 adeti Fml ağ ile 98 adedi ise Fmn ağ ile avlanmıştır. Her iki ağda balıklar %76,1 ve %77,6'lık oranlarla en fazla alt kısımlarda (1 ve 2. Fanya) yakalanma dağılımı göstermiştir. Demersal özellik gösteren bu balıkların orta (3, 4 ve 5. Fanya) ve üst bölümlerde (6 ve 7. Fanya) daha az yakalandığı belirlenmiştir. Sonuçları, fanyalı uzatma ağlarında hedef dışı türlerin avcılığının azaltılması ve tür seçiciliği için modifiye ve iyileştirme çalışmalarına katkı sağlayabileceği düşünülmektedir.

Anahtar Kelimeler
Fanyalı uzatma ağı
Hedef dışı türler
Balık dağılımı
Karadeniz

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Giriş

Dünyada su ürünleri avcılığı avlama, yakalama ve toplama, olmak üzere üç farklı yöntemle kıyı balıkçılığı (küçük ölçekli) ve endüstriyel balıkçılık (büyük ölçekli) faaliyetleri ile sürdürülmektedir. Avlanılacak türlerin sürü yapısı, yaşam ve yüzme özellikleri dikkate alınarak bu avcılık modellerinden biri seçilmektedir. Bu yöntemlerde kullanılan av araçları aktif ve pasif olarak iki ana gruba ayrılmaktadır (Sainsbury, 1996). Sabit av araçları pasif av araçları olup belirli bir bölgeye batırıcı ve yüzdürücüler yardımıyla sabitlenerek su ürününün av aracına doğru yaklaşması ve temasa girmesi yoluyla avlanmanın gerçekleştiği av araçlarıdır. (Bjordal, 2002).

Uzatma ağları ülkemiz kıyı balıkçığında kullanılan çok türe dayalı avcılık yapılabilen en önemli pasif av araçlarıdır. Uzatma ağları yapı olarak sade ve fanyalı olmak üzere iki ana grupta toplanmaktadırlar. Uzatma ağlarında tor ağ olarak monofilament ve multifilament materyaller kullanılmaktadır Uzatma ağlarının av verimi ve av kompozisyonu av aracının yapısal ve materyal özelliklerine göre değişiklik göstermektedir (Özdemir ve Erdem, 2006). Uzatma ağlarıyla demersal balıklar yanında pelajik ve semi-pelajik birçok türün avcılığı da yapılabilmektedir (Sainsbury, 1996; Kara ve Özekinci, 2002).

Su ürünleri avcılığında kullanılan tüm av araçlarında olduğu gibi uzatma ağlarındaki en önemli problemlerden biri hedef türlerin avcılığını artırırken hedef dışı türlerin avcılığının azaltılarak tür seçiciliğinin sağlanabilmesidir (Hamley, 1980; Özdemir ve ark., 2003). Hedef dışı türler ağlarda saturasyona sebep olurken ağın yapısını bozmakta ve av etkinliğini azaltmaktadır (Dickson, 1989). Ayrıca avcılık sonrası balıkçılar için iş gücü ve zaman kayıplarına neden olmaktadır. Karadeniz'de uzatma ağları ile hedef tür olarak barbunya, mezgit, istavrit, lüfer, tirsi balıkları avlanırken, hedef dışı tür olarak yakalanan iskorpit, gelincik balığı, kaya balıkları, küçük dil balıkları ve lapin balıkları avcılık üzerinde olumsuz etkiler yapmaktadır (Özdemir ve ark., 2003). Bir diğer sorun ise yengeç ve deniz salyangozu türlerinin ağa yakalanan balıklarla beslenmek üzere ağa yaklaşmaları ve yakalanmalarıdır. Yakalanan bu hedef dışı türler hedef balık türlerinin kalitesini bozarken ağın materyalini de zarar vermektedirler (Aksu, 2006; Özdemir ve Erdem, 2007a; Özdemir ve ark., 2017).

Seçiciliğin sağlanmasında kullanılan uzatma ağlarının yapısal özellikleri yanında, materyali, ağ göz açıklığı, donam faktörü, göz açıklığı, rengi gibi faktörler etkili olabilmektedir (Angelsen ve Olsen, 1987; Stewart, 1987; Holst ve ark., 2002). Pasif ve aktif olarak kullanılan av araçlarının asıl yapısını bozmadan, av aracı üzerine bazı yapıların eklenmesi ve modifikasyonlarla seçiciliğin sağlanabileceği belirtilmektedir (Aydın ve ark., 2001; Madsen ve Holst, 2002, GodØy ve ark., 2003; Aksu, 2006; Tokaç ve ark., 2010; Özbilgin ve ark., 2012; Ceylan ve Şahin, 2019).

Son yıllarda norsel ve sardon gibi özel yapıların uzatma ağlarında kullanılması ile bazı hedef dışı türlerin avcılığının azaltılabileceği tespit edilmiştir. Özellikle uzatma ağlarında norsel kullanımında yengeç türlerinin, sardon kullanımı ile hedef dışı balık türlerinin av miktarında azalmalar gözlenmiştir (GodØy ve ark., 2003; Gökçe, 2004; Aksu, 2006).

Bu araştırmada Karadeniz kıyı balıkçılığının önemli av araçlarından biri olan fanyalı uzatma ağlarına hedef balık türleri (barbunya, mezgit, istavrit, lüfer) ile birlikte hedef dışı olarak yakalanan balık türlerinin ağ üzerindeki yakalanma dağılımları tespit edilmiş ve konumları belirlenmiştir. Türlerin ağ üzerindeki dağılımları dikkate alınarak, sonuçların av aracı modifikasyonu ve tür seçiciliğinin sağlanması için kullanılabilirliği tartışılmıştır.

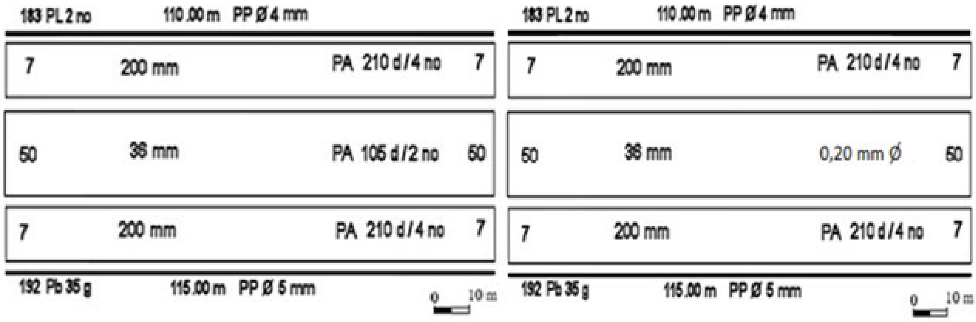
Materyal ve Yöntem

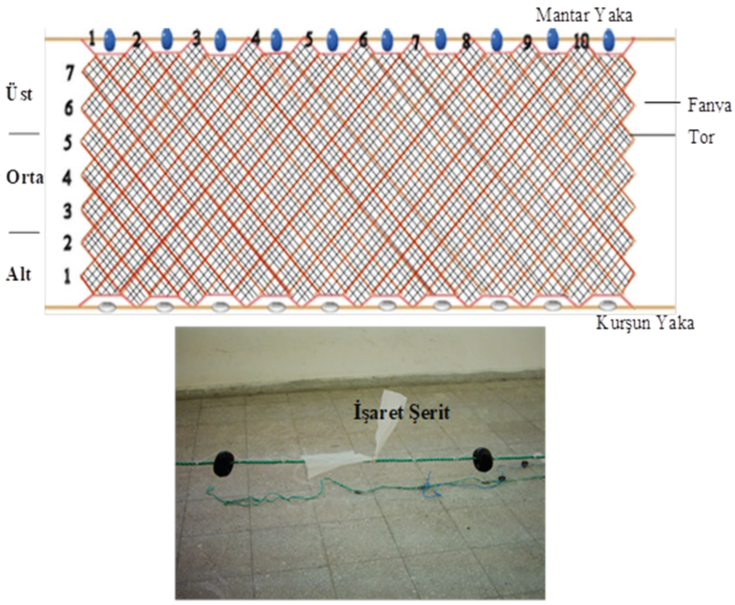
Araştırma Karadeniz'in Sinop kıyılarında 1 Ocak 2002 ve 31 Aralık 2002 tarihleri arasında yürütülmüştür. Kullanılan ağlar 0,20 mm Ø tek katlı monofilament (Fmn) ve 105D/2 no bükümlü ip multifilament (Fml) olmak üzere iki farklı materyale sahiptir. Ağların tor ağı 36 mm ve fanya ağı 200 mm göz açıklığında olup yüksekliği 7 göz derinliktedir. Fanya ağında donam faktörü (E) 0,70, F/tor oranı 3/4, tor ağ kısmının donam faktörü ise (E) 0,55 tir (Şekil 1). Denemelerde 3 adet multifilament ve 3 adet monofilament olmak üzere toplam 6 posta ağ kullanılmıştır.

Balıkların dikey yöndeki konum tespiti için yükseklikteki fanya göz sayısı (7 göz), dikkate alınmıştır. Yatay yöndeki konum için donatılmış ağın mantar yakası 10 eşit parçaya ayrılarak işaretleme yapılmıştır. Böylece ağ üzerinde X (fanya gözü no) ve Y (yatay bölme no) koordinatlarına sahip bir düzlem elde edilmiştir (Şekil 2).

Ağlar denize genellikle akşam gün batarken atılıp sabahın erken saatinde gün doğarken toplanmıştır. Yakalanan balıklar ağdan alınırken, her bir tür dikey konum için hangi fanyada, yatay yönde ağın hangi bölümünde yakalandı ise kayıt edilmiştir. Alınan veriler bilgisayarda Microsoft Excel 2013 programında değerlendirilerek, her tür ağların X ve Y koordinat sistemi üzerine işaretlenmiştir. Ayrıca

Şekil 1. Araştırmada kullanılan fanyalı uzatma ağının teknik özellikleri





Şekil 2. Ağların dikey ve yatay yönde bölümlerine ayrılması

verilerin Minitab 17 programında istatistiksel analizleri yapılmıştır.

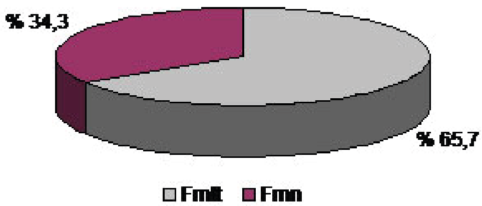
Bulgular

Araştırmada kullanılan fanyalı uzatma ağları ile iskorpit (*Scorpaena porcus*, L. 1758), gelincik (*Gaidropsarus mediterraneus*, L. 1758), kaya balıkları (*Gobius spp.*), dil balıkları (*Solea spp.*) ve Lapin balıkları (*Labrus spp.*) olmak üzere 5 hedef dışı balık türü yakalanmıştır. Türlerin toplam av miktarı 286 adettir. Balıkların %65,7 (188 adet) multifilament, %34,3 (98 adet) monofilament ağlarla avlanmıştır. Hedef dışı türlerin multifilament ağlara monofilament ağlardan 2 kat daha fazla orandan yakalandığı tespit edilmiştir (Şekil 3).

Hedef dışı tür olarak en fazla yakalanan tür 113 adet ile iskorpit balığı olmuştur. Gelincik balığı 92 adet ile ikinci sırada yer alırken ağlara 26 adet ile en az yakalanan tür dil balığıdır. Gelincik ve lapina türlerinin her iki ağa yakalanma oranın yakın olduğu görülürken, Fml ağa, Fmn ağa oranla iskorpit balığının 2,5 kat, dil balığının 12 kat ve kaya balığının 2 kat daha fazla yakalandığı tespit edilmiştir. Türlerin ağ tipine göre yakalanma miktarları ve oranları Tablo 1 de verilmiştir.

Her iki ağ ile yakalanan 286 balığın 219 adetinin 1. ve 2. Fanya bölümünden oluşturan alt kısma, 55 adetinin 3. 4. ve 5. Fanya bölümünden oluşan orta kısma 12 adetinin ise 6. ve 7. Fanya bölümünden oluşan üst kısımda dağılım gösterdiği belirlenmiştir.

Ağların materyaline göre balıkların dağılımı Fml ağın ve Fmn ağın alt bölümde 143:76, orta bölümde 36:19, üst bölümde 9:3 adet olarak tespit



Şekil 3. Ağ materyaline göre balıkların yakalanma oranları

Türler	Ağlar				Toplam	
	FML		FMN			
	N	%	N	%	N	%
İskorpit	81	71,7	32	28,3	113	39,6
Gelincik	49	53,3	43	46,7	92	32,2
Kaya Balıkları	19	67,9	9	32,1	28	9,8
Lapin Balıkları	15	55,6	12	44,4	27	9,5
Dil Balığı	24	92,3	2	7,7	26	9,1
Toplam	**188**	**65,7**	**98**	**34,3**	**286**	**100**

Tablo 1. Yakalanan balıkların ağ tipine göre av miktarı ve oranları

edilmiştir. Fml ve Fmn ağların fanya bölümleri dikkate alınarak yapılan varyans analizi sonucunda balıkların yakalanma miktarları arasında gözlenen farkın istatistiksel olarak önemli ($p<0.05$) olduğu tespit edilmiştir (Tablo 2).

Tartışma

Araştırmada bölgede fanyalı uzatma ağlarının hedef türü olmayan 5 türden 286 adet balık yakalanmıştır. Balıkların %65,7 oranla multifilament ağlara daha fazla yakalandığı, monofilament ağlara %34,3 oranla daha az yakalandığı görülmektedir. Özdemir ve ark. (2017) aynı bölgede multifilament fanyalı ağlarla yaptıkları çalışmada hedef dışı balıkların (%83,65) ve yengeçlerin (%16,35) av oranının hedef türlerden (barbunya ve mezgit) daha yüksek olduğunu belirtmektedir.

Aksu (2016) multifilament uzatma ağlarının av veriminin monofilament ağlardan daha düşük olduğunu ancak hedef dışı türlerin av miktarına göre tersi bir durum oluştuğunu ifade etmektedir. Sümer (2003) uzatma ağlarının av verimi ve seçiciliğinin ağ materyaline göre değişim gösterdiğini monofilament ağların multifilament ağlara göre daha avantajlı olduğunu bildirmektedir. Uzatma ağlarına yakalanan hedef dışı türlerin ağ üzerindeki birçok olumsuz etkisi nedeni ile materyal seçiminin önemi dikkati çekmektedir. Monofilament ağların düşük hedef dışı av (by-catch) oranı, hedef türleri avlama etkinliği ve seçicilik gücü, monofilament ağlardan yüksek olduğu bir çok araştırmada ortaya konulmuştur (Potter ve Pawson, 1991; Gurbet ve ark., 1998; Balık, 2001; Faife 2003; Sümer ve ark., 2010).

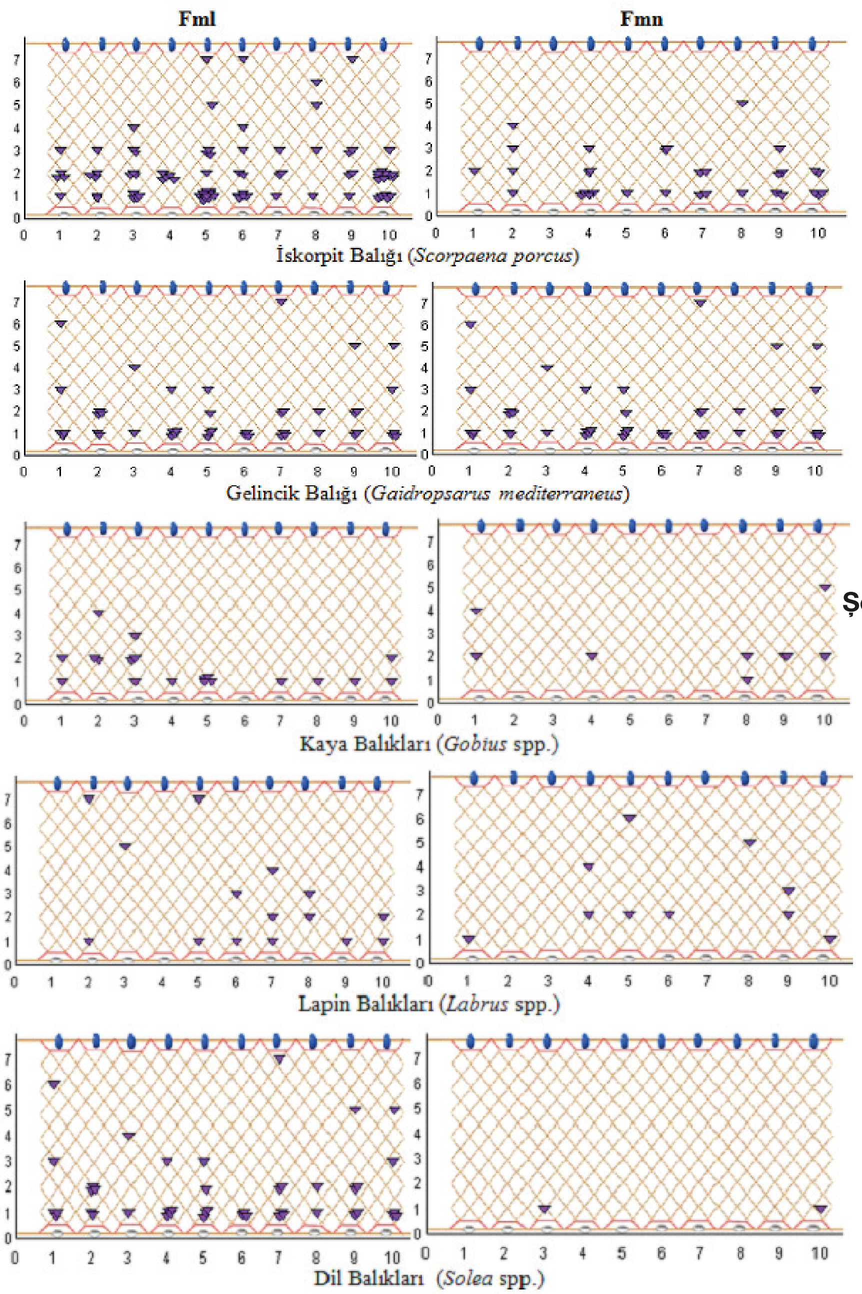
Lamberts (2001), de farklı göz açıklıklarına sahip multifilament uzatma ağları ile yaptığı araştırmada ağı yüzey paneli, dip paneli ve orta kısım olmak üzere 3 bölüme ayırmıştır. Toplam 46 türün yakalandığı denemelerde farklı türlerin farklı bölgelere yakalandığını tespit etmiştir. Türlerin 26'sının orta kısımda, 18 türün üst kısımda, 2 türün ise dip kısımda dağılım gösterdiği belirlenmiştir.

Özdemir ve Erdem (2007a) aynı özelliklerdeki ağların hedef türlerinden istavrit, barbunya ve mezgit balıklarının ağ üzerindeki yakalanma dağılımlarını incelemiştir. Barbunya balığının ağın alt bölümünde yoğun yakalandığı, mezgit balığının orta kısmında, istavrit balıklarının orta ve üst bölümlerinde daha fazla yakalanma dağılımı gösterdiğini belirlemişlerdir. Araştırmada türlerin

	Fml						Fmn					
	Alt[a]		Orta[b]		Üst[c]		Alt[a]		Orta[b]		Üst[c]	
	Fanya 1-2		Fanya 3-4-5		Fanya 6-7		Fanya 1-2		Fanya 3-4-5		Fanya 6-7	
Türler	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
İskorpit	60	74,1	17	21	4	4,9	25	78,2	7	21,8	-	-
Gelincik	37	75,5	9	18,4	3	6,1	34	79,1	7	16,3	2	2
Dil Balığı	20	83,3	4	16,7	-	-	2	100	-	-	-	-
Kaya Balığı	17	89,5	2	10,5	-	-	7	77,8	2	22,2	-	-
Lapin	9	60	4	26,7	2	13,3	8	66,7	3	25	1	8,3
Toplam	**143**	**76,1**	**36**	**19,1**	**9**	**4,8**	**76**	**77,6**	**19**	**19,4**	**3**	**3**

Tablo 2. Ağların bölümlerine göre balıkların yakalanma miktarları

(a,b,c): Farklı harflerle gösterilen gruplar arasındaki farklar önemlidir ($p<0.05$)



Şekil 4. Balıkların ağlar üzerindeki yakalanma konumları ve dağılımları

yaşam ve yüzme özelliklerine uygun bir dağılım gösterdiği tespit edilmiştir.

Kara ve ark. (1994), fanyalı uzatma ağlarını üç bölüme ayırarak ısparoz balığının ağın hangi bölümüne daha fazla yakalandığını tespit etmişlerdir. Günün zamanına göre türün ağ üzerinde yakalandığı bölümün değiştiği belirlenmiştir. Balıkların ağ yüzeyindeki dağılımlarının gece vakti % 65 lik oranda ağın alt bölümlerinde, sabah tan vaktinde %57'lik oranda orta bölümlerinde, gündüz ise %42'lik oranla orta bölümlerde olduğu saptanmıştır.

Demersal özellikteki iskorpit ve dil balıklarının birkaç tanesinin ağın üst kısmındaki fanya gözlerine yakalanması ağın akıntı ve su hareketleri nedeniyle yükseklik kaybetmesi ya da deniz dibine yatması nedeniyle balıkların ağ ile temasa girmesi neticesinde yakalanma olasılığını güçlendirmektedir (Şekil 4).

Stewart (1987), akıntı, rüzgar ve su hareketlerinin uzatma ağlarının yüksekliklerini etkilediğini gözlemlemiştir. Akıntılı sulara bırakılan 3,2 metre yüksekliğindeki bir uzatma ağının 1 metreden daha az yüksekliğe ulaştığını, mezgit balıklarının büyük çoğunluğunun uzatma ağının kurşun yaka bölümünde yakalandığını tespit etmiştir.

Özdemir ve Erdem (2007b), farklı rüzgar durumlarında kullanılan monofilament ve multifilament fanyalı uzatma ağlarının hedef ve hedef dışı türlerin av miktarlarının rüzgar durumuna göre değişiklik gösterdiğini saptamışlardır.

Özdemir ve ark. (2017) fanyalı uzatma ağlarına by-catch olarak yakalanan yengeçlerin tür çeşitliliği av miktarının ağların kullanıldığı derinlik ve mevsime göre büyük değişim gösterdiğini ve bu kriterlerin by-catch oranının azaltılmasında önemli bir faktör olarak dikkate alınması gerektiğini belirtmektedir.

Yapılan araştırmada demersal özellik gösteren iskorpit, gelincik, kaya balığı, lapin ve dil balıklarının her iki ağ tipi ile ağın alt bölümlerinde (Fanya 1-2) daha fazla dağılım gösterdiği, tespit edilmiştir. Özellikle iskorpit, gelincik ve dil balıklarında bu dağılım çok daha belirgin görülmektedir. Ayrıca dil balığının monofilament ağ ile çok az miktarda yakalanmış olması dikkat çekicidir (Şekil 4). Çok katlı bükümden oluşan multifilament ağların özellikle yoğun dikenli vücut formu ile iskorpit balığının takılma, tutunma ve sıkışma sonucunda tek katlı monofilament ağlara oranla avlanma olasılığını artırdığı söylenebilir.

Sonuç

Sonuç olarak, araştırmada Karadeniz'in Sinop kıyılarında kullanılan fanyalı uzatma ağları ile hedef türler dışında avlanan hedef dışı balıkların ağ üzerindeki yakalanma konumları tespit edilmiştir. Türlerin vücut şekli, yüzme ve yaşam özelliklerine bağlı olarak ağ ile etkileşim ve yakalanma özellikleri ortaya çıkarılmaya çalışılmıştır.

Birçok iç ve dış faktörden etkilenen balıklar av aracı ile karşılaştıklarında farklı davranışlar sergileyebilirler. Bu nedenle balık avcılığında kullanılacak ağların tüm özellikleri dikkate alınarak seçim yapılmalıdır. Ayrıca hedef türlerin avcılığını etkilemeyecek şekilde by-catch oranının düşürülmesi için ağlarda yapılacak iyileştirme ve modifikasyon (alt yakada geniş gözlü sardon ağı donamı, alt yakaya branda eklenmesi, ağ ile kurşun yaka arasına uygun boyutlarda tel, plastik, ahşap çubuklar veya halat donatılması) çalışmalarında bu sonuçların kullanılması faydalı olacaktır.

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The capacity analysis of aquaculture production facilities from the Mediterranean region of Turkey

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ABSTRACT

The Mediterranean Region of Turkey covers 17 % of the total number of aquaculture facilities and has only 8.5% total production capacity of the country. Considering the long coastline of Turkey in the Mediterranean, it can be said that this production figure is very low. In this study, therefore, fish production facilities in the Mediterranean Region of Turkey were analyzed and a decision support system was developed for the competent authorities and investors for future planning and investment activities. For these purposes, the production capacity statistics of the facilities for the year 2019 were taken into consideration. The random tree algorithm, which is one of the data mining methods, was used in data analysis and to set a decision support system. In the region, there is a total of 342 facilities engaged in aquaculture production in cages (31.28%), concrete ponds (60.81%), earth pools (5%), pond area (1.46%), closed-circuit (0.29%), and tanks (0.88%). It is seen that trout facilities constitute 87.42% and 59.66% of these facilities in number and capacity, respectively. The sea bream and sea bass facilities contribute to this capacity with 30.99 %. It was observed that the most concrete pond in the region was in Antalya province and the most cage was in Isparta province. All of the facilities that make production in concrete ponds are trout and 66.45% of these facilities are below 23 thousand kg of production capacity. They are 7 trout and 2 sea bream soil pond facilities having production capacity between 8750 kg and 140 thousand kg, and 2 African catfish,1 aquarium and 1 sea bass soil pond facilities having production capacity between 140 -350 thousand kg in the region. The production capacity of one of the trout facilities producing in pond areas is 24 thousand kg less and the other one is between 36 thousand tons and 59 thousand tons. It is seen that the capacity of 2 carp facilities producing in the pond area is between 24 thousand and 36 thousand kg and the capacity of 1 aquarium fish production is more than 59 thousand tons. Trout, catfish, sea bream and sea bass are produced in cages in the region. Of the 85 plants with a capacity of less than 550,000 kg, the rest of the plants producing trusses in trusses produce trout, except for one (catfish production). Trout are produced in all 6 facilities between 675 thousand kg and 925 thousand kg in cages. Sea bream and sea bass production are carried out in 3 plants with a capacity between 975 thousand kg and 1950 thousand kg, and sea bream are produced in 3 plants with a capacity between 1950 and 2500 thousand kg. As a result, the expansion of fish farming in cages, especially in the eastern part of the Mediterranean Region, will not only provide support to these regions but will also allow the fisheries production of our country to grow exponentially.

Keywords

Mediterranean region of Turkey
Aquaculture production facilities
Data mining

Türkiye'nin Akdeniz Bölgesinde yer alan su ürünleri üretim tesislerinin kapasite analizi

ÖZET

Akdeniz Bölgesi ülkemizin toplam üretimindeki tesis sayısı açısından yüzde % 17'si ne, üretim kapasitesi bakımından ise ancak % 8,5 ine denk gelmektedir. Akdeniz'deki uzun sahil şeridini düşündüğümüzde bu üretim rakamının oldukça düşük olduğu söylenebilir. Bu çalışmada Akdeniz Bölgesinde yer alan balık üretim tesisleri analiz edilerek, gelecekte yapılacak planlama ve yatırım faaliyetleri için yetkili otoriteler ve yatırımcılara bir karar destek sistemi oluşturulmaya çalışılmıştır. Bunun için tesislerin 2019 yılına ait üretim kapasitesi istatistikleri dikkate alınmıştır. Verilerin analizinde ve karar destek sistemi oluşturmada veri madenciliği yöntemlerin den "Random tree" algoritması kullanılmıştır. Bölgede ağ kafes (% 31,28), beton havuz (% 60,81), toprak havuzlarda (% 5,26), gölet alanı (% 1,46), kapalı devre (% 0,29) ve tanklarda (% 0,88) üretim yapan toplam 342 tesis bulunmaktadır. Bu tesislerin sayıca ve kapasite olarak sırası ile % 87,42 ve % 59,66 kısmını alabalık tesislerinin oluşturduğu, kapasite olarak bunu % 30.99 luk payla çipura-levrek tesislerinin sağladığı görülmektedir. Bölgede en fazla beton havuzun Antalya ilinde, en fazla ağ kafesin ise Isparta ilinde olduğu görülmüştür. Beton havuzlarda üretim yapan tesislerin tamamı alabalık tesisi olup, bu tesislerin % 66,45 inin üretim kapasitesinin 23 bin kg ın altındadır. Toprak havuzlarda üretim kapasitesi 8750 kg ile 140 bin kg arasında bulunan tesislerde Alabalık (7 adet) ve çipura (2 adet) yetiştirilmekte, 140 bin kg ile 350 bin kg arasında Karabalık (2 adet), Akvaryum (1 adet) ve Levrek (1 adet) üretimi yapılmaktadır. Gölet alanlarda üretim yapan Alabalık tesislerinden 1 tanesinin üretim kapasitesinin 24 bin kg az, diğerinin ise 36 bin ton ile 59 bin ton arasındadır. Gölet alanda üretim yapan 2 adet sazan işletmesinin kapasitesinin 24 bin ile 36 bin kg arasında olduğu ve 1 adet akvaryum balıkları üretimi yapan işletmenin ise kapasitesinin 59 bin tondan fazla olduğu görülmektedir. Bölgede ağ kafeslerde Alabalık, yayın, çipura ve levrek üretimi yapılmaktadır. Ağ kafeslerde üretim yapan tesislerden kapasiteleri 550 bin kg altında bulunan 85 tesisten 1 tanesi hariç (yayın üretimi) geriye kalanı alabalık üretmektedir. Ağ kafeslerde üretim kapasitesi 675 bin kg ile 925 bin kg arasında 6 tesisin tamamında alabalık üretilmektedir. Kapasitesi 975 bin kg ile 1950 bin kg arasında 3 tesiste Çipura ve levrek üretimi yapılmakta, yine kapasitesi 1950 nin kg ile 2500 bin kg arasında bulunan 3 tesiste daha çipura levrek üretimi yapılmaktadır. Sonuç itibari ile özelikle Akdeniz Bölgesinin doğusunda ağ kafeslerde balık yetiştiriciliğinin yaygınlaştırılması sadece bu bölgelere destek sağlamanın ötesinde ülkemiz su ürünleri üretim rakamlarının katlanarak büyümesine imkân oluşturacaktır.

Anahtar Kelimeler

Akdeniz bölgesi
Su ürünleri üretim tesisleri
Veri madenciliği

Cite this article as

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Giriş

Su ürünleri yetiştiriciliği, sucul canlıların özellikleri göz önünde bulundurularak kontrollü bir şekilde üretilmesi, büyütülmesi ve çoğaltılması anlamına gelmektedir (Demir, 2011; Şimşek ve Can, 2019). Türkiye su ürünleri yetiştiriciliğinde son 30 yıl içinde ciddi bir atılım ile birlikte kalite ve miktar açısından önemli bir artış göstermiştir. (Çavdar, 2009; Güney ve Aydın, 2016; Emiroğlu ve ark., 2019). Denizde levrek ve çipura, iç sularda alabalık üretiminin öncülüğünde yıllık üretim rakamı yıllık %10'un üstünde bir ivmeyle 300.000 tonu aşmıştır. Yine bu üretim rakamının çok önemli bir kısmı (177.539 ton) ihraç edilerek yıllık 1 milyar dolara yakın gelir elde edilmiştir. Su ürünleri üretimin önemli bir kısmı Avrupa ülkelerine yapılırken, yine bu ülkelere ihraç edebildiğimiz tek hayvansal üründür (Erün, 2010). Bu bağlamda öncelikle su ürünlerinin üretiminin sürdürülebilir olması ve sürdürülebilir ekosistem üzerinde etkileri düşünüldüğünde bu üretim önem arz etmektedir (Doğan, 1997; Ermiş, 2008; Yavuzcan ve ark., 2010; Can ve Demirci, 2012; Gezmen ve ark., 2015).

Dünya su ürünleri üretimi, 2016 itibariyle 171 milyon tona ulaştığı ve artık bu toplam üretim rakamın %53'lük oranının yetiştiricilik kaynaklı olduğu bildirilmektedir (FAO, 2018). Türkiye'de ise avcılık verileri 500.000 bin ton üretim rakamından son 20 yıl içerisinde 300.000 ton kadar düşmüştür (TUİK, 2018). Bu bağlamda su ürünleri üretimimizde yetiştiricilik 2018 yılında avcılık üretimini geçmiştir. Türkiye su üretim yetiştiricilik tesisleri bakımından bölgesel dağılım değerlendirmesi yapıldığında Ege bölgesi %61 ile ilk sırada ve takiben Doğu Anadolu bölgesi %11, Karadeniz bölgesi %9, Akdeniz bölgesi %8, İç Anadolu bölgesi %6, Güneydoğu Anadolu Bölgesi %4 ve Marmara bölgesi %1 olarak sıralanmaktadır (Anonim, 2018; BSGM, 2019; Şimşek ve Can, 2019).

Bu çalışma Akdeniz bölgesindeki su ürünleri yetiştiricilik tesislerinin bütüncül olarak ele alınması ve sektörel değerlendirme yapılması amacını taşımaktadır. Akdeniz Bölgesi su ürünleri doğası itibarı ile potansiyel açısından uygun olmakla birlikte, üretim kapasitesi rakamları ülke geneline oranla (%8,5) istenilen kapasitede olmadığı düşünülmektedir. Dolayısıyla bu çalışma ile Akdeniz Bölgesinde yer alan balık üretim tesisleri analiz edilerek, gelecekte yapılacak planlama ve yatırım faaliyetleri için yetkili otoriteler ve yatırımcılara karar destek sistemi oluşturulması amaçlanmıştır.

Materyal ve Yöntem

T.C. Tarım ve Orman Bakanlığından 2019 yılına ait veriler temin edilmiş olup istatistik değerlendirmede bu sonuçlar değerlendirilmiştir. Temin edilen istatistiklerde il, üretim metodu, tür ve üretim kapasite bilgileri yapılan temel hesaplama ve algoritma çözümlemelerinde dikkate alınmıştır. Algoritma olarak veri madenciliğinde kullanılan algoritmalardan "Random-tree" algoritması kullanılmıştır. Bu algoritma değişken sayısının fazla olduğu dönemlerde hızlı karar verme amacıyla kullanılan bir yöntemdir (Kotthoff ve ark., 2017). Hesaplamalarda Microsoft Excel ve Weka 3.8.3 yazılımı kullanılmıştır

Bulgular ve Tartışma

Akdeniz bölgesinde su ürünleri üretimi yapılan 8 ilde, 342 su ürünleri üretim tesisi bulunmaktadır (Tablo 1). Akdeniz Bölgesi su ürünleri üretim tesisleri türlere göre sayı ve kapasiteleri Tablo 2'de gösterilmektedir. Bu tesislerin sayı (%87,42) ve ağırlıkça (%59,66) alabalık tesisleri oluşturmaktadır. Bölgede alabalık üretim kapasitesi 23.435 tondur. Bölgedeki tesis sayısı olarak daha az olmasına rağmen 15.000 ton civarında levrek çipura üretim kapasitesi vardır. Akdeniz bölgesi işletme sayısı açısından ülke genelinin %17'sini oluştururken

Tablo 1. Akdeniz Bölgesi İllere ve Üretim Metoduna Göre su Ürünleri Yetiştiricilik Tesis Sayıları

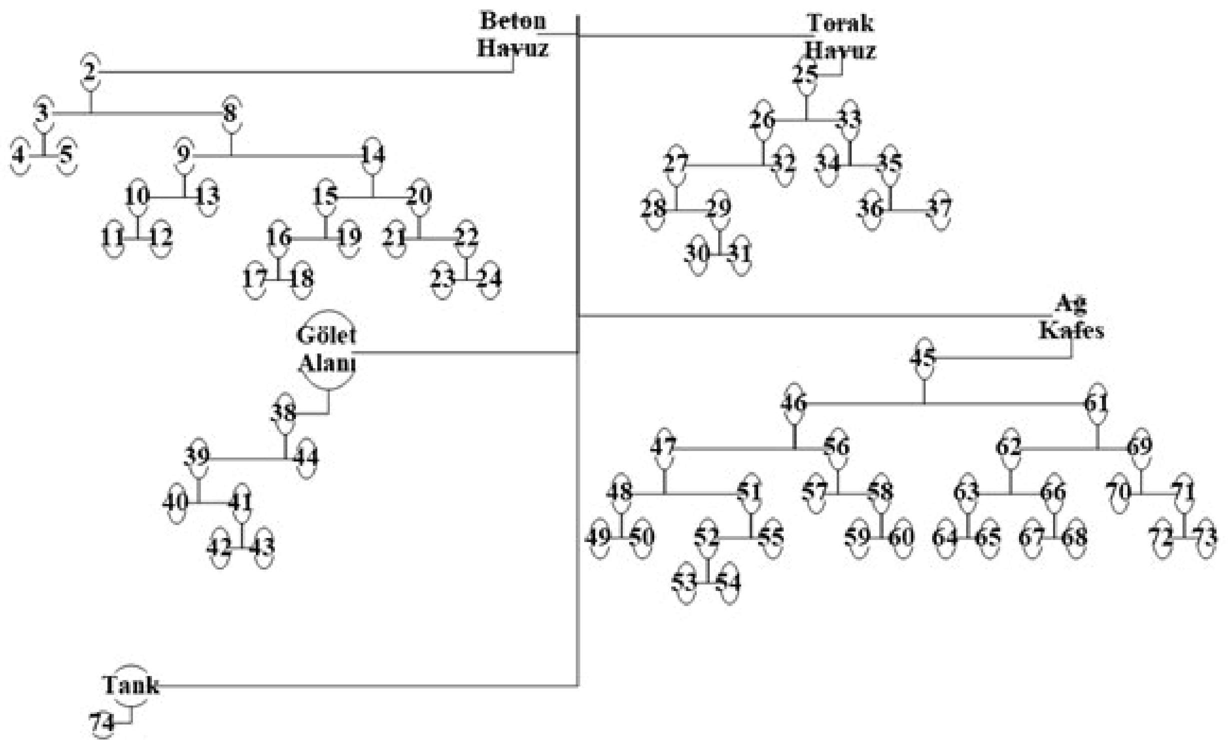
İller	Su Ürünleri Üretim Yöntemi						Toplam
	Ağ Kafes	Beton Havuz	Gölet Alanı	Kapalı Devre	Tank	Toprak Havuz	
Adana	6	19		1			26
Antalya	18	56				4	78
Burdur	24	20			1	2	47
Hatay	2	7	3			3	15
Isparta	29	52	2			1	84
Kahramanmaraş	24	20				2	46
Mersin	3	32			2	6	43
Osmaniye	1	2					3
Toplam	107	208	5	1	3	18	342

Tablo 2. Akdeniz Bölgesi Türlere Göre Su Ürünleri Yetiştiricilik Tesis Sayı ve Kapasiteleri

Tür	Su Ürünleri Yetiştiricilik İşletme			
	Sayı	%	Kapasite (ton)	%
Akvaryum Balıkları	13	3,80	400	1,01
Alabalık	299	87,42	23.435	59,66
Çipura	1	0,29	2.000	5,09
Çipura-Levrek	13	3,80	12.174	30,99
Karabalık	4	1,16	200	0,50
Levrek	3	0,87	550	1,40
Levrek-Alabalık	1	0,29	28	0,07
Sazan	5	1,46	122	0,31
Tiapia	1	0,29	147	0,37
Yayın	2	0,58	220	0,56
Genel Toplam	342		39.275	
Ülke içi %	17,03		8,55	

kapasite olarak ancak %8,5'ni oluşturmaktadır. Tablo 1 ve 2'deki değerler incelendiğinde bölgede üretim kapasitesi yüksek olan deniz ağ kafes işletme alanında genele göre düşük olduğu söylenebilir.

Akdeniz Bölgesi su ürünleri yetiştiricilik tesislerini analiz etme amacıyla üretim metotları, türler ve işletme kapasitelerine göre bir değerlendirme yapılmıştır. Bu istatistiksel değerlendirme ile mevcut tesisler gruplandırılarak hedef kırım (ayırım) noktaları belirlenmiştir. Şekil 1'de bu kırım ayrılma görüntüsü random ağacı ile sunulmaktadır. Bu şekildeki kodlamalar ise Tablo 3'de açıklanmaktadır. Burada ilk doğal olarak türlerden ziyade üretim metoduna göre bir ayırım söz konusu olmuştur. Beton havuzlarda yetiştirilen tür alabalıktır, alabalık işletmeleri yıllık kapasitesi 9 tonun altındaki 59 işletme (2-5 kod), 9-30 ton arasında 72 adet işletme (8-13 kod) ve 30 tondan daha fazla üretim kapasitesi olan 27 işletme ile şekillenmiştir. Aynı şekilde kapasite artırımına göre daha detaylı ayırım söz konusudur.



Şekil 1. Akdeniz Bölgesi Su Ürünleri Üretim Tesisleri Random Ağacı Kod Dağılımları

Tablo 2. Şekil 1'de gösterilen kod dağılımlarının açıklamaları (üretim rakamları kg)

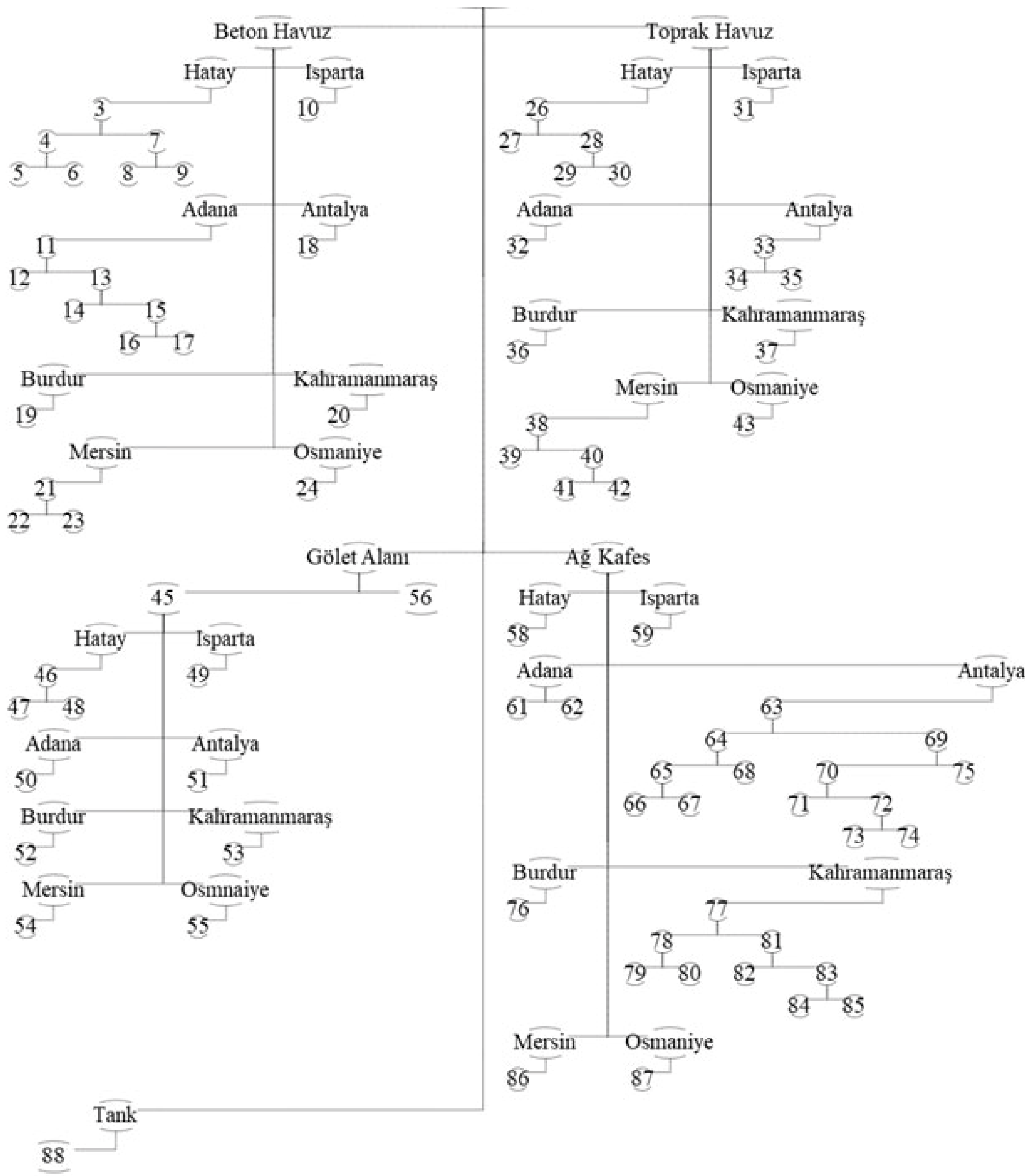
Kod	Kırılma Noktası Tanımlaması	Üretim Türü	Tesis Sayısı	Kod	Kırılma Noktası Tanımlaması	Üretim Türü	Tesis Sayısı
1	Beton Havuz			37	Gölet alanı		
2	<23000	Alabalık	59	38	<59500		
3	<9500			39	<24000	Alabalık	1
4	>9500	Alabalık	1	40	>24000		
5	<11000	Alabalık	45	41	<36500	Sazan	2
6	>11000			42	>36500	Alabalık	1
7	>23000			43	>59500	Akvaryum	1
8	<27750			44	Ağ Kafes		
9	<26750			45	<550000		
10	<25500	Alabalık	11	46			
11	>25500	Alabalık	1	47			
12	>26750:	Alabalık	1	48	<19000:	Alabalık	3
13	>27750			49	>19000	Yayın	1
14	<77500			50	>22500		
15	<29500			51	<28500		
16	<28500	Alabalık	4	52	<26500	Alabalık	12
17	>28500:	Alabalık	9	53	>26500	Alabalık	1
18	>29500	Alabalık	15	54	>28500:	Alabalık	6
19	>77500			55	>34500		
20	<90000	Alabalık	4	56	<185000	Alabalık	40
21	>90000			57	>185000		
22	<107500	Alabalık	3	58	<210000		
23	>107500	Alabalık	5	59	>210000	Alabalık	22
24	Toprak Havuz			60			
25	<27300			61			
26	<22500			62	<675000		
27	>8750	Alabalık	3	63	<625000:	Alabalık	2
28	<15000			64	>625000:		
29	>15000	Çipura	2	65	>675000		
30	>22500	Alabalık	1	66	<925000:	Alabalık	2
31	>27300	Alabalık	3	67	>925000:	Alabalık	2
32	<140000			68	>975000		
33	>140000			69	<1950000	Çipura Levrek	3
34	<350000	Karabalık	2	70	>1950000		
35	>350000	Akvaryum	1	71	<2500000	Çipura	1
36		Levrek	1	72	>2500000	Çipura Levrek	2
				73	Tank	Tilapia	1

Su ürünleri yetiştiriciliği için izin veren kurum ve kuruluşlar ile yatırımcılar ve finansal destek sağlayan kamu ve özel sektöre Akdeniz bölgesinde bulunan su ürünleri tesislerinin mevcut durumlarının tesis kapasitesi temelli ayrıntılı analizi yapılmış ve gelecekte bu bölgede yapılması planlanacak proje ve tesisler için bu anlamda kararlarını bilgiye dayalı vermeleri için algoritma temelli kararlar (kurallar) oluşturulmaya çalışılmıştır. Yapılan değerlendirme il bazında yapılmıştır. Akdeniz Bölgesi'ndeki üretim tesislerinin bu bölgede bulunan sekiz ile göre karşılaştırmalı bir değerlendirme yapılmıştır. Bu amaçla Şekil 2' de gösterilen dağılım bölgedeki tesislerin illerden ziyade üretim metoduna göre şekillendiğini göstermektedir. Burada projeler hazırlanırken tip proje olarak adlandırıldığımız hazır projelerin pratikte uygulandığı kanaati oluşmaktadır. Bu gösterimde beton havuzlar, toprak havuzlar, gölet alanı ve ağ kafes uygulamalarının olduğu görülmektedir. Ancak her ilde üretimin farklılıklar göstererek şekillendiği anlamı çıkarılmamalıdır.

Beton havuzlarda ürettim Antalya, Isparta, Burdur gibi illerde çok daha yaygın olmakla birlikte bu illerde kullanılan projeler benzerlik gösterdiği için kapasite açısından herhangi bir farklılık göstermemektedir. Bu benzerlik yönetim açısından doğal olarak kolaylık sağlamakta olduğu düşüncesindeyiz. (Kod 10,18,19,20). Bu illerde yapılan su ürünleri üretimi ve beton havuzlarda alabalık olarak şekillenmiştir. Bu üretim metodu sayı olarak bölgedeki üretim tesislerinin çok önemli bir kısmını kapsamaktadır.

Şekil 2'de gösterilen Hatay ilinde Beton havuzlarda üretim kapasiteleri farklı oranlarda şekillenmektedir. Ancak en az beton havuzda alabalık üretimi yapılan illerden biride Hatay'dır. Oysa Hatay ili Amanos Dağlarında oldukça zengin su kaynaklarına sahiptir. Yalnız bölgedeki güvenlik sebebiyle bu alanlara su ürünleri yatırımları

Şekil 2. Akdeniz Bölgesi İllere Göre Su Ürünleri Üretim Tesisleri Random Ağacı Kod Dağılımları



Tablo 4. Şekil 2'de gösterilen kod dağılımlarının açıklamaları (üretim rakamları kg)

Kod	Kırılma Noktası Tanımlaması	Üretim Türü	Tesis Sayısı	Kod	Kırılma Noktası Tanımlaması	Üretim Türü	Tesis Sayısı
2	Beton Havuz			46	Hatay		
3	Hatay			47	<36500	SS	2
4	<20000			48	>=36500	A	1
5	<12500	A	1	49	Isparta	A	1
6	>=12500:A	A	2	50	Adana		
7	>=20000			51	Antalya		
8	<62500	AKV	1	52	Burdur		
9	>=62500	AKV	2	53	K.maraş		
10	Isparta	A	44	54	Mersin		
11	Adana			55	Osmaniye		
12	<26250	A	9	56	>=59500	AKV	1
13	>=26250			57	Ağ Kafes		
14	<28250	L A	1	58	Hatay	ÇL	2
15	>=28250			59	Isparta	A	29
16	<29500	A	1	60	Adana		
17	>=29500	A	1	61	<62500	ÇL	2
18	Antalya	A	51	62	>=62500	A	5
19	Burdur	A	18	63	Antalya		
20	K.maraş	A	18	64	<400000		
21	Mersin			65	<34500		
22	<52500	A	29	66	<28500	A	5
23	>=52500	K	1	67	>=28500	A	1
24	Osmaniye	A	2	68	>=34500	A	6
25	Toprak Havuz			69	>=400000		
26	Hatay			70	<1500000		
27	<114800	K	1	71	<800000	ÇL	2
28	>=114800			72	>=800000		
29	<350000	AKV	1	73	<975000	A	1
30	>=350000	L	1	74	>=975000	ÇL	1
31	Isparta	A	1	75	>=1500000	Ç	1
32	Adana			76	Burdur	A	24
33	Antalya			77	K.maraş		
34	<17500	A	3	78	<22500		
35	>=17500	S	1	79	<17000	A	1
36	Burdur	A	2	80	>=17000	Y	1
37	K.maraş	A	2	81	>=22500		
38	Mersin			82	<175000	A	12
39	<17500	ÇL	2	83	>=175000		
40	>=17500			84	<220000	A	1
41	<52500	L	2	85	>=220000	A	8
42	>=52500	K	1	86	Mersin	ÇL	3
43	Osmaniye			87	Osmaniye	A	1
44	Gölet Alanı			88	Tank	T	1
45	<59500						

yeterince yapılamamış durumdadır. Hatta daha önceki yıllarda kurulan tesisler zaman içerisinde güvenlik nedeniyle kapanması söz konusu olmuştur. Amanos Dağ Derelerindeki su kaynakları güvenlik nedeniyle tam olarak araştırılmış durumda dahi değildir. Bu bölgeler yaz aylarında bölge halkı tarafından yaygın olarak yerleşim için kullanılmakla birlikte, su ürünleri yatırımları açısından hala güvenli bulunmamaktadır.

Akdeniz Bölgesi'nde gölet alanlarında ve toprak havuzlarda yapılan su ürünleri üretim tesisleri az sayıda olmakla birlikte mevcuttur. Bu tesislerde farklı kapasitelerinde farklı su ürünleri üretimleri her il için söz konusudur.

Akdeniz'de ülkemizdeki önemli bir üretim olanağı ağ kafeslerde levrek ve çipura balığı üretimi genel olarak olması gerekenin altında olduğu görülmektedir. Antalya, Mersin ve Hatay illerinde az sayıda kafes işletmesi mevcuttur Mersin'de 4 Hatay'da halihazırda 2 tesis bulunmaktadır. Hatay'da bulunan tesislerin üretim kapasiteleri üçer bin ton olup, Mersin'deki tesislerde 950 tonluk tip projeler mevcuttur. Aslında Hatay ili kıyısında olan İskenderun Körfezi ve Samandağ Körfezi açıklarında levrek ve çipura üretimi Türkiye'nin en uygun üretim alanlarından birdir. Çünkü bu alanlarda su sıcaklığı kış aylarında ılıman olmakla birlikte yaz aylarında da yüzey suyunun dalgalı ve hareketli olmasına bağlı olarak aşırı ısınması ve oksijen düşüklüğü Ege Bölgesine nazaran söz konusu değildir. Ayrıca bölgedeki dip akıntıları tesislerin dinamik kalmasını sağlamaktan doğal olarak yoğun balık yetiştiriciliği için uygun ortam oluşturmaktadır. Ancak 15 yıldır özellikle Hatay ilinde yeni su ürünleri ağ kafes işletme projesinin kabul edilmemesi bu bölge için önemli bir kayıp olarak görülmelidir. Bu bölgede Mersin ve Hatay sahilleri ile Adana ili Karataş açıkları ağ kafes tesisleri için oldukça uygun sahalardır. Bu bağlamda bu alanlara bir planlama kapsamında yeni tesisler projelendirilmesi ülke su ürünleri üretim açısından oldukça önemlidir. Bu bölgelerde gerekli görülen ağ kafes tesisleri kurulduğu takdirde Türkiye'nin su ürünleri üretim rakamları

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