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Original Article/Full Paper

GENETIC DIVERSITY OF THE ENDEMIC SPECIES SHABBOUT (*Arabibarbus grypus* (HECKEL, 1843)) BASED ON PARTIAL CYTOCHROME B SEQUENCES OF MITOCHONDRIAL DNA

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ABSTRACT

Arabibarbus grypus (Heckel, 1843), a species endemic in river systems of Euphrates and Tigris, is an economically important freshwater fish. In this study, the genetic diversity of *Arabibarbus grypus* populations was determined basen on partial cytochrome b gene sequence of mtDNA. Totally 31 samples were collected from four localities and five polymorphic sites and five haplotypes were identified by carrying out mtDNA analysis. Mean haplotype (Hd) and nucleotide diversity (π) were calculated to be 0.348 and 0.00144 respectively. All values obtained following neutrality tests were found to be negative and statistically insignificant. Median joining network revealed that haplotype H1 was at the center of the network and was dominant. In the current survey, certain haplotypes (H2, H4, H5) identified for mtDNA cytochrome b gene are the new results to the literature and presented a novel data set for genetic diversity of this species.

Keywords: *Arabibarbus grypus*, Cytochrome b, Genetic diversity, Euphrates River, Tigris River

Introduction

Euphrates and Tigris Rivers are from important natural sources of fish diversity and fishing and also possess a considerable potential for meeting the need of food. Developed countries have started to conduct overall studies about species particularly with economic importance following the classification of fish in inland waters (Kaya, 2012). A majority of fish species inhabiting in basin of Euphrates and Tigris belongs to the family Cyprinidae. Because several species of this family are consumed for food, they posses economic importance (Parmaksız et al., 2016). The fish preferred most by local people thanks to its delicious meat is *Arabibarbus grypus* (Shabbout). The fish distributed in Iran, Turkey, Syria, and Iraq is an endemic species thriving in river systems of Euphrates and Tigris (Nikpei, 1996; Abdoli, 2000; Khodadadi et al., 2016). Endemic fish species of fish are important in terms of ecological aspects and assumed as gene banks of an ecosystem (Khodadadi et al., 2016).

Some studies conducted on this species include age, growth, and reproductive traits (Oymak et al., 2008); heavy metal concentration in tissues (Oymak et al., 2009); determination of spermatological and hematologic characteristics (Dogu et al., 2014); the relationships between sagittal otolith size and length of the fish (Dusukcan et al., 2015); investigation for concentration of mercury in edible muscle tissues (Asefi and Zamani-Ahmadmahmoodi, 2015); the effects of probiotics derived from Lactobacillus species on immunologic parameters of Shabbout (Mohammadian et al., 2016); sperm morphology, motility and composition of seminal plasma parameters (Khodadadi et al., 2016); determination of genetic diversity utilizing from gene sequences of mtDNA COI (Parmaksiz et al., 2017).

Despite Oymak et al., (2009) stated in their study that Shabbout was abundant in the Euphrates, the number of individuals has decreased recently due to overhunting. It is crucial to know well about genetic diversity of this fish to ensure continuity of stocks and to obtain high yield from these stocks of the fish which is considered as an alternative to carp or trout for inland water fish farming (Gokcinar, 2010). There are several genetic markers based on DNA, however mtDNA studies have been made popular by developments of sequence analysis in recent years (Liu and Zhou, 2016). mtDNA, as an important and common molecular marker, has been used widey to estimate molecular variability and population genetics of numerous organisms (Xu et al., 2011). Different mtDNA gene sequences can be used to determine the variation in fish (Saraswat et al., 2014). Diversity in mtDNA cyt b gene is suitable for population genetic studies in cyprinid fishes (Fayazi et al., 2006).

The aim of this research is to determine genetic diversity of *A. grypus* populations in Euphrates and Tigris rivers via sequence analysis for mtDNA Cyt b fragment.

Materials and Methods

Collection of fish samples: A total of 31 individuals (15 from Euphrates and 16 from Tigris River) were collected via fishing method. 2 g of specimen was dissected from muscle tissue on the base of pectoral or dorsal fins of fish samples, held in refrigerator at 4°C inside micro centrifuge tubes with 1.5 mL volume, containing 95% ethanol until DNA isolation process.

DNA isolation: Total DNA was isolated from muscular tissue using GeneJET Genomic DNA Purification Kit (Thermo Scientific). Total DNA was obtained by practiced the protocol for the kit. To control the existence of DNA, 2 µl was taken from DNA samples of each individual, placed in to tank including 0.8% agarose gel, 0.5xTBE (Tris/Boric acid/EDTA Buffer) solution with the addition of 2 µl of stain (3x Loading dye) and SYBR Green, run in electrophoresis at 120 Volts for 30 minutes, then viewed in device giving off ultraviolet (UV) light (SmartView Pro Imager System, Major Science).

Amplification of target mtDNA site via polymerase chain reaction (PCR): Primers used for amplification of mtDNA Cytochrome b gene in the study (Briolay et al., 1998) were given below:

L15267: 5'-AATGACTTGAAGAACCACCGT-3'

H15891: 5'-GTTTGATCCCGTTTCGTGTA-3'

The PCR amplification process was carried out in a BIO-RAD T100™ Thermal Cycler under the following conditions: 3 minute at 95°C for initial denaturation and 30 seconds at 95°C for the second denaturation, 30 seconds at 58°C for annealing, 45 seconds at 72°C for extension, 35 cycles in total and a final extension at 72°C for 10 minutes. The amounts of DNA, concentrations of chemicals, and annealing temperatures of primes used in PCR amplification reactions were optimized by gradient PCR device. PCR mixture used in order to amplify this gene is as follows; a total volume of 25 µL containing 0.5 mM of each primer, 0.2 mM of each dNTP, 1x PCR buffer, 2.5mM $MgCl_2$, 1 unit Taq polymerase and approximately 60 ng of template DNA.

2% agarose gel was used to control final products of PCR process. Agarose gel which was included SYBR Green was run at 100 V electric current for 30 after placing in a tank with 0.5x TBE solution and loading2 µl of PCR product and

2 µL of stain in to wells, then monitored under UV device. (Figure 1).

Obtained PCR products were analyzed via 3500 XL Genetic Analyser (Thermo Fisher Scientific) by a commercial company.

Analysis of mtDNA cyt b sequences: Raw data of mtDNA sequences, which were delivered to us by commercial company, were evaluated and converted in to FASTA format by using Chromas Pro v 2.0.1 (Technelysium Pty Ltd). Resulting sequences in FASTA format were aligned utilizing BioEdit software version 7.2.5 program.

The number of polymorphic sites and haplotypes, diversity of haplotypes and nucleotides, Tajima D and Fu's statistics for the populations were identified by using DnaSP5.10.01 program (Rozas et al., 2003). The phylogenetic relationship between haplotypes was identified via Network version 5.0 program.

Results and Discussion

Genetic variation: Approximately 600 bp fragment of mtDNA Cytochrome b gene was sequenced from a total of 31 *A. grypus* samples in Euphrates and Tigris Rivers, 5 polymorphic sites and 5 haplotypes were identified. Nucleotide variations of this region were shown in Table 1.

Haplotype diversity (Hd) and nucleotide diversity (π) for each locality were given in Table 2.

In Table 2, H1 is the haplotype which has the highest frequency commonly seen in all localities. Haplotype H2 was observed only in Bozova locality, H3 in both Çermik and Dicle locality, haplotypes H4 and H5 in Dicle locality only. While Siverek locality had the lowest values in terms of both haplotype and nucleotide diversity, other localities had similar results. The locality with the highest nucleotide diversity is Bozova.

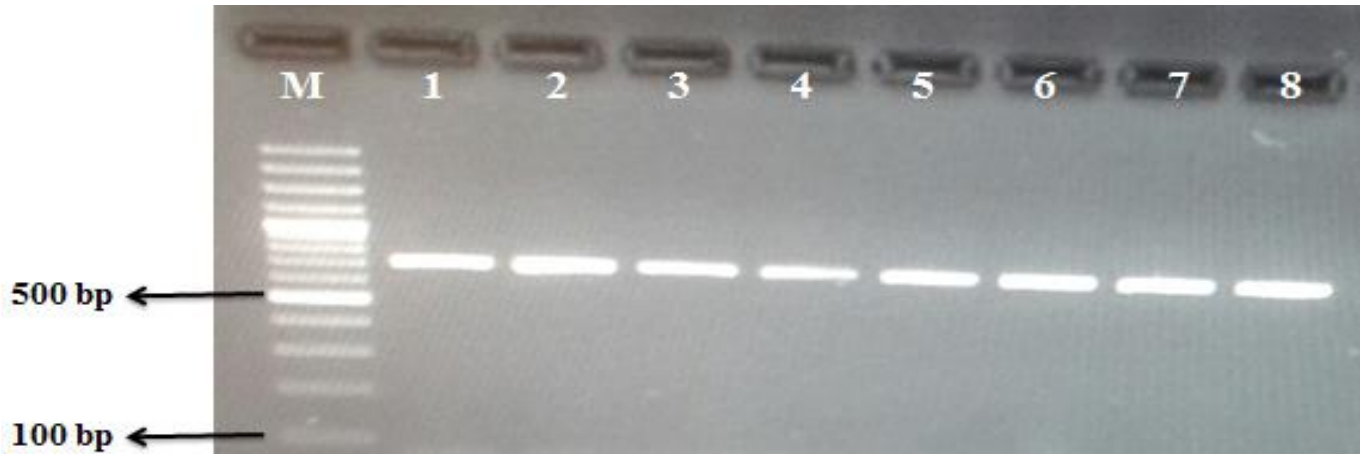

Figure 1. Image of PCR Products (M: Marker; bp: base pairs)

Table 1. Haplotypes and nucleotide variations of mtDNA Cytochrome b gene

Haplotypes	291	340	417	453	471
H1	G	T	G	C	G
H2	A	C	.	.	A
H3	A	C	.	.	.
H4	.	.	.	T	.
H5	.	.	A	.	.

Table 2. Genetic diversity of *A.grypus* localities based on mtDNA cytochrome b gene sequence and neutrality tests (N= number of individuals, Nh: number of haplotypes, Hd: haplotype diversity, π: nucleotide diversity)

River System	Locality	N	Nh	Haplotype frequency	Hd	π
Euphrates River	Siverek	5	1	H1 (1.0000)	0.000	0.00000
Euphrates River	Bozova	5	2	H1 (0.8000)	0.400	0.00194
				H2 (0.2000)		
Euphrates River	Çermik	5	2	H1 (0.8000)	0.400	0.00175
				H3 (0.2000)		
Tigris River	Dicle	16	4	H1 (0.7500)	0.442	0.00135
				H3 (0.1250)		
				H4 (0.0625)		
				H5 (0.0625)		

In Table 2, H1 is the haplotype which has the highest frequency commonly seen in all localities. Haplotype H2 was observed only in Bozova locality, H3 in both Çermik and Dicle locality, haplotypes H4 and H5 in Dicle locality only. While Siverek locality had the lowest values in terms of both haplotype and nucleotide diversity, other localities had similar results. The locality with the highest nucleotide diversity is Bozova.

In Median-Joining Network created for 31 *A. grypus* samples analyzed 5 haplotypes were identified in total, resulting network includes existence of a central haplotype (H1) indicating an evolutionary connection. It is also likely to say that all other haplotypes are associated with haplotype H1 (Figure 2).

Neutrality tests: Neutrality tests (Tajima's D and Fu's Fs) were applied separately for each river. Tajima's D statistic was -0.94808 for Euphrates river and -1.26856 for Tigris river, -1.28294 in total, and found to be statistically insignificant ($p>0.05$). Fu' Fs values were determined as -0.006 for Euphrates river and -0.993 for Tigris river, -1.28294 in total, and found to be statistically insignificant ($p>0.05$).

In the present study, genetic diversity of populations was evaluated by conducting sequence analysis of approximately 600 bp of mtDNA cyt b. five polymorphic sites and five haplotypes were identified for this gene analyzed. Considering the fact that haplotype H1 was the most prevalent one with totally 25 individuals including 3 haplotypes (H1, H2, H3) in the Euphrates, 4 (H1, H3, H4, H5) in the Tigris, therefore it is possible to speculate that Haplotype H1 was ancestral because it was common in all populations. Even though haplotypes H1 and H3 were commonly seen in both river systems, haplotype H2 was observed only in the Euphrates, haplotypes H4 and H5 in only in individuals from the Tigris. Mean haplotype diversity (Hd) and nucleotide diversity (π) were calculated to be 0.442 and 0.00152 for individuals from Tigris River; 0.257 and 0.00138 for individuals from Euphrates River, respectively. Both values of Tigris River were higher. Therefore, it can be suggested to collect samples from Tigris River for the studies on aquaculture of this species. Mean haplotype diversity (Hd) and nucleotide diversity (π) were calculated to be 0.348 and 0.00144 for all of the individuals, respectively. Parmaksız et al., (2017) identified in their study on mtDNA COI gene of *A. grypus* that haplotype diversity and nucleotide diversity were 0.246 and 0.00045; respectively. The results in the present study were higher. Haplotype diversity was 0.642

and nucleotide diversity was 0.00138 in the study by Parmaksız and Eksi (2017) conducted for mtDNA COI gene in *Capoetta trutta* populations inhabiting in the same river systems, while nucleotide diversity was similar compared to the present survey, haplotype diversity was higher. Environmental heterogeny and population size may support protection of high population diversity in populations (Nei, 1987; Avise, 1998). Haplotype diversity of *A. grypus* species was found to be lower because the number of individuals decreased thanks to overhunting.

This fish species is caught by fishermen and local people because all of the localities where samples of our research were collected are near to residential areas. The fish caught are both consumed by locals and sold to neighboring provinces. Genetic diversity of *A. grypus* populations has been decreasing due to overhunting.

Median joining network analysis revealed that haplotype H1 was at the center of network and dominant, also all other haplotypes consisted of haplotype H1 indicating it was the ancestral one.

Some haplotypes identified in the present study possess new results for mtDNA cyt b gene, created an important data set for genetic diversity of this species. (Table 3).

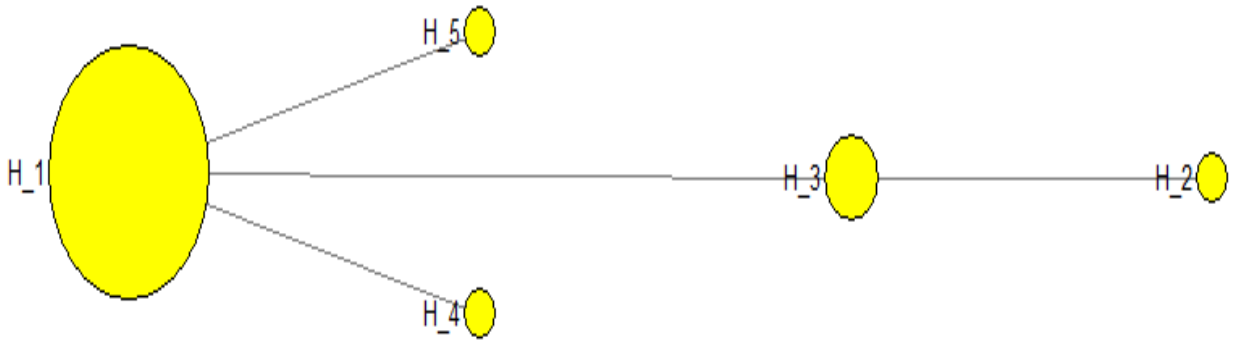

Figure 2. The model of *A. grypus* cyt b haplotypes

Table 3. Total cyt b haplotypes of *A. grypus* in the present study and GenBank

Haplotype	**GenBank Data**
H1	This study and KF876028, KF876027, AF145945
H2	This study
H3	This study and KF876026
H4	This study
H5	This study

Conclusions

This species is endemic and the most economically important species in the region. The population of this species have been influenced by pollution, destruction of habitat and especially over fishing exploitation. In this study, the sampling localities were only four localities. Further study based on microsatellite markers and mtDNA marker (D-loop) a comprehensive sampling collection is needed to extend for genetic diversity.

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EFFECT OF SAVORY EXTRACT SUPPLEMENTATION ON SOME PRODUCTIVE TRAITS AND ECONOMIC EFFICIENCY OF COMMON CARP (*Cyprinus carpio* L.)

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ABSTRACT

The purpose of this study is to evaluate the effect of a dietary savory extract supplement on the survival rate, growth performance, feed conversion ratio and economic efficiency of common carp (*Cyprinus carpio* L.) reared in a recirculation system. Thirty-two carps were allotted into two experimental variants, each of them comprising two replications with 8 fish in a group. The average initial live weight of fish from both replications from the control group (CG) and experimental group (EG) was 866.56±113.99 g and 866.81±119.10 g, respectively ($p>0.05$). They were kept in concrete tanks with efficient water volume of 0.8 m^3, elements of the recirculation system. Carps were fed pelleted carp feed with 25% crude protein, produced with pellet size of 6 mm. The feed of fish from the EG was supplemented with 1% powdered savory extract, after lubricating the pellets with 5 ml sunflower oil per 100 g feed. Control carp received the same amount of sunflower oil-lubricated feed. The daily ration of fish from both replications was 1.8% of their live weight. The experiment duration was 45 days. Survival rates during the experiment showed 100% survival in carps, supplemented with 1% savory extract as well as in control fish. The average individual weight gain of carps from the two EG replications (supplemented with 1% savory extract) was 154.63±28.39 g, which was higher than that of controls by 57.18% (Table 3), as the differences were statistically significant ($p<0.001$). At the end of the trial, the analysis of consumed feed amount showed that feed conversion ratio in the group supplemented with 1% savory extract was 2.25±0.43 e.g. by 67.11% lower than that of control group, as the differences were statistically significant ($p<0.001$). The group that received 1% savory extract exhibited better economic conversion ratio (1.98), by 42.42% lower than that of the non-supplemented group.

Keywords: Common carp, Savory extract, Feed conversion ratio, Weight gain, Survival rate, Economic efficiency

Introduction

The monitoring of fish nutrition and the amount of unconsumed feed help optimize feeding and economic management of the farm, improve profitability and reduce the negative impact of fish production on the environment (Atanasov et al., 1999). In recent years, the fish feed has included a variety of nutritional supplements to improve its quality. Furthermore, dietary additives should improve feed utilization. Conducted experiments with various types of feed supplements (Jayaprakash and Euphrasia, 1996; Polat and Beklevik, 1999; Citarasu et al., 2003; El-Dakar et al., 2007). One of the requirements of this approach is the use of organic ingredients in the production of feed for various species, including biologically based immune-stimulants, which improve the health status and reduce the mortality of cultivated hydrobiones (Raa 1996). They are a requirement of organic aquaculture and are widely used in the feed industry (Galleoti, 1998; Best, 2002; Li and Gatlin, 2004; Costa – Pierce, 2010). The use of plant extracts as supplements in fish feed is harmless to fish and the environment (Gabor et al., 2010; Gabor et al., 2011). At present, interest in modern standards and requirements related to organic aquaculture is increasing in the European Union, the US and other countries (Staykov et al., 2005). The ultimate success in aquaculture depends on thorough knowledge of biology, controlling the production cycle and maintain a close link between nutrition and health status (Wedemeyer 1997, Staykov et al., 2005). Many authors have described the beneficial effects of the use of food additives on the survival and productivity of fish and treatment of various infectious diseases and parasites in fish (Zhou and Li 2004; Culjak et al. 2006; Stratev et al., 2018). However, studies that have assessed the effect of phytoadditives on growth indicators and feed conversion parameters for different farmed fish species are few.

The savory (*Satureja hortensis*) is a species of the Lamiaceae family, grown in warm temperate regions of the northern hemisphere, whose fresh and dried leaves are used as a spice. They are known to have antimicrobial, antitumor, antimutagenic, antigenotoxic, analgesic, antispasmodic, anti-inflammatory, angiogenic, antiparasitic, antiplatelet, and antioxidant properties (Charles, 2012). The influence of savory (*Satureja hortensis*) on the gut micro flora, immune response and blood biochemical parameters of juveniles carp (*Cyprinus carpio*) is reported by Mousavi et al., (2016).

The purpose of this study is to evaluate the effect of a dietary savory extract supplement on the survival rate, growth performance, feed conversion ratio and economic efficiency of common carp (*Cyprinus carpio* L.) reared in a recirculation system.

Materials and Methods

Thirty-two common carps were allotted into two experimental variants, each of them comprising two replications, with 8 fish in a group. The average initial live weight of carps from the control group (CG) and experimental group (EG) was 866.56±113.99 g and 866.81±119.10 g, respectively. Fish were kept in concrete tanks with efficient water volume of 0.8 m^3, elements of the recirculation system. They were fed pelleted carp feed with 25% crude protein, produced by the Top mix company, with pellet size of 6 mm. The feed of fish from the EG was supplemented with 1% powdered savory extract after lubricating the pellets with 5 ml sunflower oil per 100 g feed. Control carps received the same amount of sunflower oil-lubricated feed. The nutrient content in the pelleted feed of both groups' common carp (*Cyprinus carpio* L.) is as follows presented:

- **CG:** Crude protein- 25%; Crude lipids -3.10 %; Crude fiber -6 %; Crude ash - 8%; P- 1.04%; ME- 11.10MJ/kg; Vitamin A-4800 IU/kg; Vitamin D-900 IU/kg;
- **EG:** Crude protein- 25%; Crude lipids -3.10 %; Crude fiber -6 %; Crude ash - 8%; P- 1.04%; Savory extract 1 %; ME- 11.10MJ/kg; Vitamin A-4800 IU/kg; Vitamin D-900 IU/kg.

The daily ration of fish from both replications was 1.8% of their live weight and they were fed three times per day. The experiment duration was 45 days.

- The hydrochemical parameters in the recirculating system of the common carp (*Cyprinus carpio* L.) were determined using methods adapted for fish-farming and MultiLine P4 as follows: Quantity of the dissolved oxygen/mg.l^{-1}; pH; Electrical conductivity/ µS.cm^{-1} and BDS EN 27888; Quantity of nitrates, mg.l^{-1} – BDS 17.1.4.12:1979; Quantity of nitrites, mg.l^{-1} – BDS ISO 26777:1997.

The above water parameters were daily measured.

- The economic efficiency analyses of the savory extract supplementation in the diet of carp (*Cyprinus carpio* L.), cultivated in recirculation system, data for feed conversion ratio, weight gain and survival rate were used. Comparisons of these traits were made between the fish of the different experimental groups and the costs for the pelleted feed were determined. The price cost for 1 kg weight gain of the fish, cultivated in recir-

culation systems was determined. The economic conversion ratio (ECR) was calculated, using the following equation (Piedecausa et al., 2007):

- ECR = Cost of Diet x Feed Conversion Ratio (FCR)

Statistical evaluation of the data was done by STATISTICA 6.0 software (StatSoft Inc., 2002).

Results and Discussion

During the trial period the hydrochemical parameters in the recirculation system were maintained in the optimal limits for common carp. Their values during the experiment are presented in Table 1.

The water temperature for the two experimental groups was 24.00 ±1.48ºC. Dissolved oxygen content from both replications of control and experimental variants was 6.63 ±0.32 $mg.l^{-1}$ and 6.68 ±0.36 $mg.l^{-1}$, respectively, but differences were not significant ($p>0.05$). Water pH from both replications of CG and EG was 7.66 ±0.24 and 7.64 ±0.21, respectively, as no significant differences between the replicates were found ($p>0.05$). Electric conductivity of water during the experiments was 675 ±25.00 $\mu S.cm^{-1}$.

The results of Table 2 shows fish production parameters in both experimental groups and economic efficiency of common carp.

Table 1. Water parameters in the recirculation system during the experiment with common carp

Parameter	n	CG	EG	Optimum values (Regulation № 4/2000)
		$\bar{x}$ ±SD	$\bar{x}$ ±SD	
Temperature, ºC	45	24.00 ±1.48	24.00 ±1.48	22.0-26.0
Dissolved oxygen, $mg.l^{-1}$	45	6.63 ±0.32	6.68 ±0.36	> 5
pH	45	7.66 ±0.24	7.64 ±0.21	6.5-8.5
Electric conductivity, $\mu S.cm^{-1}$	45	675 ±25.00	675 ±25.00	-

Table 2. Fish production parameters and economic efficiency of common carp, grown in recirculation system

Parameter	n	CG	EG
		$\bar{x}$ ±SD	$\bar{x}$ ±SD
Initial body weight, g	16	866.56 ±113.99	866.81 ±119.10
Final body weight, g	16	964.94 ±92.04	1021.44 ±118.28
Survival rate, %	16	100	100
Average individual weight gain, g	16	98.38 ±25.63	154.63 ±28.39***
FCR	16	3.76 ±1.39	2.25 ±0.43***
ECR		2.82	1.98

*** $p \leq 0.001$

The average initial live weight of carps from both replications of control and experimental variants was 866.56 ±113.99 g and 866.81 ±119.10 g, respectively, but differences were not statistically significant ($p>0.05$). By the end of the experiment, there was a tendency to higher average live weight of fish, fed with 1% savory extract supplemented pellets – 1021.44 ±118.28 g vs 964.94 ±92.04 g in control fish ($p>0.05$).

Survival rates during the experiment showed 100% survival in fish supplemented with 1% savory extract as well as in control carps.

The average individual weight gain of fish from the two EG replications (supplemented with 1% savory extract) was 154.63 ±28.39 g which was higher than that of controls by 57.18% (Table 2), as the differences were statistically significant ($p<0.001$).

At the end of the experiment, it was calculated that feed conversion ratio in experimental carps, supplemented with 1% savory extract, was 2.25 ±0.43 on the average, e.g. by 67.11% lower than that of control group, as the differences were statistically significant ($p<0.001$) (Table 2).

The better utilization of the pelleted feed supplemented with 1% savory extract had a beneficial effect on the growth performance of experimental carps. In the beginning of the trial, the body weight of all carps was similar were similar 866.56 ±113.99 g and 866.81 ±119.10g ($p>0.05$). At the end, supplemented fish tended to have insignificantly higher average live weight than controls whose live weight were by 5.86% lower ($p>0.05$) (Table 2). These results confirm Mousavi et al. (2016), whose reported better indicators of the gut microflora, immune response and blood biochemical parameters by adding 1% savory powder to juveniles carp feed. The results obtained in these studies are probably due to improved metabolism of nutrients in fish that receive savory extract.

The chosen experimental period was comparatively short, but some tendencies were established in current study. More experiments with long trial period were needed in the future to confirm the received results.

In the Table 2 are presented and the results of the economic conversion ratio of the used pelleted feed. Its price was 750 BGN per ton, VAT excluded for CG. To this feed price, the costs for the savory extract supplement should be added, which made the pellets of the experimental group more expensive by 130 BGN per ton, VAT excluded.

The group that received 1% savory extract exhibited better economic conversion ratio (1.98), by 42.42% lower than that of the non-supplemented group.

Conclusion

The study showed that the savory extract might successfully be used as a feed additive to the diet of common carp. Its supplementation to the pellets influenced positively the growth, did not have negative effect on the survival rate of the fish, enhanced the weight gain, reduced the feed conversion ratio, as well as the economic conversion ratio.

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FILLETING YIELD, BODY CHARACTERISTICS AND LENGTH WEIGHT RELATIONSHIP OF FOUR FISH SPECIES FROM LOWER RIVER BENUE MAKURDI NIGERIA

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ABSTRACT

Fillet yield, length-weight relationship and condition factor of four commercial fish species including: *Protopterus annectens, Labeo coubie, Auchenoglanis occidentalis and Mormyrus rume* from lower river Benue Makurdi Nigeria were determined. A total of 600 fish samples were used, 50 individuals regarding each species for the period of three months. Fish samples were collected and transported to the University of Agriculture Makurdi, Department of Fisheries and Aquaculture laboratory where data were recorded on: The Total weight (TW), Total length (TL), Standard length (ST), Visceral weight (VW), Head length (HL), Weight of bones (WB), Weight of fins (WF) and Weight of fillet (WF) from the four fish species. Large differences in the fillet yield were observed among the species studied. L*abeo cuobie* had the highest fillet percentage yield (65.51 %) while *Auchenoglanis occidentalis* had the lowest fillet percentage yield (56.85 %). There was a linear relationship between fish length and fillet, also, significant correlation was found between fillet yield and body measurements (weight and length).

Keywords: Filleting yield, Physical characteristics, Fish species, River Benue, Condition factor

Introduction

Study of characteristics of fish quality requirement and assessment indices are basic trade relations processes in deciding prosperity of commercial fisheries products. Therefore, study of fish products are deemed to be of paramount importance (El Tay, 1994). Processors, nutritionists and consumers, all have direct interest in the physical and chemical composition of fish. This can be done through the studying of general condition of fishes via studying their body weight, body length and filleting yield indices. This allows some flexibility in assessing the actual amount of fish tissue consumed and inedible parts discarded.

River Benue is the major tributary of the Niger River and it is approximately 1400 km long and is almost entirely navigable during the summer months. At this occasion, it is an important transportation route in the regions through which it flows.

It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Reservoir, in to Nigeria south of the Mandara mountains, and through Jimeta, Ibi and Makurdi before meeting the Niger at Lokoja.

The river's largest tributary is the Mayo Kebbi, which connects it with the Logone River (part of the Lake Chad system) during floods. Other tributaries are Taraba River and River Katsina Ala. The river overflows its banks during the rainy season (May-October), but decreases drastically in volume leaving tiny island in the middle of the river during the dry season (November-April). The river contains several species of fresh water fishes of different families such as Protopteridae, Claroteidae, Mormyridae and family Cyprinidae. Little work has been done in these fish species concerning fish flesh quality, filleting yield and body weight characteristics particularly in River Benue. However, fragmented studies were done by a few researchers on these river namely Solomon and Akogu (2005), Olufeagba and Okomoda (2015) and Solomon *et al.*, (2015), these researchers worked on the aspect of morphometric characteristics composition of some commercial fish species of the River Benue. The species studied included, *Protopterus annectens, Labeo coubie, Auchenoglanis occidentalis* and *Mormyrus rume*. The results of body weight composition and yield indices revealed clearly that the percentage decreased in the order of fillet, head, skeleton, viscera and skin for the most of studied fish species. Therefore, this study is designed to determine the fillet yield, length-weight relationship and condition factor of four commercial fish species from lower river Benue Makurdi Nigeria.

Materials and Methods

Sampling Site

The fish samples were collected from River Benue at Wadata Market, Makurdi the capital of Benue State, Nigeria, located at longitude 7º 43' N and latitude 8° 32' E.

Experimental Fish Species

A total of 600 individuls, belonging to four families, were sampled for this study. These families include, Protopteridae, Claroteidae, Cyprinidae and Mormyridae. The studied fishes were represented by four species, namely, *Protopterus annectens annectens, Labeo coubie, Auchenoglanis occidentalis* and *Mormyrus rume*. Each species were composed of 50 samples each for the period of three months. The samples were collected fresh with cast and set net by the fishermen at landings area. The fish with crushed ice for preservation during assessment. The whole fresh samples were taken to the Department of Fisheries and Aquaculture laboratory Federal University of Agriculture Makurdi where their total and standard length were recorded (in cm) using measuring rule (ruler) and total body weights were recorded in grams using an electronic weighing balance. The fishes were then filleted, eviscerated, beheaded using a sharp knife. The weight of viscera, fillets, heads, and skeletons (frames) were weighed separately using weighing balance. A pooled mean of these weights were calculated and used to estimate the percentage of each part of the dress out - Fillets, head, gut and frame relative to the weight of whole fish.

Data Collection

Data were collected on: the total weight (g), total Length (cm), standard length (cm), visceral weight (g), head length (cm), weight of bones (g), weight of fins (g) and weight of fillet (g) from the four fish species.

Statistical Analysis

The data was analyzed using one way ANOVA statistical methods according to social science software (SPSS, version 17.0), followed by Duncan multiple range tests, and the difference between species was investigated by Independent sample T test Correlations between body size (weight and length) and fillet weight and yield were analyzed by Pearson's coefficient for linear regression (r). The differences were considered significant at $P<0.05$. All data were expressed as mean ±S.E.M

Results and Discussion

Results from this study shows a significant variation in the mean, carcass composition and filleting yield indices of fish investigated. The fillet percentage was highest for the *Labeo coubie* (65.51 %) and lowest for *Auchenoglanis occidentalis*. (56.85 %). The highest filleting yield of *Labeo coubie* was due to small viscera (5.63 %) and skeleton (8.27 %) while the lowest filleting yield of *Auchenoglanis occidentalis sp*. was due to its large head, which measured (25.87 %). These results were in agreement with Eyo (1991), Abanu and Ikeme (1988) and Ali *et al.*, (1992). *Auchenoglanis occidentalis possessed* large head (25.87 %) which had an adverse effect on the filleting yield of their bodies. Also there were some attributes, which were responsible for decreasing the filleting yield such as skeleton and fins in the case of *Auchenoglanis occidentalis*, which recorded 8.89%, for skeleton and 3.69% for fins. *Labeo coubie* had moderate head and skeleton weights which resulted in the high filleting yield (65.51 %) among the studied fishes, although the head of the *Labeo coubie* was large and long compared to the rest of its components. This did not affect its filleting yield which was (65.51 %) because it had lower skeleton percentage (8.27 %).

Generally, the filleting yield of the studied fish species was a reflection of their anatomy i.e. species with large heads and skeleton relative to musculature give lower filleting yield than those with smaller heads and skeletons (Eyo, 1991; Ali e*t al.*, 1992). On the other hand, *Auchenoglanis occidentalis* had high inedible parts (head, skeleton and fins). These inedible parts are often discarded except for a few considerations where head, skeleton and gonads are used as by-products and sometimes used as diet for low-income people.

The edible parts (fillets) weight of studied fishes was very low when compared with fishes such as carp (53 %) and trout (70 %) (FAO, 1985). Since these inedible body components (head, skeleton, skin and viscera) are usually discarded except for a few considerations where heads and skeletons are eaten, the purchaser may thus suffer economic loss. Therefore, the use of such inedible parts for manufacture of fish silage or fish meal in different fisheries sectors is suggested. Length-weight relationships of fishes are often used to study the indication of fatness, general well-being or gonad development. It is also assumed that heavier fish of a given length are in better condition. Venu and Kurup (2003) noted that for an ideal fish, which maintain dimensional equality, the isometric value of b would be 3. The correlation coefficient was all positive and highly significant for *A. occidentalis* in River Benue which indicates that the length increases with increase in weight of the fish. This is in agreement with previous studies on different fish species from various water bodies (Layèyè, 2006), (Ayoade and Ikula, 2007). However, Shinkafi and Ipinjolu (2010) reported allometric growth pattern for *A. occidentalis* in River Rima, North-western Nigeria and consistent 'b' value for A. occidentalis in this study. Ikongbeh *et al.,* (2012a) reported allometric growth pattern for *B. docmac*, from Lake Akata, Benue State, Nigeria. Isometric growth pattern was also reported for *C. auratus*. (Ikomi, and Odum, 1998). It was observed in the present study, that mean condition factor for *A. occidentalis* were less than '1' which indicates that the condition of the fish species can be improve, this implies that increase in length brought about little proportional increase in weight. Ikongbe *et al.,* (2012b), reported similar observation in *C. nigrodigitatus*, and *B. docmac* from Lake Akata, Benue State, Nigeria. Condition factor is not constant for a species or population over a time interval and might be influenced by both biotic and abiotic factors such as feeding regime and state of gonadal development. There are also suggestions that fish condition can be influenced by certain extrinsic factors such as changes in temperature and photoperiod (Youson, *et al*., 1998). It was observed that the yield of fish was a reflection of its structural anatomy. Fish with small heads and viscera regardless of the season of spawning as in the case of *Labeo coubie* and Mormyrus *rume* produced a higher filleting yield than those with larger heads and viscera as in the case of *Auchenoglanis occidentalis* and *Protopterus annectens*. *Auchenoglanis occidentalis* had the height mean value of condition factor 0.88 and R^2 value was 0.56 which indicates a negative allometric growth with the variation in the body weight correlating with changes in the length.

The length weight relationship of Protopterus annectens were as shown in figure 5, 6, 7 and 8 showed that the four fish species under this study exhibited negative allometric growth. This indicated that growth in length increase as weight increases and also the rate of increase in body length was not proportional to the increase in body weight. This result is different from the one obtained by Oniye *et al.*, (2006) when he obtained the b-value for male and female P. annectens in Jachi dam, Nigeria to be 3.12 and 3.22 respectively. This could be due to the condition of the fish caught during different season, location, sex, sample site and nature of the water body. The regression coefficient of 0.83 compares favourably with the 0.86 and 0.84 obtained by Oniye *et al.,* (2006) for *Murmyrus rume*. Fafioye and Oluajo (2005) also obtained a condition factor of 1.00 for some other fish species from Epe Lagoon**.**

Conclusion

In conclusion, there was a higher correlation coefficient value in the length-weight relationship for all the fish species in this study. Also, yield of fish was a reflection of its structural anatomy. Fish with small heads and visceral regardless of the season of spawning as in the case of *Labeo coubie* and Mormyrus *rume* produced a higher filleting yield than those with larger heads and viscera as in the case of *Auchenoglanis occidentalis* and *Protopterus annectens*. *Auchenoglanis occidentalis* had the highest mean value of condition factor 0.88 and R^2 value was 0.56 which indicates a negative allometric growth with the variation in the body weight correlating with changes in the length.

Table 1. Mean Percentage Carcass Composition and Fillet Yield of Four Fish Species from Lower Rive Benue.

Body Characteristics	*Protopterus annectens*	*Auchenoglanis occidentalis*	*Labeo coubie*	*Mormyrus rume*	*P-Value*
Total Weight (g)	270.31 ±14.81^{c}	211.34 ±12.85^{b}	158.04 ±10.00^{a}	169.18 ±11.81^{a}	0.00
Total Length (cm)	42.85 ±1.24^{b}	29.87 ±0.85^{a}	28.97 ±0.75^{a}	30.03 ±1.05^{a}	0.00
Standard Length(cm)	37.95 ±1.15^{b}	24.58 ±0.70^{a}	23.84 ±0.65^{a}	24.82 ±0.78^{a}	0.00
% Visceral Weight(g)	13.57 ±0.39^{c}	6.41 ±0.34^{b}	5.63 ±0.23^{ab}	5.24 ±0.14^{a}	0.00
% Weight of Head (g)	13.25 ±0.25^{a}	25.87 ±0.64^{c}	15.54 ±0.44^{b}	16.60 ±0.37^{b}	0.00
% Weight of Fin (g)	1.24 ±0.10^{a}	3.69 ±0.15^{c}	2.40 ±0.09^{b}	2.26 ±0.11^{b}	0.00
% Weight of Bone (g)	9.79 ±0.34^{c}	8.89 ±0.21^{b}	8.27 ±0.26^{b}	7.22 ±0.15^{a}	0.00
% Fillet Yield	60.29 ±0.61^{b}	56.85 ±0.69^{a}	65.51 ±0.60^{c}	65.40 ±0.46^{c}	0.00

**Mean in the same row with different superscripts differ significantly (P<0.05)*
(a, ab, b, and c denote the levels of significant different)

Table 2. Body Characteristics of Selected Four Fish Species from Lower River Benue

Body Characteristics	*Protopterus annectens*	*Auchenoglanis occidentalis*	*Labeo coubie*	*Mormyrus rume*	*P-Value*
Total Weight	270.31 ±14.81^{c}	211.34 ±12.85^{b}	158.04 ±10.00^{a}	169.18 ±11.81^{a}	0.00
Total Length	42.85 ±1.24^{b}	29.87 ±0.85^{a}	28.97 ±0.75^{a}	30.03±1.05^{a}	0.00
Standard Length	37.95 ±1.15^{b}	24.58 ±0.70^{a}	23.84 ±0.65^{a}	24.82 ±0.78^{a}	0.00
Visceral Weight	33.42 ±1.54^{c}	12.29 ±0.89^{b}	9.66 ±0.86^{ab}	8.38 ±0.58^{a}	0.00
Head Length	6.23 ±0.24^{b}	6.36 ±0.23^{b}	5.72 ±0.20^{b}	4.73 ±0.28^{a}	0.00
Weight of Head	37.90 ±2.65^{b}	55.07 ±3.73^{c}	22.91 ±1.26^{a}	25.95 ±1.63^{a}	0.00
Weight of Fins	3.54 ±0.34^{a}	7.28 ±0.48^{b}	3.56 ±0.23^{a}	3.84 ±0.32^{a}	0.00
Weight of Bone	28.70 ±2.42^{c}	18.21 ±1.13^{b}	12.70 ±0.82^{a}	13.51 ±1.05^{a}	0.00
Fillet Weight	161.84 ±8.91^{b}	119.81 ±7.97^{a}	107.93 ±7.03^{a}	114.57 ±8.44^{a}	0.00
Condition Factor	0.47 ±0.04^{a}	0.88 ±0.06^{c}	0.73 ±0.05^{b}	0.63 ±0.04^{b}	0.00
Fillet Yield	60.29 ±0.61^{b}	56.85 ±0.69^{a}	65.51 ±0.60^{c}	65.40 ±0.46^{c}	0.00

**Mean in the same row with different superscripts differ significantly (P<0.05)*
(a, ab, b, and c denote the levels of significant different)

Table 3. Correlation of the Body Characteristics of *Protopterus annectens* in Lower River Benue Makurdi.

	TW	TL	SL	VW	HL	HW	WF	WB	WFL	K
TW										
TL	0.603*									
SL	0.649*	0.956*								
VW	0.862*	0.643*	0.672*							
HL	0.713*	0.800*	0.835*	0.752*						
HW	0.935*	0.469*	0.511*	0.755*	0.600*					
WF	0.636*	0.316*	0.279*	0.502*	0.383*	0.668*				
WB	0.853*	0.355*	0.395*	0.673*	0.488*	0.950*	0.602*			
WFL	0.973*	0.614*	0.661*	0.840*	0.712*	0.862*	0.600*	0.742*		
K	-0.160	-0.636*	-0.618*	-0.233*	-0.430*	-0.123	-0.062	-0.065	-0.143	
FY	-0.020	-0.032	-0.014	-0.049	-0.065	-0.161*	--0.043	-0.282*	0.175*	0.217*

**Correlation significant at P<0.05*

KEY: TW= Total Weight, TL=Total Length, SL=Standard Length, VW=Visceral Weight, HL= Head Length, HW=Weight of Head (g), WF=Weight of Fins, WB=Weight of Bones, K Condition Factor, WFL=Fillet Weight.

Table 4. Correlation of the Body Characteristics of Mormyrus in River Benue Nigeria.

	TW	TL	SL	VW	HL	HW	WF	WB	WFL	K
TW										
TL	0.929*									
SL	0.888*	0.976*								
VW	0.925*	0.877*	0.850*							
HL	0.876*	0.829*	0.772*	0.821*						
HW	0.955*	0.906*	0.878*	0.900*	0.812*					
WF	0.835*	0.700*	0.676*	0.731*	0.688*	0.790*				
WB	0.973*	0.909*	0.863*	0.912*	0.890*	0.904*	0.753*			
WFL	0.977*	0.919*	0.877*	0.911*	0.885*	0.932*	0.837*	0.976*		
K	-0.237*	-0.448*	-0.451*	-0.247*	-0.309*	-0.210*	0.012	-0.247*	-0.239*	
FY	0.487*	0.442*	0.452*	0.373*	0.456*	0.296*	0.441*	0.506*	0.542*	-0.138

**Correlation significant at P<0.05*

KEY: TW= Total Weight, TL=Total Length, SL= Standard Length, VW=Visceral Weight, HL= Head Length, WH=Weight of Head, WF=Weight of Fins, WB=Weight of Bones, K Condition Factor, WFL=Fillet Weight.

Table 5. Pearson Correlation of the Body Characteristics of *Auchenoglanis occidentalis* in River Benue Nigeria

	TW	TL	SL	VW	HL	HW	WF	WB	WFL	K
TW										
TL	0.769*									
SL	0.729*	0.957*								
VW	0.812*	0.654*	0.636*							
HL	0.622*	0.666*	0.610*	0.439*						
HW	0.903*	0.586*	0.567*	0.710*	0.507*					
WF	0.794*	0.565*	0.536*	0.766*	0.442*	0.726*				
WB	0.939*	0.723*	0.696*	0.763*	0.612*	0.820*	0.760*			
WFL	0.929*	0.757*	0.712*	0.723*	0.590*	0.766*	0.689*	0.876*		
K	-0.065	-0.509*	-0.526*	-0.102	-0.249*	0.030	0.002	-0.056	-0.103	
FY	-0.062	0.122	0.134	-0.148	-0.033	-0.326*	-0.139	-0.059	0.121	-0.271

**Correlation significant at P<0.05*

KEY: TW= Total Weight, TL=Total Length, SL=Standard Length, VW=Visceral Weight , HL= Head Length, WH=Weight of Head, WF=Weight of Fins, WB=Weight of Bones, K Condition Factor, WFL=Fillet Weight

Table 6. Pearson Correlation of the Body Characteristics of *Labeo coubie* in River Benue Nigeria

	TW	TL	SL	VW	HL	HW	WF	WB	WFL	K
TW										
TL	0.692*									
SL	0.674*	0.973*								
VW	0.898*	0.495*	0.459*							
HL	0.622*	0.906*	0.907*	0.379*						
HW	0.959*	0.706*	0.681*	0.912*	0.646*					
WF	0.904*	0.584*	0.546*	0.856*	0.520*	0.894*				
WB	0.962*	0.681*	0.652*	0.899*	0.616*	0.952*	0.880*			
WFL	0.985*	0.719*	0.714*	0.861*	0.668*	0.937*	0.881*	0.940*		
K	0.047	-0.439*	-0.423*	0.092	-0.328*	-0.019	0.080	-0.019	0.031	
FY	0.294*	0.343*	0.399*	0.044	0.386*	0.159	0.136	0.133	0.394*	0.188*

**Correlation significant at P<0.05*

KEY: TW= Total Weight, TL=Total Length, SL=Standard Length, VW=Visceral Weight , HL= Head Length, WH=Weight of Head, WF=Weight of Fins, WB=Weight of Bones, K Condition Factor, WFL=Fillet Weight

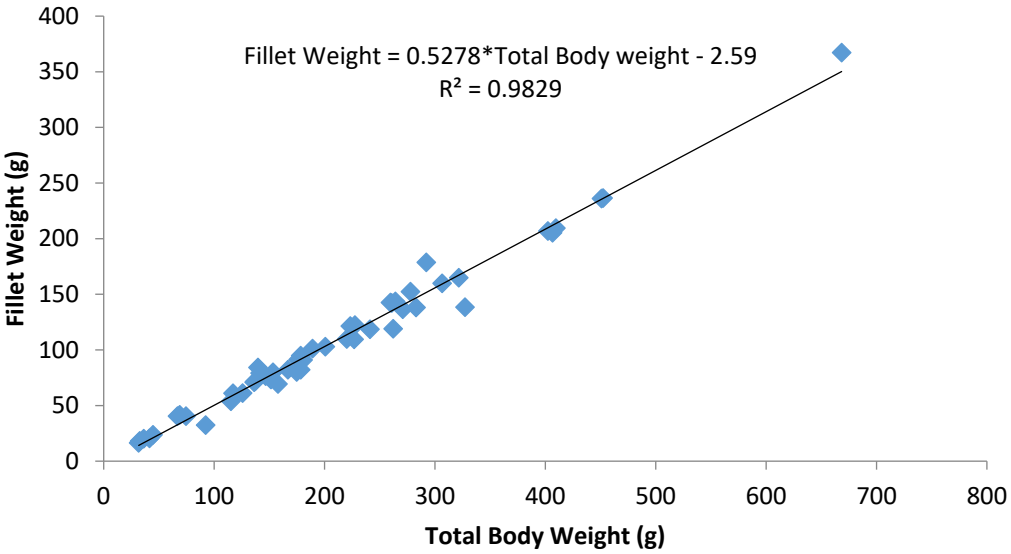

Figure 1. Body Weight and Fillet Yield Relationship of *Auchenoglanis occidentalis* from River Benue

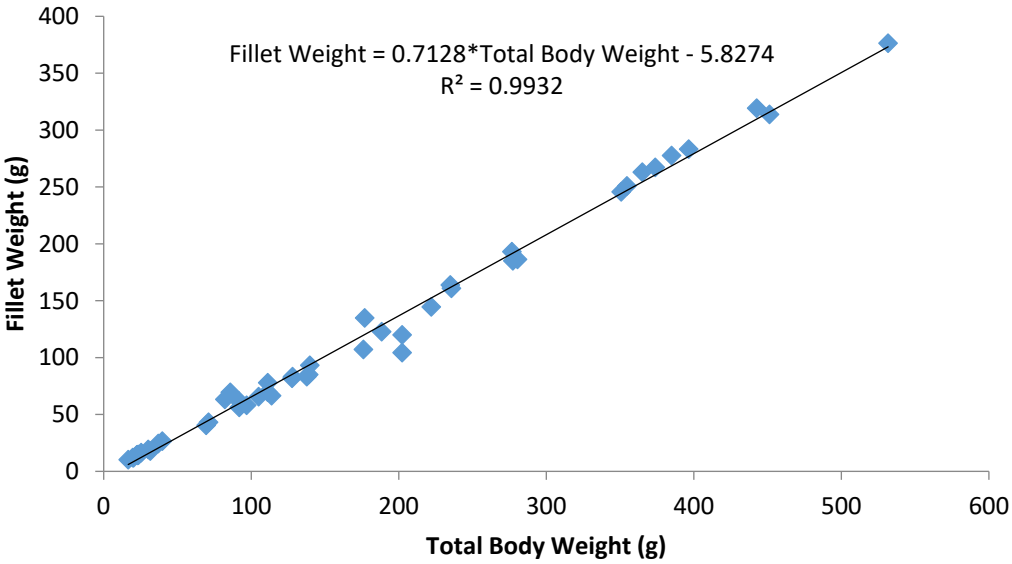

Figure 2. Body Weight and Fillet Yield Relationship of *Mormyrus rume* from River Benue

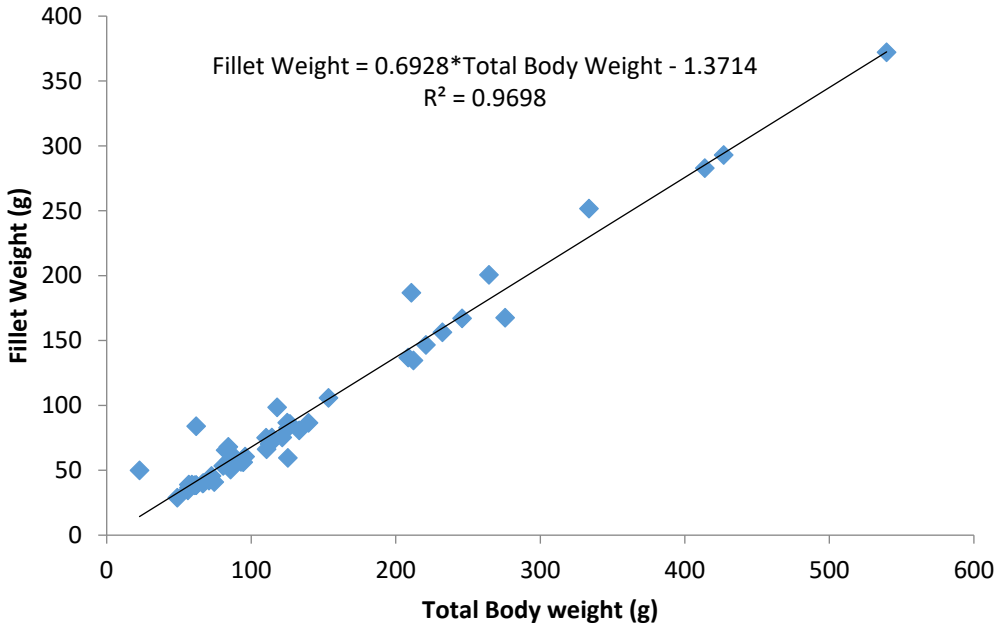

Figure 3. Body Weight and Fillet Yield Relationship of *Labeo coubie* from River Benue

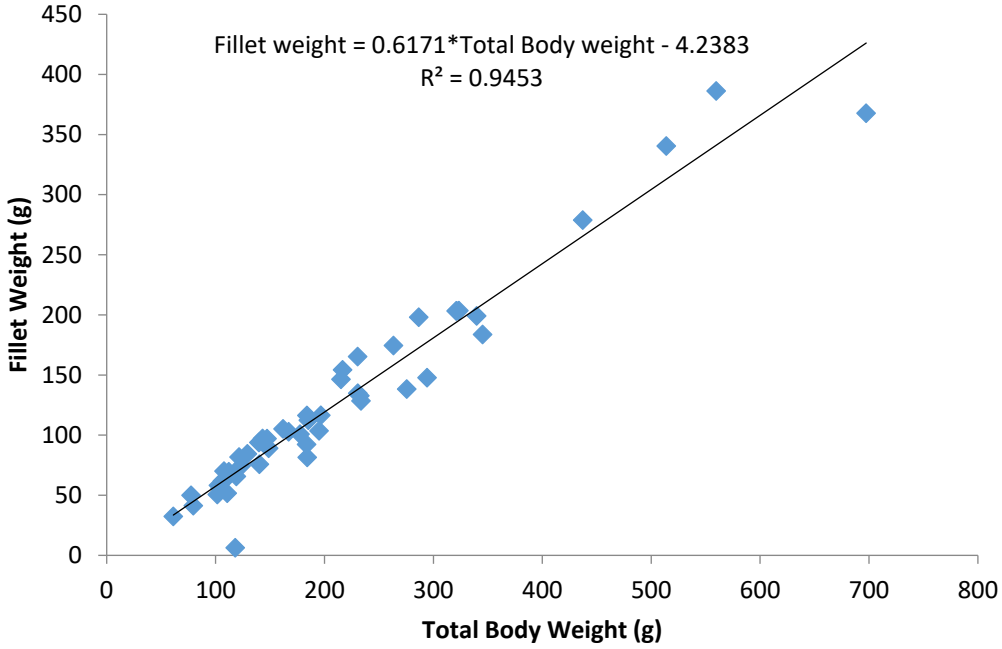

Figure 4. Body Weight and Fillet Yield Relationship of *Proptopterus annectens* from River Benue

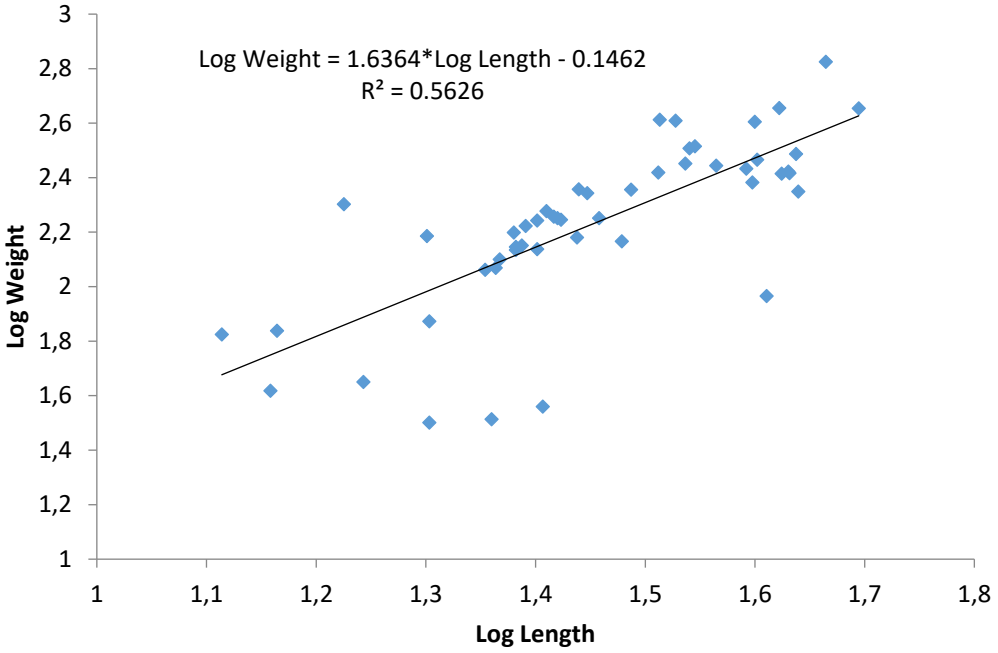

Figure 5. Length-Weight Relationship of *Auchenoglanis occidentalis* from Lower River Benue

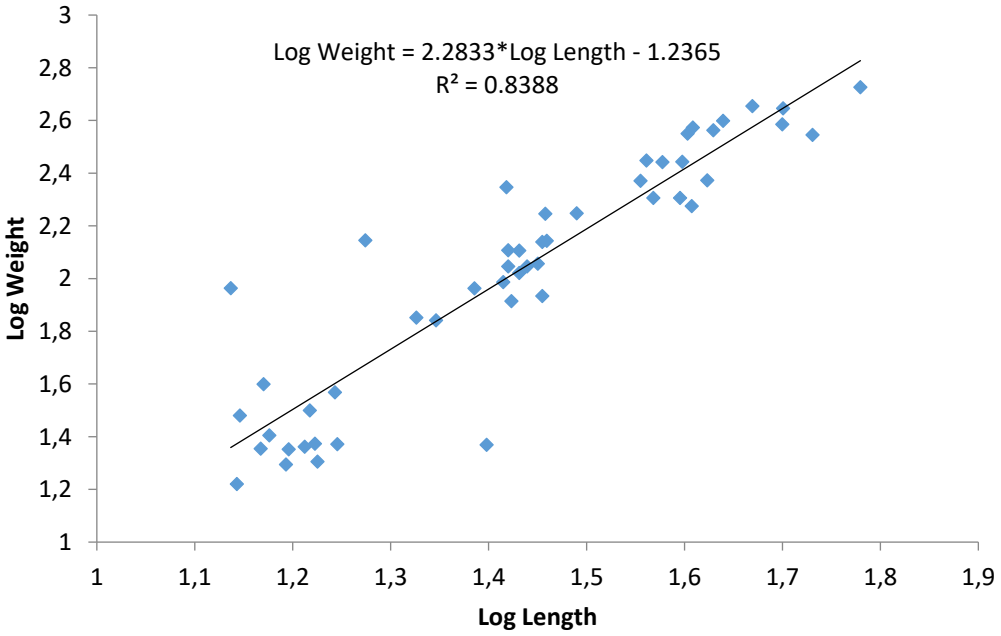

Figure 6. Length-Weight Relationship of *Mormyrus rume* from Lower River Benue

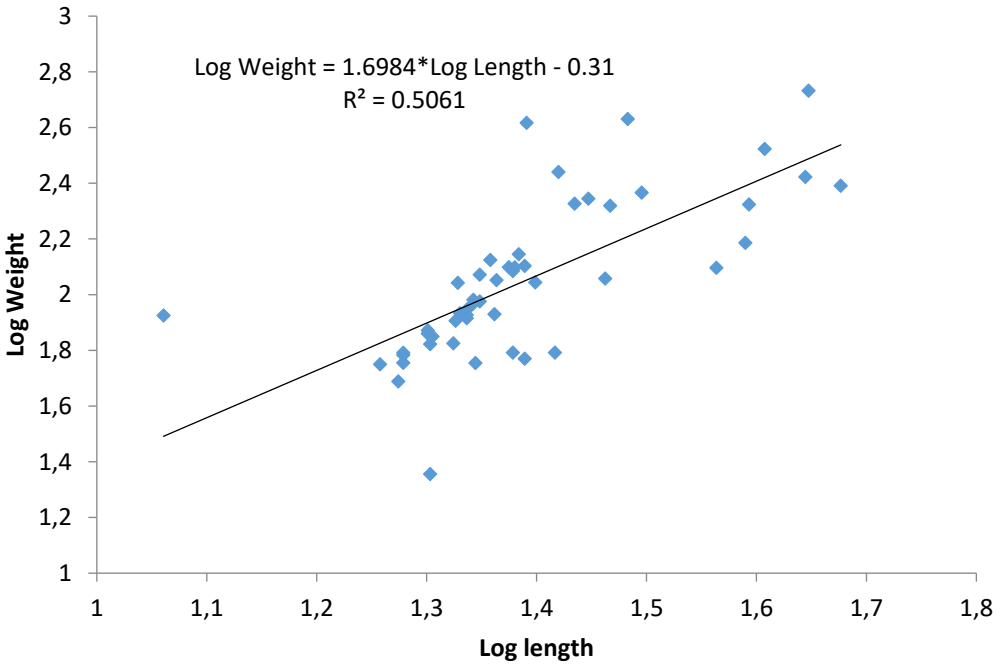

Figure 7. Length-Weight Relationship of *Labeo coubie* from Lower River Benue

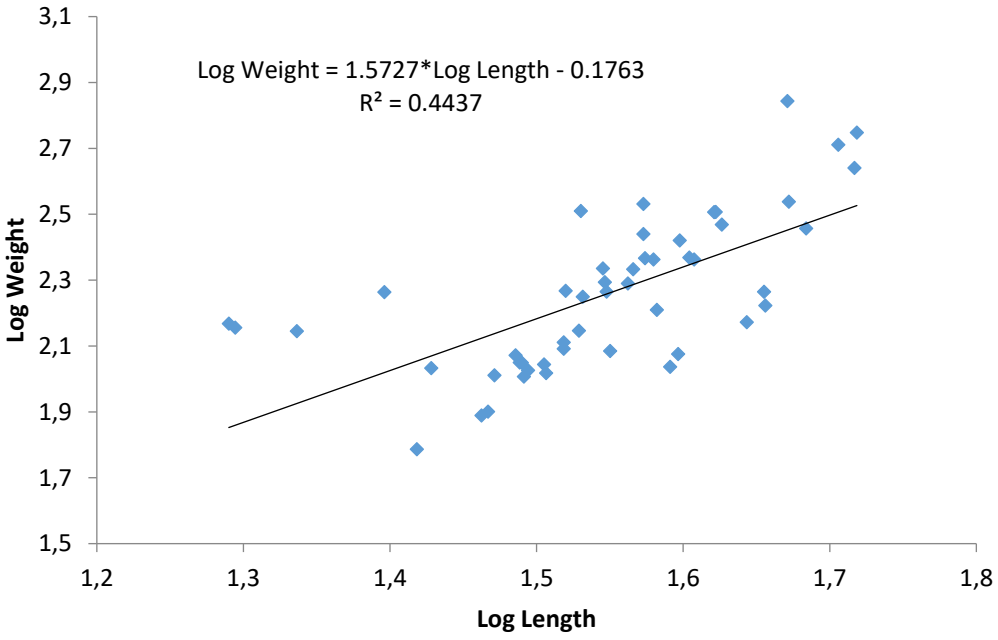

Figure 8. Length-Weight Relationship of *Protopterus annectens* from Lower River Benue

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Original Article/Full Paper

GÜNEYDOĞU KARADENİZ RİZE SARAYKÖY PLAJINDA PLASTİK KİRLİLİĞİ

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ÖZ

Yüksek nehir deşarjına sahip yarı kapalı bir deniz olan Karadeniz'de, çöpler önemli bir çevresel problemdir. Plastik çöpler dünya genelinde olduğu gibi Karadeniz'de de deniz çöplerinin en yaygın olanıdır. Güneydoğu Karadeniz'de Rize ili Sarayköy plajında plastik çöpler Haziran 2016-Mart 2017 tarihleri arasında izlenmiştir. Plaj çöpleri mevsimsel olarak OSPAR plaj izleme metodolojisi takip edilerek 100 m'lik plaj kesitinde toplanmış ve tiplerine ayrılmışlardır. Çalışma süresince, 43 farklı tip plastik çöp belirlenmiştir. OSPAR çöp fotoğraf kılavuzunda kaydı olmayan 1 yeni plastik çöp tipi (borular) listeye ilave edilmiştir. Plajda en yüksek yaz ve en düşük ilkbaharda olmak üzere ortalama 1.90 ±1.49 adet/m^2 ve 14.85 ±12.83 g/m^2 plastik çöp bulunmuştur. Çalışma süresince köpük süngerler ve plastik/polistiren parçalar (2.5-50 cm) en sık rastlanılan çöp tipi olarak bulunmuştur. Plajda plastik çöpler kullanım alanlarına göre değerlendirildiğinde, yiyecek, içecek ve genel paketleme ilk üç sırada yer almıştır. Plajda bulunan küçük plastik parçalar rüzgarlarla kolaylıkla denize taşınabilirlikleri ve yakın gelecekte mikro- ve nanoplastikleri oluşturacak olmaları göz önünde bulundurulduğunda, Karadeniz ekosistemi için büyük tehdit oluşturdukları düşünülmektedir.

Anahtar Kelimeler: Plastik, Köpük Sünger, Kirlilik, Karadeniz

ABSTRACT

PLASTIC POLLUTION ON RIZE SARAYKOY BEACH IN THE SOUTHEASTERN BLACK SEA

Marine litter is an important environmental problem in the Black Sea which is a semi-enclosed with high river discharge. Plastics are the most common marine litter in the Black Sea as it's in the other regions in the world. Plastic litter were monitored in the Saraykoy beach of Rize in the South-Eastern Black Sea between June 2016 and March 2017. The beach litter collected seasonally following OSPAR beach monitoring methodology and collected in 100 m beach section and separated into types. During the study, 43 different types of plastic litter were identified. A new plastic litter type (pipes) was added to OSPAR litter photo guide. In the beach, average 1.90 ±1.49 pieces/m^2 and 14.85 ±12.83 g/m^2 plastic litter were found with the highest in summer and the lowest in spring. During the study, foam sponges and plastic/polystyrene pieces (2.5-50 cm) were the most common type of litter. According to usage, food related, beverages and general packaging comprised top three in the beach. Our results suggest that small plastic pieces might easily transport to the sea by wind and break down to micro- and nanoplastics which would be harm to Black Sea ecosystem.

Keywords: Plastic, foam sponge, pollution, Black Sea

Giriş

Deniz çöpleri, nehirlerle, kanalizasyon veya drenaj sistemleri yoluyla, erozyon, rüzgâr gibi doğal yollarla denize ve kıyısal ortama taşınan üretilmiş/işlenmiş kalıcı madde olarak tanımlanmaktadır (UNEP, 2005; Galgani vd., 2010). Deniz çöpleri, okyanuslarda, denizlerde, nehir ağızlarında ve kıyı şeritleri boyunca yaygın bir problemdir (OSPAR, 2007). Deniz çevresinde her geçen gün artarak biriken çöpler, okyanus ve denizlerdeki yaşamı tehdit etmektedir (Derraik, 2002). Plastikler, dünya genelinde kıyı ve denizlerde çöplerin büyük bir kısmını oluşturmaktadır (Galgani vd., 2010). Plastikler düşük yoğunluğu, hafif oluşu, dayanıklılığı, kolay işlenebilirliği ve düşük maliyetli olması dolayısı ile 20. yüzyılda günlük yaşamın her alanında kullanılmaya başlanmıştır (Derraik, 2002). 1950'lerden bu yana plastik üretimi yıllık ~ %8.6 oranında artarak, yaklaşık 330 milyon ton/yıl düzeyine ulaşmıştır (PlasticsEurope, 2017). Yapılan hesaplamalara göre yıllık plastik üretiminin %10'u denizlerde sonlanarak, deniz çöplerinin %80'inini, plaj çöplerinin ise %50-80'ini oluşturmaktadır (Derraik, 2002; OSPAR, 2007). Kıyı ve denizlerde akümüle olan plastikler, besin zannedilerek tüketilmekte ve canlılarda sindirim, boşaltım, üreme problemlerine, dolanma yoluyla yaşamsal fonksiyonlarını kısıtlamaya hatta sonlandırmaya varacak bir dizi olumsuz etkiye sahiptir (Laist, 1997; Derraik 2002; Kühn, vd., 2015). Şu ana kadar yapılan çalışmalarda yaklaşık 267 denizel türün etkilendiği rapor edilmiştir (Laist, 1997; Derraik, 2002). Ayrıca plastikler canlı yaşamı için substrat oluşturarak (Chapman ve Clynick 2006), patojen/istilacı türleri akıntılar ve rüzgarlar yolu ile ait olmadıkları bölgelere taşıyarak, biyoçeşitliliği de etkileyebilmektedirler (Kiessling vd., 2015). Bentik bölgede akümüle olan plastik çöpler yapay resif gibi davranabilseler de birçok canlı için habitat kaybına neden olmaktadırlar (Laist, 1997; Derraik, 2002). Plastik çöpler ayrıca kıyısal bölgede estetik olarak istenmeyen görüntülere sebebiyet vererek turizmi olumsuz etkilemekte, hatta yaralanmalara neden olarak insan sağlığını da tehdit etmektedir (UNEP 2011; Galloway, 2015).

Karadeniz yüksek nehir deşarjı ile karakterize olan yarı kapalı bir denizdir ve 21 ülkeden ~170 milyonun üzerinde insanın drenaj alanını oluşturmaktadır (BSC, 2007). Yerleşim merkezlerinin kıyısal bölgeye yoğunlaştığı Karadeniz, yoğun bir balıkçılık alanı ve önemli bir nakliye güzergâhıdır (BSC, 2007). Tüm bu özelliklerinden dolayı kirliliğe karşı savunmasızdır ve deniz çöpleri en büyük çevresel problemlerden biri haline gelmiştir (BSC, 2007). Karadeniz'in Türkiye kıyılarında yapılan çalışmalarda, deniz dibinde (Topçu ve Öztürk, 2010) ve plajlarda (Güneroğlu, 2010; Topçu vd. 2013; Vişne ve Bat, 2016; Terzi ve Seyhan, 2017; Simeonova vd., 2017) yüksek miktarda çöp rapor edilmiş ve plastiklerin en yüksek orana sahip çöp tipi olduğunu bildirilmiştir. Tüm Karadeniz'i saat yönünün tersine dönen kıvrımlı sırt akıntısı (Oğuz vd.,1993) plastikleri kaynağından çok uzak noktalara taşıyarak, kirliliğin sınır ötesi bir problem olmasına neden olabilmektedir (Topçu ve Öztürk, 2010; Aytan vd., 2016).

Plastiklerin artan küresel bir sorun olması dolayısı ile gelecekte miktarın azaltılması ve gerekli tedbirlerin alınabilmesi için, mevcut durumunun, olası kaynaklarının ve taşınım yollarının belirlenmesi önem arz etmektedir. Bu çalışma ile, Rize ilinde seçilen Sarayköy plajında mevsimsel olarak plastiklerin, tipleri, sayıca ve ağırlıkça miktarları, olası kaynakları ve taşınım yolları araştırılmıştır.

Materyal ve Metot

Çalışma Alanı

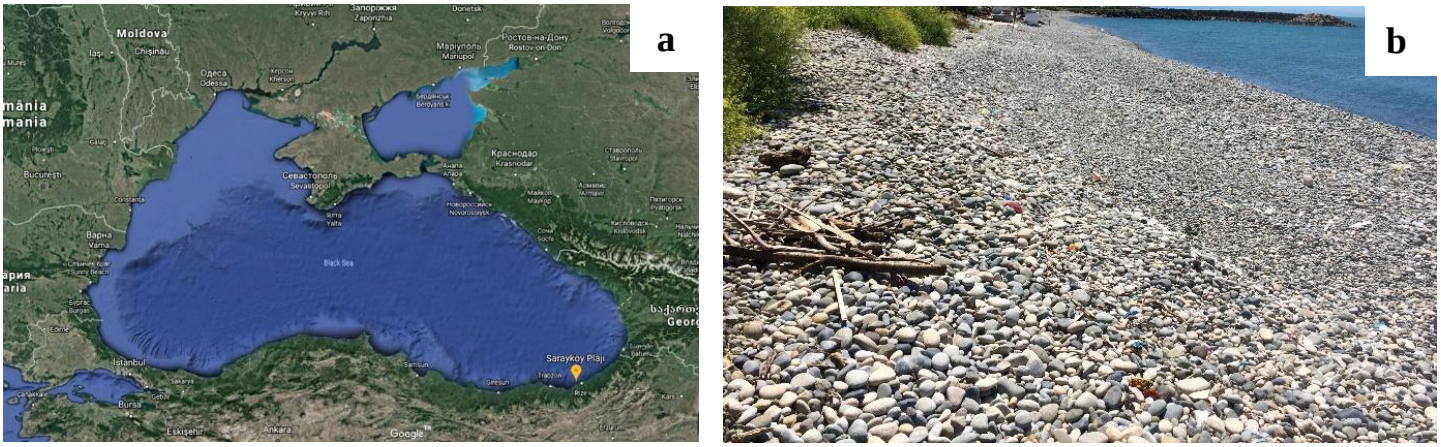
Dik yamaçlı dağların kıyıya paralel uzandığı Güneydoğu Karadeniz, dar bir kıyısal şerit ile karakterize olmaktadır. Şehirlerin büyütülmesi ve yol yapımı gibi amaçlarla sahilin doldurulmasından dolayı doğal plajların çoğu yok olmuştur. Halkın kullanımına açık, ulaşılabilir, sınırlı sayıda plaj bulunmaktadır. Sarayköy plajı, Rize ilinin batısında (13 km), İyidere İlçesinin doğusunda (2 km) ve en yakın akarsu olan İkizdere çayının doğusunda (5,8 km) yer alan ve kuzeybatı yönünde bakan bir plajdır. 330 m uzunluğunda ve yaklaşık 20 m genişliğindeki plaj, ortalama eğime (eğim %20-30) sahiptir ve irili ufaklı taşlardan oluşmaktadır. Plajın her iki yanında büyük kayalardan oluşan dalgakıranlar mevcuttur. Plaj yalnızca Haziran ayının ikinci yarısı ile Eylül ayının ikinci yarısı arası (İlk-, ortaöğretim yaz tatili periyodu), güneşli günlerde halk tarafından yüzme/güneşlenme amaçlı kullanılmaktadır. Bu dönemde plajda iki küçük ölçekte kafe işletilmektedir. Plaj etrafında yer alan evlerin büyük kısmı eski ve terkedilmiş olup, geri kalan evler yazlıkçılar tarafından kullanılmaktadır. Bu dönemler dışında plaj nadir olarak amatör balıkçılar tarafından ziyaret edilmektedir.

Saha ve Laboratuvar Çalışmaları

Plaj örneklemeleri 12 Haziran 2016, 2 Ekim 2016, 26 Aralık 2016 ve 19 Mart 2017 tarihlerinde gerçekleştirilmiştir. Örneklemeler, OSPAR (Kuzey-Doğu Atlantik Deniz Çevresinin Korunması Sözleşmesi) plaj araştırmaları protokolü takip edilerek 100 m plaj kesitinde (denizden 20 m, kıyıya paralel 100 m) gerçekleştirilmiştir (OSPAR, 2007) (Şekil 1). Çöpler beş kişi tarafından, kıyı çizgisinden kenar çizgisine kadar, eşit aralıklarda hatlara bölünerek taranmış

küçük, büyük ayırt etmeksizin tüm çöpler toplanmıştır. Toplama işleminin ardından çalışma alanında çöpler OSPAR tarafından oluşturulan metodolojiye göre ana kategorilere ayrılarak sınıflandırılmıştır. Ayrılan plastik çöpler laboratuvar ortamına getirilerek, OSPAR (2010) fotoğraf kılavuzundaki kategorilere göre ayrıldıktan sonra sayım, tartılma işlemi yapılarak fotoğraflanmıştır. Her bir plastik çöp tipinin sayısı ve ağırlıkları kaydedilmiştir. Plastik çöp bolluğu, sayıca adet/m^2 ve ağırlıkça g/m^2 olarak ifade edilmiştir. Plastik çöplerin tahmini kullanım alanlarının belirlenmesi amacı ile çöpler genel paketleme, yiyecek, içecek, inşaat, sigara ile ilgili, balıkçılık, giyim ve tanımlanamayan kategorilerine de ayrılmıştır. Toplanan plastik çöplerin arasında yabancı kökenli çöpler sayılmış ve hangi ülke kökenli oldukları kaydedilmiştir.

Plaj çöpü dağılımında mevsimsel farklılıklar olup olmadığı one-way ANOVA ile test edilmiştir. İstatistiksel analizlere başlamadan önce verilere logaritmik dönüşüm yapılarak normal da ğılım gösterip göstermedikleri test edilmiştir.



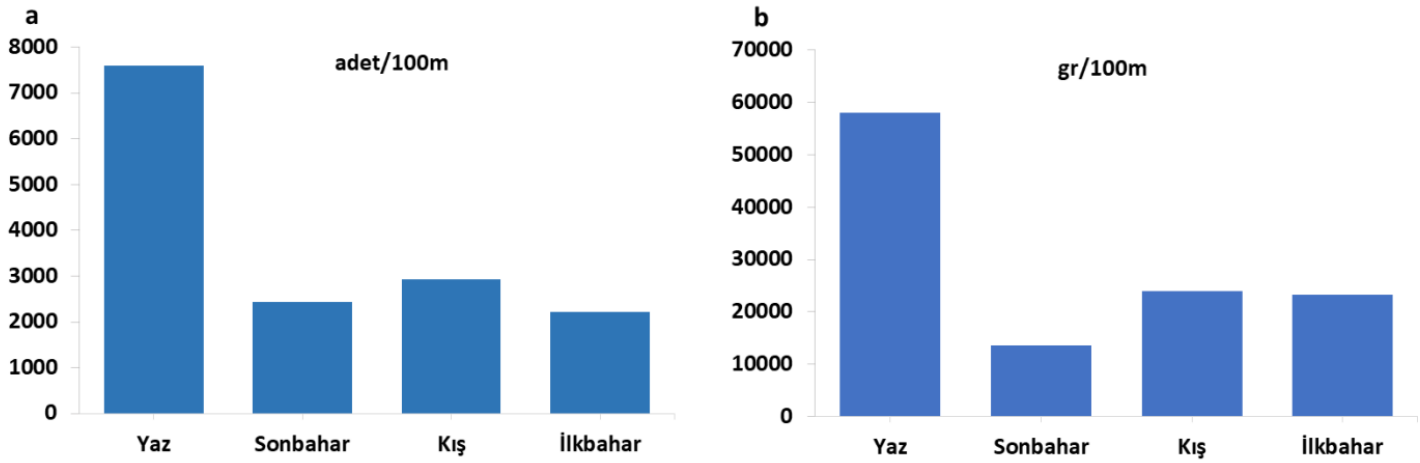
Şekil 1. Çalışma alanı (a) ve Sarayköy plajının genel görüntüsü (b).

Figure 1. Study area (a) and general view of Saraykoy beach (b).

Bulgular ve Tartışma

Sarayköy plajından Haziran 2016 ile Mart 2017 tarihleri arasında toplam 15193 adet/100 m (ortalama 3798 ±2546) ve 118.7 kg/100m (ortalama 29.6 ±19.45) ağırlığında plastik toplanmıştır. Çalışmada yıl genelinde, plastik yoğunluğu (ort ± std) 1.90 ±1.49 adet/m^2 ve 14.85 ±12.83 g/m^2 olarak hesaplanmıştır. Topçu vd. (2013)'nin Batı Karadeniz'de yaptığı çalışmada, 0.88 ±0.95 adet/m^2 plaj çöpünün %91'ini plastiklerin oluşturduğunu rapor etmiştir. Güney Karadeniz Sinop Sarıkum Lagünü kıyısında gerçekleştirilen çalışmada plaj çöp yoğunluğunun 1.033-2.352 adet/m^2 olduğu ve plastik çöplerin toplam çöpün %95.6'sını oluşturduğu rapor edilmiştir (Vişne ve Bat, 2016). Yakın zamanda Terzi ve Seyhan (2017) Türkiye'nin Doğu Karadeniz sahillerini kapsayan çalışmalarında 0.16 ±0.02 adet/m^2 plaj çöpünün % 61.6'sını plastik çöpler oluşturmuştur. Simeonova vd. (2017)'de Karadeniz'in Bulgaristan kıyılarındaki çalışmasında 0.0587 ±0.005 adet/m^2 olan plaj çöpünün % 84.3'ünü plastik çöp olarak rapor edilmiştir. Karadeniz plajlarında bulunan ortalama çöp yoğunluğu bölgesel farklılıklar gösterse de plastik baskınlığı tüm çalışmalarda ortak sonuç olduğu görülmektedir.

Yapılan çalışma sonucunda, OSPAR çöp fotoğraf kılavuzuna göre 43 farklı tip plastik çöp belirlenmiştir. OSPAR çöp fotoğraf kılavuzunda kaydı olmayan 1 yeni çöp tipi (borular) listeye ilave edilmiştir (Tablo 1). Plastik çöplerin mevsimsel ölçekte 100 m'lik plaj kesitinde yoğunlukları incelendiğinde; en bol 7591 adet (% 50) ile yaz mevsiminde olduğu gözlenmiştir. Onu takip eden mevsimler, kış 2934 adet (% 19), sonbahar 2444 adet (%16) ve en son ilkbahar 2224 adet (% 15) olmak üzere mevsimsel olarak baskın olduğunu kaydedilmiştir (Şekil 2a). Plastik çöpler ağırlık bakımından mevsimsel açıdan incelendiğinde, yaz mevsimi ilk sırayı alırken (% 49), kış (%20.2), ilkbahar (% 19.6) ve sonbahar mevsimi (%11) tarafından takip etmiştir (Şekil 2b). Plastik yoğunluğu mevsimler arasında istatistiksel anlamda farklılık göstermiştir (one-way ANOVA, $p<0.05$). Yaz mevsiminde plastik yoğunluğu istatistiksel olarak önemli derece yüksek bulunmuştur (t-test, $p<0.05$).



Şekil 2. Sarayköy plajında plastik çöplerin sayıca (a) (adet/100 m) ve ağırlıkça (b) (g/100 m) mevsimsel dağılımı.

Figure 2. Seasonal distribution of plastic litter in terms of number (a) (number/100 m) and weight (b) (g/100m) on Saraykoy Beach.

En sık rastlanan ilk 15 plastik çöp listesi incelendiğinde (Şekil 3), yaz mevsiminde 100 m'lik plaj kesitinde ilk sırayı cips/tatlı ve lolipop paketleri 1159 adet (%15) ile alırken, plastik/polistiren parçalar (2.5-50 cm) 1023 adet (%13.5) ile ve köpük sünger 1015 adet (% 13.4) ile ilk üç sırada yer almıştır. Plastik çöplerinin yaz mevsiminden sonra en bol bulunduğu kış mevsiminde, köpük sünger 609 adet (% 21) ile, plastik/polistiren parçalar (2.5-50 cm) 525 adet (% 19) ile ve yiyecek kaplar 340 adet (% 12) ile; sonbahar mevsiminde, cips/tatlı ve lolipop paketleri 413 adet (% 17) ile, köpük sünger 401 adet (% 16) ve plastik/polistiren parçalar (2.5-50 cm) 299 adet (% 12) ile; ilkbahar mevsiminde ise köpük sünger 833 adet (% 17) ile, plastik/polistiren parçalar (2.5-50 cm) 322 adet (% 14) ve yiyecek kapları 227 adet (% 10) ile ilk üçe yerleşmiştir (Şekil 3). Yapılan çalışmalarda, Simeonova vd. (2017) Bulgaristan kıyılarında ve Terzi ve Seyhan (2017) Doğu Karadeniz kıyılarında plastik çöpleri sayıca en yüksek yaz mevsiminde rapor edilmiştir. Topçu vd., (2013) ise Batı Karadeniz kıyılarında plastik çöplerin sayıca en fazla sonbahar mevsiminde gözlendiğini ve bu durumun şiddetli yağışlar, dalgalar ve örneklemeler öncesinde ve sırasında güçlü kuzey rüzgarlardan kaynaklanabileceğini bildirmiştir. Güneydoğu Karadeniz'de yürütülen bu çalışmada yaz mevsimi örneklemesi plaj, halk kullanımına açılmadan önce yapılmıştır. Dolayısı ile yazın bulunan yüksek çöp yoğunluğunun uzun süreli akümülasyondan kaynaklandığı düşünülmektedir. Sonbahar mevsiminde örnekleme plaj, halk tarafından kullanımın sona erdiği ve kafelerin kapandığı dönemi takiben gerçekleştirmiştir. Dolayısı ile plaj yaz ve sonbahar örneklemeleri arasında halk tarafından kullanılmış olsa da plajdaki işletme sahipleri tarafından da temizlenmiştir.

Çalışma genel olarak değerlendirildiğinde, en sık rastlanan çöp sırasıyla, köpük sünger (%19), plastik/polistiren parçalar (2.5-50 cm) (%14), kapaklar (%11), cips/tatlı ve lolipop paketleri (%10.7) ve yiyecek kapları (%9) olarak bulunmuştur. Topçu vd. (2013) Batı Karadeniz'de yaptıkları çalışmada, plastik içinde tanımlanamayan küçük parçacıkların (<10 cm) önemli yer işgal ettiğini bildirmişlerdir. Sinop Sarıkum Lagünü kıyısında hızlı tüketim ürünleri ve tanımlanamayan plastiklerin en çok rastlanılan çöp olduğunu bildirilmiştir (Vişne ve Bat, 2016). Doğu Karadeniz kıyılarında yapılan çalışmada genel paketleme ürünleri içinde yer alan köpüklerin önemli bir yer tuttuğu bildirilmiştir (Terzi ve Seyhan, 2017). Çalışmanın sonuçları Türkiye'nin Karadeniz kıyılarında yapılan diğer çalışmalarla uyum göstermektedir. Bulgaristan kıyılarında sigara izmaritleri ve filtreleri (%43.7), plastik kapaklar (%13.7) ve plastik bardaklar (%11.5) baskın çöp olarak bildirilmiştir (Simeonova vd., 2017). Güneydoğu Karadeniz'de yapılan bu çalışmada, sigara izmaritleri (OSPAR No: 64) OSPAR plaj çöpü fotoğraf kılavuzunda kâğıt/karton kategorisi içerinde değerlendirildiği için bu çalışmada yer verilmemiştir.

Tablo 1. Sarayköy plajında tespit edilen plastik çöplerin birim alandaki m^2 adet ve ağırlıkları (Ort: ortalama, Ss: standart sapma).

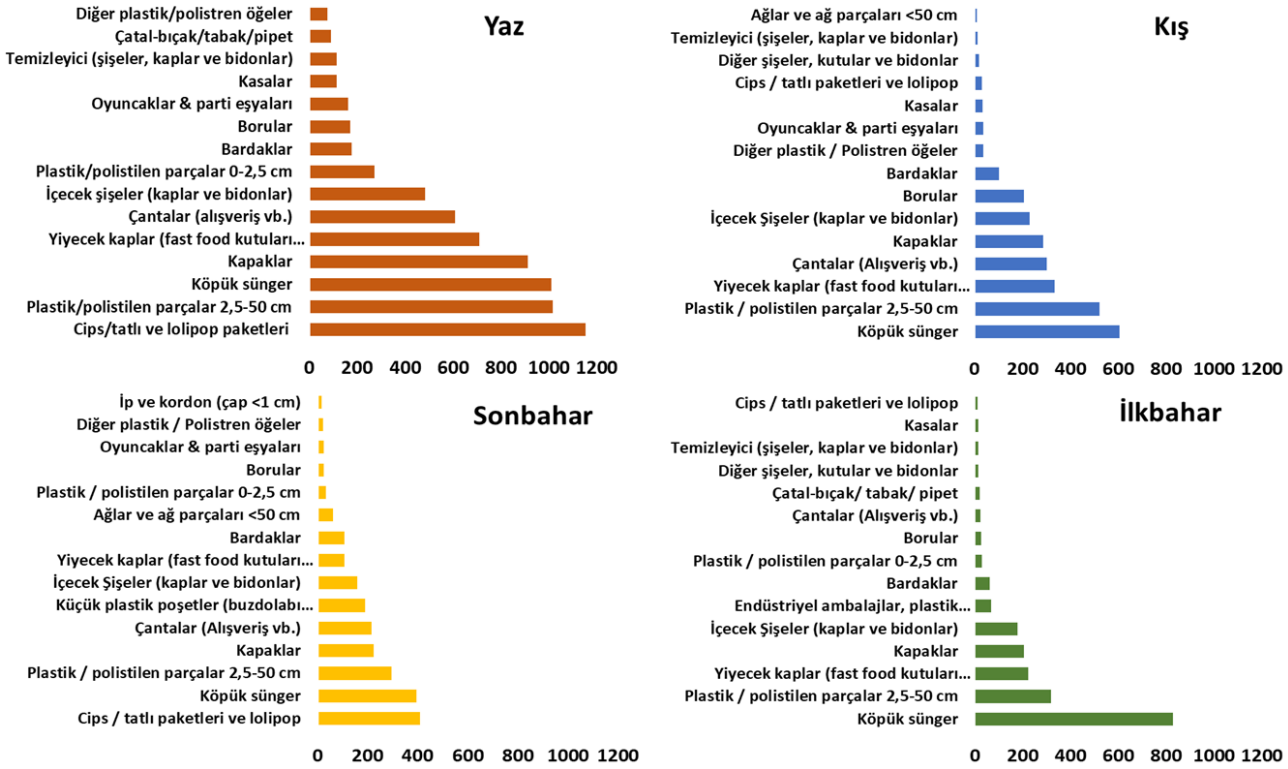
Table 1. Number and weight of plastic litter found in Saraykoy Beach (Ort: mean, Ss: standart deviation).

No	OSPAR No	Tip	Toplam (adet)	Ort	Ss (±)	Ağırlık (g)	Ort	Ss (±)
1.	1	4/6 -poşet bağları	47	11.75	20.9	330	82.5	119.6
2.	2	Çantalar (Alışveriş vb.)	1170	292.5	244.6	4109	1027.3	917
3.	3	Küçük plastik poşetler (buzdolabı poşeti vb.)	216	54	95.1	761	190.3	368.1
4.	4	İçecek Şişeler (kaplar ve bidonlar)	1071	267.75	150	23904	5975.9	3861.5
5.	5	Temizleyici (şişeler, kaplar ve bidonlar)	155	38.75	54.8	2429	607.3	1139.9
6.	6	Yiyecek kaplar (fast food kutuları dahil)	1395	348.75	261.2	8157	2039.2	1287.1
7.	7	Kozmetik (şampuan, deodorant, duş jeli vb.)	60	15	22.8	1631	407.7	586.8
8.	8	Motor yağı kapları ve bidonları <50 cm	20	5	8	1681	420.2	599.9
9.	9	Motor yağı kapları ve bidonları> 50 cm	1	0.25	0.5	1177	294.3	588.5
10.	11	Enjektörle sıkılan kutular (silikon vb.)	40	10	5.8	1412	353	476.2
11.	12	Diğer şişeler, kutular ve bidonlar	53	13.25	11	2561	640.3	646.5
12.	13	Kasalar	178	44.5	53.3	3741	935.2	1366.3
13.	14	Araba parçaları	4	1	2	129	32.2	64.4
14.	15	Kapaklar	1648	412	339.9	6924	1731.1	1396.2
15.	16	Çakmaklar	34	8.5	6.4	349	87.3	67
16.	17	Kalemler	18	4.5	2.5	135	33.8	34.5
17.	18	Taraklar/ saç fırçaları	7	1.75	2.2	130	32.4	45
18.	19	Cips / tatlı ve lolipop paketleri	1624	406	534.2	1399	349.8	422.8
19.	20	Oyuncaklar & parti eşyaları	250	62.5	70.5	3497	874.3	666
20.	21	Bardaklar	469	117.25	48.3	988	247	95.3
21.	22	Çatal-bıçak/ tabak/ pipet	124	31	44.1	109	27.4	23.8
22.	24	Fileli sebze torbaları	69	17.25	12.1	1926	481.6	297.8
23.	113	Eldivenler (sanayi/ profesyonel eldiven)	1	0.25	0.5	27	6.6	13.3
24.	114	Istakoz/ balık etiketleri	5	1.25	1	27	6.7	5.1
25.	31	Halat (çap> 1 cm)	11	2.75	1.5	335	83.7	60.3
26.	32	İp ve kordon (çap <1 cm)	24	6	10	40	9.9	11.8
27.	115	Ağlar ve ağ parçaları <50 cm	122	30.5	28.5	500	125	133.8
28.	116	Ağlar ve ağ parçaları> 50 cm	20	5	3.9	152	38.1	37.1
29.	33	Dokunmuş ağlar / kordon / halat ve ip	16	4	4.1	352	88	103.8
30.	35	Olta (misina)	4	1	1.4	618	154.5	244.6
31.	37	Şamandıralar ve dubalar	22	5.5	1.7	2231	557.7	823.4
32.	39	Çemberleme bandı	62	15.5	5.9	141	35.2	15.4
33.	40	Endüstriyel ambalajlar, plastik kaplama	123	30.75	36.9	1010	252.6	342.5
34.	41	Fiberglas	2	0.5	1	129	32.2	64.5
35.	42	Kasklar/Baretler	1	0.25	0.5	122	30.6	61.2
36.	43	Av tüfeği kartuşları	52	13	14.8	222	55.4	82.1
37.	44	Ayakkabı/ sandaletler	50	12.5	11.7	6043	1510.8	1214.7
38.	45	Köpük sünger	2858	714.5	266.9	8692	2172.9	1367
39.	117	Plastik / polistiren parçalar 0-2.5 cm	358	89.5	126.3	117	29.3	19.9
40.	46	Plastik / polistiren parçalar 2.5-50 cm	2169	542.2	336.2	16675	4168.8	2950.1
41.	47	Plastik / polistiren parçalar >50 cm	24	6	5	1720	660.1	475.2
42.	48	Diğer plastik / polistiren öğeler	167	41.75	29	2769	692.1	367
43.	Yeni	Borular	449	112.25	94.8	8440	2110	2198.5
		TOPLAM	**15193**	**3798.2**	**2971.7**	**118761**	**29690.3**	**25661.5**

Tablo 2. Plastik çöplerin tahmini kullanım alanlarının mevsimsel dağılımı (adet/100 m) (ort: ortalama, Ss: standart sapma).

Table 2. Seasonal changes on possible usages of plastic litter (number/100 m) (Ort: mean, Ss: standard deviation).

	Yaz	Sonbahar	Kış	İlkbahar	Toplam	Ort	Ss	%
İçecek	1640	506	662	480	3288	822	551.2	21.6
Tanımlanamayan	1705	417	649	414	3185	796.25	615.8	21
Yiyecek	1969	526	380	268	3143	785.75	795.9	20.5
Genel paketleme	874	607	724	246	2451	612.75	267.8	16
Balıkçılık	810	181	102	489	1582	395.5	322.9	10.4
İnşaat	547	189	412	312	1460	365	151.8	10
Giyim	28	13	0	9	50	12.5	11.7	0.3
Sigara	18	5	5	6	34	8.5	6.4	0.2
Toplam	**7591**	**2444**	**2934**	**2224**	**15193**	**3798.25**	**2723.33**	



Şekil 3. Plajda en sık rastlanan 15 plastik çöpün mevsimsel dağılım (adet/100 m).

Figure 3. Seasonal distribution of most common 15 plastic litter (number/100 m).

Çalışmada, Türkiye piyasasında bulunmayan ve yabancı ülkelerce barkodlanan çeşitli plastik şişe, kapak ve yiyecek ambalajları bulunmuştur. Toplamda 32 adet (%0.2) olmak üzere yıl boyunca en çok yabancı orijinli plastik çöp ilkbahar (%0.09) ve kış (%0.07) mevsimlerinde tespit edilmiştir. Topçu vd. (2013), Batı Karadeniz kıyılarından toplanan çöplerin yarısının yabancı kökenli olduğu ve en çok sonbahar mevsiminde gözlendiği rapor edilmiştir. Vişne ve Bat (2016), Sinop Sarıkum Lagünü kıyısında yabancı kökenli çöp miktarını %2.38 olarak belirlemiş ve çoğunlukla Karadeniz'e komşu ülkelerden kaynaklandığını rapor etmiştir. Bu çalışmada Karadeniz'de yürütülen önceki çalışmalara göre daha düşük oranda yabancı etiketli çöp bulunmuştur. Bu farklılığın plastik çöplerin çoğunun etiketlerinin okunamaz durumda olduğu ve birçoğunun küçük parçalara ayrıldığından kaynaklanabileceği gibi, bölgesel bir farklılıkta olabileceği düşünülmektedir. Sarayköy plajında bulunan çöplerin etiketleri incelendiğinde, Gürcistan, Rusya, Ukrayna ülkelerine ait oldukları ve kıyısal akıntılar

yoluyla komşu ülkelerden gelen karasal çöplerden ya da Karadeniz'deki uluslararası gemi taşımacılığıyla plaja ulaştıkları düşünülmektedir.

Plastik Çöplerin Tahmini Kullanım Alanları

Yapılan çalışmada, plastik çöplerin kullanım alanlarına göre miktarları belirlenmiştir. Çalışma yıl genelinde değerlendirildiğinde, en fazla içeceklerle (%21.6) ilgili plastik çöp bulunmuştur. Diğer kaynaklara bakıldığında sırasıyla, en çok tanımlanamayan (%21), yiyecek (%20.5), genel paketleme (%16), balıkçılık (%10.4), inşaat (%10), giyim (%0.3) ve sigara ile ilgili (%0.2) olarak sıralanmıştır (Tablo 2).

Kullanım alanlarına göre plastik çöplerin mevsimsel olarak dağılımı tablo 2'de verilmiştir. Yaz mevsimine bakıldığında, en fazla yiyecek (%26), tanımlanamayan çöpler (%22) ve içecek (%21.6) ile ilgili çöp toplanmıştır. Sonbahar mevsiminde, en fazla genel paketleme (%25), yiyecek (%22) ve içecek (%21) alanları olarak devam ederken; kış mevsiminde en fazla genel paketleme (%25), içecek (%23) ve tanımlanamayan (%22) çöpler; ilkbahar mevsiminde ise, en fazla balıkçılık (%22), içecek (%21.6) ve tanımlanamayan (%19) çöpler toplanmıştır (Tablo 2). Topçu vd., (2013)'nin yaptığı çalışmada, çöpün %52'sinin kullanım kategorisinin tanımlanamadığı ve geri kalan çöplerin çoğunun farklı kaynaklara sahip olabilecek içecekle (%19) ilişkili olduğunu rapor edilmiştir. Terzi ve Seyhan (2017)'nin yaptığı çalışmada, çöplerin bir kısmı parçalanma nedeniyle ayırt edilemez durumda olmasından dolayı kullanım alanlarına göre sınıflandırılamadığı ve tanımlanabilen çöplerin çoğunun içecek ve genel paketleme alanlarına dahil olduğu rapor edilmiştir. Tanımlanamayan plastik çöpler, UV ve dalga hareketi sonucunda her geçen gün daha küçük parçalara ayrılmaktadır (Arthur vd., 2009). Mikro- (<5mm) ve nanoplastik (<100 µm) olarak adlandırılan bu küçük plastik parçacıklar denizel yaşamı ve dolaylı olarak insan sağlığını tehdit etmektedir (Thompson vd., 2004; Browne vd., 2008; Boerger vd., 2010; Cole vd., 2013). Güneydoğu Karadeniz'de geniş bir alanı kapsayan çalışmada Aytan vd. (2016) yüzey sularında yüksek mikroplastik konsantrasyonu ($0.6\text{-}1.2x10^3$ adet m^{-3}) rapor etmişlerdir. Yakın zamanda Sinop Sarıkum kıyılarından rapor edilen bir diğer çalışmada da yüksek konsantrasyonda mikroplastik rapor edilmiştir (Öztekin ve Bat, 2017). Dolayısı ile bu çalışmada yüksek miktarda bulunan ve rüzgâr ile kolaylıkla denizel ortama taşınabilecek bu plastik parçacıkların, Karadeniz ekosistemi için ciddi tehdit oluşturduğu düşünülmektedir.

Yıl genelinde en sık rastlanan plastik çöp tipi olarak kaydedilen köpük sünger (OSPAR No:45) Topçu vd. (2013) tarafından Batı Karadeniz'de yapılan çalışmada köpük süngerin %9'luk kısmı oluşturduğu ve %0.5'lik kısmının balıkçılık kaynaklı olduğu bildirilmiştir. Terzi ve Seyhan (2013) tarafından yapılan ve Doğu Karadeniz sahillerindeki deniz çöplerinin incelendiği çalışmada ise balıkçılık sezonunda (1 Eylül-15 Nisan) yüksek oranda balıkçılar tarafından kullanılan strafor köpük kutulara rastlanmıştır. Bu durumun kutuların uygunsuz şekilde elden çıkarılmasından kaynaklandığı ve hafif oldukları için akıntılar ve rüzgarlar vasıtasıyla bir bölgeden diğerine kolayca taşınabildiği sonucuna varılmıştır. Güneydoğu Karadeniz yoğun balıkçılık faaliyetlerinin gerçekleştiği bir bölge olması dolayısı ile balıkçıllık faaliyetlerinin plajda yüksek miktarda bulunan köpüklerin önemli bir kaynağı olduğu düşünülmektedir.

Sonuç

Çalışma bölgesinde plastik çöplerin yüksek miktarda bulunması, denizel yaşam ve insan sağlığı bakımında oluşturabileceği olası tehditler göz önüne alındığında endişe vericidir. Sarayköy plajında yiyecek-içecek paketleri ve torbaları içine alacak şeklide hızlı tüketim ve genel paketlemeden gelen ürünler kirliliğin başlıca sebebi olmuştur. En sık rastlanan plastik çöp tipi olan köpük süngerlerin ise yüksek oranda balıkçılık sektöründen kaynaklandığı düşünülmektedir. Önemli bir balıkçılık alanını temsil eden Güneydoğu Karadeniz'de kıyıya ve denizel ortama terk edilecek balıkçılık kaynaklı çöpün azaltılması için balıkçılıklara çevre eğitimleri verilmesi büyük önem arz etmektedir. Ayrıca yerel yönetimlerin daha etkili çöp yönetimi sağlaması ve halkın plastikleri az kullanmaya, yeniden kullanmaya ve geri dönüştürmeye teşvik edilmesinin uzun vadede denizel ortama ulaşması olası çöplerin miktarında azalmaya yardımcı olacağı düşünülmektedir.

Teşekkür

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BEHAVIOR AND RESPONSE OF JAPANESE CATFISH (*Silurus asotus*) IN CAPTIVITY PROVIDED WITH AN ARTIFICIAL MICROHABITAT MOSAIC

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ABSTRACT

Rearing of Japanese catfish (*Silurus asotus*) requires special considerations for designing of facilities and management. Information on its biology in natural environment provides ideas for developing suitable culture systems. For this species, underwater artificial microhabitat structures are needed to perform its normal behavior. The fish shows distinct preferences for some designs based on visual cues and its decision to make use of these structures is guided by other cues probably related to light and water flow. Microhabitat structures can make a real difference to managing stress of captivity in this species. Absence of a suitable structure causes 'habitat bottleneck' that develops aggressive behavior. However, the intraspecific antagonistic behavior gives way to social tolerance among conspecifics. Microhabitat metrics is important in addition to physical attributes of the structure so as to allow social grouping in the fish under favorable conditions.

Keywords: Japanese catfish, Microhabitat, Preferences, Culture system

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Introduction

Habitat preferences of fish have been a subject of much attention in conservation and management of fish populations (Peterson et al., 2004; Gaillard et al., 2010). Recent years have witnessed a growing interest in mimicking natural conditions in culture systems for reasons of sustainability (Shapawi and Shaleh, 2015). Habitat as a package of resources (food and shelter) and environmental conditions (abiotic and biotic) determines the presence, survival and reproduction of a population (Sinclair et al., 2005). In aquaculture, efforts are made to provide suitable conditions for the stocked species but entirely replicating a vast environment with its enormous variety of resources is not achievable in a limited space. However, it is possible to imitate certain basic features (microhabitat) of the larger ecosystem.

There are many underwater environments and objects but fish selects resources and conditions that enable it to perform normal activities. Obviously, suitability of those microhabitat features would greatly influence the living condition, feeding and growth of the captive stocks. Generally, the animals select structural microhabitat (i.e., available resources or conditions) in a way that is intended to increase their performance while reducing stress (Gaillard et al., 2010). A sustained stress would obviously reduce growth and promote disorderly behavior. Underwater structure in the form of a shelter where fish spends considerable part of its time is an important microhabitat.

In this study an attempt has been made for developing a suitable culture system for the Japanese catfish (*Silurus asotus*) and for this purpose some essential information on environmental biology of the fish was necessary. A survey of published literature shows that while there is a great deal of interest in habitat selection of many fish species, there is a glaring knowledge gap as far as the Japanese catfish is concerned. The authors are not aware of any published paper on preferences of artificial microhabitats of this fish in a culture system. A pertinent research hypothesis for this study is to accept the microhabitat selection by the fish in a culture system as a process of behavioral response and making choices which would influence its condition. The objective of this work is limited to observing the artificial microhabitat preferences of the catfish when provided with a mosaic of underwater structures in the culture tanks.

Materials and Methods

Specimens of the Japanese catfish from the same stock averaging 16.9 cm and weighing 30 g were selected for the experimental trials. This size group of a sibling class was available in adequate numbers for the experiment. After 7 days of acclimatization in the hatchery, the fish were stocked at the rate of 10 specimens/ton The tanks (5-ton capacity) were aerated to maintain dissolved oxygen in the range of 5-6 ppm. The fish were offered pellet feed daily at the rate of 3% of body weight. Feed was supplied by a local company, Leong Hup Feedmill Private Limited. This feed is considered suitable generally for tropical carnivorous catfishes that require protein-rich diets.

Water was renewed daily in the morning to remove waste and maintain a good environment for the fish. One tank that served as control did not contain any artificial microhabitat (AH0) while the others were provided with underwater rounded and elongated structures of different designs that included: green high-density *polyethylene* net (AH1) (Figure 1a), green plastic grass structure (AH2) (Figure 1b) green polyvinyl chloride pipe (AH3) (Figure 1c), and grey polyvinyl pipe (AH4) (Figure 1d). These structures were similar in length (30 cm) and diameter (8 cm). Observations on the behavior of captive fish were made during day and night. These included their activities related to feeding, preference for underwater structures, swimming and other activities. Except the control set (AH0) that contained no microhabitat structure, all the other underwater structures (AH1, AH2, AH3, AH4) were placed in the same tank so as to offer equal choice to the fish to select the microhabitat structure according to its preferences. Experiment lasted three weeks. This period was enough to establish microhabitat preferences of the fish because the pattern was repeated, with no departure or exceptions under conditions the fish was exposed to.

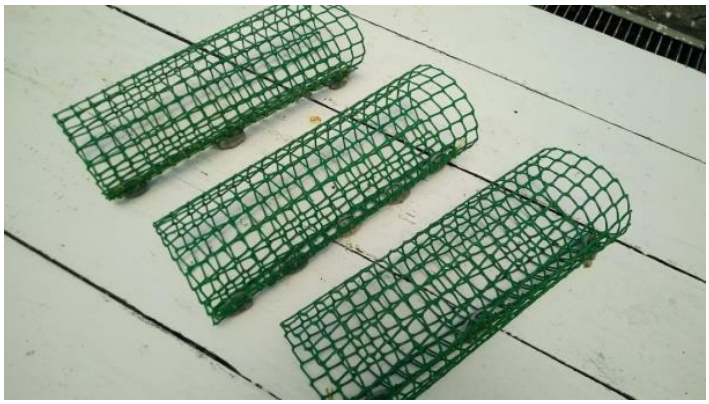

Figure 1a. Green HDPE net artificial substrate (AH1)

Figure 1b. Green artificial grass structure (AH2)

Figure 1c. Green PVC structure (AH3)

Figure 1d. Grey PVC structure (AH4).

Results and Discussion

Japanese catfish showed nocturnal feeding habit. Generally, it was inactive during the day but moved freely at night, actively looking for food. The fish did not pick up food from water column but consumed when it settled down at the tank bottom.

During the day, in tank without underwater structure (AH0), the fish showed obvious signs of stress in the form of unusual frantic movement and frequent rubbing against tank bottom. The stress appeared to have resulted in extreme aggression among conspecifics that were seen biting and injuring each other.

In order to determine what types of underwater structures can contribute to welfare of the fish, its response to a mosaic of four artificial microhabitat structures was observed. Fish were seen entering the structure AH1 that allowed a free flow of water and did not curtail light penetration. Installing structure AH2 next to AH1 resulted in the fish moving out of the latter and entering AH2 whose surface was grassy in design.

Placing other structures (AH3 and AH4) provided better insights into microhabitat selection. The fish entered AH3 and AH4 and showed no tendency to move out throughout the day. The AH3 and AH4 structures were devoid of mesh holes of the type developed for AH1 and perforations designed for AH2. These were made up of solid walls that provided more stable conditions, prevented water flow from sides and curtailed light penetration. Probably, in the dim internal environment of these opaque structures the preference for background color was not so important.

When the fish entered the stable microhabitat structures there was no aggressive behavior even though the specimens were in close proximity. Obviously, stress of not being able to find a suitable underwater shelter turns into aggression. Interestingly, this intraspecific antagonism is not a continuous process or an inherent behavior, since the same individuals interacted differently in a short period of time when conditions changed. The antagonism was strong, in the form of indulgence of physical harm, but the way it rapidly pacified when the shelter was made available was remarkable.

Nocturnal feeding behavior of the fish seen in this study is concordant with the observations made earlier in its native environment by Dulmaa (1999) and Kim et al. (2005). This pattern of behavior is probably linked to negative buoyancy of heavy anterior region and small swim bladder that do not support active forays in the water column for extended periods.

Tendency of the fish to enter the artificial microhabitat structures is consistent with its behavior of hiding under submerged objects during day time in the natural habitat. Thus, absence of any facility for shelter in the tank (AH0) was the reason for stress and aggression. Aggressive behavior displayed was typical of captive fish under stress as documented by HMC (2015). Oldfield (2011) also observed

cichlid fish in the aquarium and attributed aggression to lack of optimum conditions.

It is possible that in the absence of a microhabitat mosaic, the fish would prefer having any shelter (AH1) rather than not having any (AH0), and this might leave the fish with no option but to accept whatever physical shelter is available. Lack of a proper artificial microhabitat can be interpreted as a 'habitat bottleneck', which in this case is physical in nature. This is bound to affect the welfare of the captive fish.

It is most likely that a combination of factors, including the grassy appearance of the structure (AH2), and ability of thick artificial grass to impede free flow of water and prevented light penetration accounted for preference for AH2 vis-à-vis AH1. Investigations carried out by Katano et al. (1988) who noticed the Japanese catfish seeking areas with underwater vegetation and studies made by Huckstorf (2012) that revealed the fish's avoidance of fast-flowing water in the rivers lend credence to the present observations.

Conclusion

It seems that the fish seeks intraspecific social stability except when stress spikes and disrupts it. Based on the above observations on behavior of the catfish, it is evident that microhabitat metrics is important in a culture system. In addition to physical attributes (structure and material stability), size consideration is also necessary since this species has a tendency of staying in groups while resting, and thus the structures should have accommodating size.

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