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ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER TAM MAKALE

SLAUGHTER CHARACTERISTICS OF BIGHEAD CARP (*Hypophthalmichtys nobilis* Rich.) REARED IN POLYCULTURE BASED ON NATURAL FEEDING IN THE PONDS

Lyudmila Nikolova[1], Kostadin Dochin[2]

[1] Agricultural University, Plovdiv, Bulgaria,

[2] Institute of Fisheries and Aquaculture, Plovdiv, Bulgaria

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Corresponding author:

Lyudmila NIKOLOVA, Department of Animal Sciences, Faculty of Agronomy, Agricultural University, 4000 Plovdiv, Bulgaria

E-mail: lnn65r@abv.bg

Abstract:

An experiment on slaughter characteristics of bighead carp (*Hypophthalmichtys nobilis* Rich.) reared in polyculture of the same age, based on natural feeding in the ponds, was carried out at the Institute of Fisheries and Aquaculture – Plovdiv, Bulgaria. Some of the ponds (First Group) were not fertilized and others (Second Group) were supplemented with manure at the rates corresponding to the standards of organic production. The structure of polyculture was one and the same in all the ponds: K_1 – one-year old common carp (*Cyprinus carpio* L.) – 500 pcs.ha^{-1} (half being scale carp and the other half – mirror carp); Tp_1 – one-year old bighead carp (*Hypophthalmichtys nobilis* Rich.) – 300 pcs.ha^{-1}; A_1 – one-year old grass carp (*Ctenopharyngodon idella* Val.) – 100 pcs.ha^{-1}. The bighead carp reached a live weight of 0.766 kg under the experimental conditions, the fishes in the ponds fertilized with manure being about 13.6% heavier compared to fishes in the ponds of the other group. It was established that the slaughter yield and the relative share of the fillet in bighead carp were in average 54.3% and 35.4%, respectively, and, pond fertilization and the amount of phytoplankton did not have a statistically significant effect on fish development. The pond had a significant effect exerted through its area and by overgrowing with macrophytes. Infestation increase by up to 30% had a positive effect on the weight of the cleaned carcass, the fillet and the slaughter output.

Keywords: Bighead carp, Polyculture, Slaughter characteristics

Introduction

The technology of polyculture fish rearing is highly ecological (Nikolova, 2012). That is especially true for autochthonous polyculture based on natural feeding in the ponds. Such polyculture fully meets the standards of organic farming.

One of the most important components of the polyculture is the bighead carp (Xie, 2001). According to latest data, its annual production in Bulgaria amounts to 1 272.8 t, the species ranking third in the production structure after trout and common carp (MAF, 2015). Among the advantages of the bighead carp is its nutritional diet. Fishes of that species eat zooplankton, which develops in the ponds and the consumers increasingly prefer fish reared on natural food.

Consumers' preferences raise the interest in production systems based on natural feeding and in the quality of fish reared on natural food. At the same time, studies on autochthonous production ecosystems are still insufficient. Shi et al. (2013) studied the characteristics of the muscle nutritional composition of bighead carp fed on live food. Afzal et al. (2008) studied the growth performance of bighead carp in a monoculture system with and without supplementary feeding.

The slaughter characteristics are among the major indicators determining fish quality (Berka, 1986; Todorov and Ivancheva, 1992). They were studied in different fish species, breeds and hybrids (Hajinikolova and Grozev, 1996; Hajinikolova, 2004; Kocoura, et al., 2005) and under the conditions of different fish rearing technologies (Prikryl and Janecek, 1991; Nandeesha et al., 1998; Soliman et al., 2000; Papoutsoglou et al., 2001; Keshavanath et al., 2002; Nikolova, 2010; Varga et al., 2013).

Considering the insufficiency of data about the quality of fish reared in autochthonous polyculture, we set the aim of studying the slaughter characteristics of bighead carp reared in polyculture based on natural feeding in the ponds and the influence of some technological factors.

Materials and Methods

The study was carried out at the Institute of Fisheries and Aquaculture – Plovdiv in the frames of a research project on "Investigation on the possibility of introducing organic aquaculture in Bulgaria". Six carp-fattening ponds with a total area of 1.59 ha were used for the aim of the study. The ponds were divided into two groups: First group (three ponds) – without fertilization; Second group (three ponds) supplemented with cattle manure at the rate of 3000 $kg.ha^{-1}$. All the ponds were sterilized with burnt lime at the rate of 300 $kg.ha^{-1}$. During the 7-month vegetation period, 150 $kg.ha^{-1}$ of burnt lime were additionally used. The rate of the applied fertilizers and burnt lime were in compliance with the standards of organic aquaculture. In order to achieve the experimental aim, polyculture based on natural feeding in the ponds, i.e. "autochthonous polyculture", was established (Privezencev, 1991). One and the same stocking structure was used in all the ponds: K_1 (one-year old common carp (*Cyprinus carpio* L.) – 500 $pcs.ha^{-1}$ (half being scale carp and the other half – mirror carp); Tp_1 (one-year old bighead carp (*Hypophthalmichtys nobilis* Rich.) – 300 $pcs.ha^{-1}$; A_1 (one-year old grass carp (*Ctenopharyngodon idella* Val.) – 100 $pcs.ha^{-1}$. The initial mean weight of the common carp, bighead carp and grass carp was 0.031 kg; 0.021 kg; 0.039 kg, respectively. Routine methods applied in fishfarming were used for monitoring the environmental characteristics. Pond weed infestation was visually assessed in percentage of the total area. Four fishes from each pond were caught at the end of the vegetation season for studying the slaughter characteristics. The following indices of each individual were measured (kg): live weight; the weight of the cleaned carcass with skin and scales (without fins, intestines and head); of the skin with scales and subcutaneous fat; fins; the head without the gills; the gills; the total weight of the intestines and the fillet. The weight of the intestines also included blood and body fluids (Pokorny, 1988). The ratio between the separate body parts was calculated. The slaughter yield was calculated as a ratio of the cleaned carcass to the live fish weight and the relative share of the fillet to the cleaned carcass weight.

Polyfactor dispersion analysis was used for data processing. The linear equation model was of the following general type:

$Yijk=\mu+Ti+Bj+eijk$; (Model 1)

where: Yijk(n) – studied parameter; μ – general average constant; Ti – fixed effect of pond fertilization (manure); Bj – fixed effect of j^{-th} pond area used in the formulae as a regressor, e (…) – a residual variance.

The influence of the rest of the technological factors on slaughter characteristics was studied by including them consecutively as fixed effects under the conditions of Model 1, as follows: pond area (Model 2), pond overgrowing with weeds (Model 3), amount of phytoplankton in the pond (Model 3a).

Results and Discussion

The results of the slaughter analysis of the bighead carp were presented in Tables 1 and 2. Under the conditions of the studied technology the bighead carp reached a mean live weight of 0.766 kg, the individuals in the fertilized ponds being about 13.6% heavier compared to those in the unfertilized ponds. The mean weight of the cleaned carcass was e 0.421 kg and that of the fillet – 0.272 kg.

In a study on the growth performance of bighead carp in monoculture system with and without supplementary feeding, Afzal et al. (2008) established that in ponds fertilized with organic and mineral fertilizers, without supplementary feeding with forages, fishes having an initial weight of 0.0114 kg, reached a live weight of 0.902 kg after 12-month rearing. In our trial with supplementing the ponds with manure, the fishes having an initial mean weight of 0.021 kg, reached a mean live weight of 0.815 kg for a comparatively shorter vegetation period (7-month rearing).

Pond fertilization improves the nutrient environment of planktonphages (Grozev et al., 1999). In our study fertilization did not have a significant effect on fish development (Table 2). In both variants fishes had an equal slaughter yield, however the fillet weight of the fishes in the fertilized ponds was higher. The relative share of the fillet to the cleaned carcass was 65.5% and 63.6%, respectively, the difference being statistically insignificant (Table 1).

Table 1. Results of the slaughter analysis of fishes in the experimental ponds, kg

Indices	Fertilized		Without Manure		Total		
	LS	±Se	LS	±Se	LS	±Se	CV
Live weight	815	5.03	717	5.03	766	3.40	21.77
Head (without gills)	238.9	12.55	218.8	12.55	228.8	8.49	18.18
Gills	32.9	2.97	29.2	2.97	31.1	2.01	31.71
Skin with scales	62.5	5.52	64.6	5.52	63.6	3.74	28.81
Fins	28.0	1.41	27.2	1.41	27.6	0.96	16.96
Intestines (total)	63.1	4.59	51.4	4.59	57.2	3.10	26.57
Carcass weight	451.9	32.40	390.4	32.40	421.1	21.92	25.50
Fillet (without skin)	295.8	22.17	248.3	22.17	272.1	15.00	27.01

Table 2. Relative share of the separate parts of the fish body, % of live weight

Indices	Fertilized		Without Manure		Total		
	LS	±Se	LS	±Se	LS	±Se	CV
Head (without gills)	30.0	0.65	30.6	0.65	30.3	0.44	7.14
Gills	4.3	0.35	4.1	0.35	4.2	0.24	27.70
Fins	3.6	0.10	3.8	0.10	3.7	0.06	8.51
Intestines (total)	7.8	0.28	7.1	0.28	7.4	0.19	12.50
Carcass weight	54.3	0.83	54.3	0.83	54.3	0.56	5.09
Fillet (without skin)	36.3	1.08	34.5	1.08	35.4	0.73	10.09

Out of the studied technological factors, the pond has an effect on the slaughter characteristics of bighead carp. The pond as a factor includes the whole complex of interrelated ecological and technological characteristics. The applied poly-factor dispersion analysis showed that under the conditions of the carried out experiment, the pond had a significant effect exerted through its area and weed overgrowing. The pond area is a significant source of variation for both the growth performance, which could be seen in the dynamics of the quantitative characteristics, and, the development, reported by the differences in the relative share of the carcass and the fillet.

Macrophyte overgrowing in the experimental ponds had a significant effect on the studied characteristics. Infestation increase by 30% had a positive effect on the cleaned carcass weight (F(7.346); P<0.01) and on the fillet (F(6.448); P<0.01), (Table 3; Figure 1). Weed infestation (by up to 30%) had also a significant positive effect on the slaughter yield (F(8.790); P<0.05).

When studying the slaughter characteristics of grass carp reared under similar conditions, it was established that the increase of macrophyte infestation of the ponds by up to 30% exerted a negative effect on the weight of the cleaned carcass (Nikolova and Dochin, 2011).

Bighead carp consumes mainly zooplankton but phytoplankton is also of great importance for that fish species not only for providing feeding conditions for zooplankton but also for direct consumption.

Xie (2001) mentioned that in recent decades, there had been a number of contradictory conclusions on the digestibility of algae by bighead carp, based on the results from gut contents. The author established that bighead carps are able to collect the smallest representatives of phytoplankton, significantly smaller than their filtering net meshes, suggesting that the secretion of mucus may play an important role in collecting such small particles. Dong and Deshang (1994) mentioned that for plankton organisms about 70 µm dia., the removal rates by bighead carp were similar to those by silver carp.

Table 3. Effect of the major technological factors on the slaughter characteristics of bighead carp

Model	Factor	Live weight	Intestines		Carcass weight		Fillet	
		kg	*kg*	*%*	*kg*	*%*	*kg*	*%*
	Manure	1.735	2.982a	2.715	1.665	0	2.118	1.209
1	Pond	27.241c	22.397c	0.806	23.579c	3.386a	18.497c	0.027
	Manure	2.474	3.649a	2.58	2.394	0.005	3.025a	1.194
	Pond area	12.423b	7.017a	0.013	12.773b	6.784a	12.224b	1.632
2	Pond	0.19	0.347	0.134	0.03	1.238	0.023	0.993
	Manure	1.51	2.962	3.736c	1.139	1.064	1.79	0.813
	Overgrowing	6.319b	3.341a	0.737	7.346b	8.790a	6.448b	0.831
3	Pond	0.702	0.146	0.746	1.369	3.432a	0.488	0.043
	Manure	0.598	0.88	0.344	0.809	0.283	0.721	0.223
	Phytoplankton	0.126	0.356	1.206	0.014	0.749	0.162	0.332
3a	Pond	16.356 c	12.503b	0.019	14.972b	4.004a	10.723b	0.035

a P<0.05; b <0.01; c P<0.001

Cooke et al. (2009) studied the effect of the amount of plankton on the development of bighead carp and they found out that there was a close interrelation between the biomass of the phytoplankton and the fish growth. The authors underlined that the insufficient amount of plankton biomass could be a limiting factor for growth.

Under the conditions of the carried out experiment, we established a significant effect of plankton development on growth and slaughter characteristics of bighead carp (Table 3; Figure 2). That was probably due to the slight differences in the amount of phytoplankton in the ponds included in the separate variants.

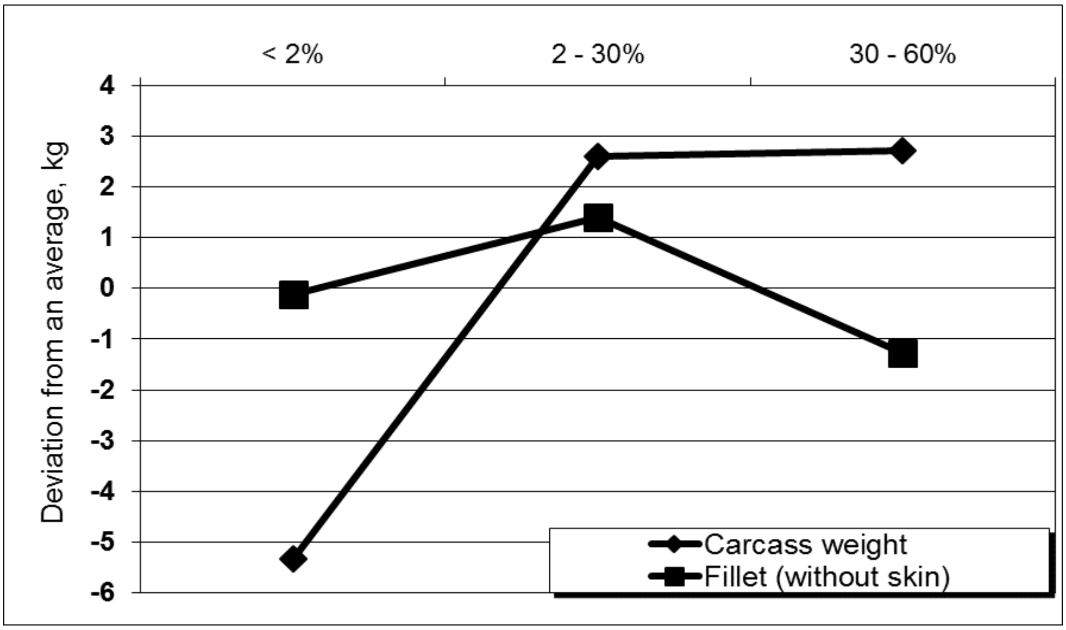

Figure 1. Effect of pond overgrowing on the slaughter characteristics of bighead carp

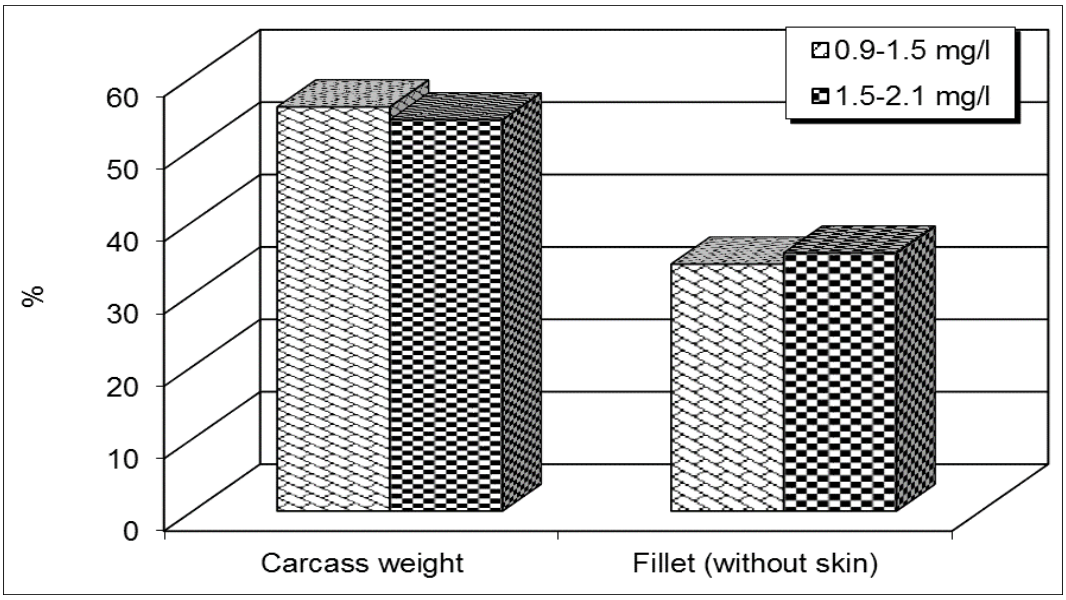

Figure 2. Effect of the amount of phytoplankton on the slaughter characteristics of bighead carp

Conclusion

Under the conditions of autochthonous polyculture of the same age (one-year old common carp (*Cyprinus carpio* L.) – 500 pcs.ha^{-1} (half being scale carp and the other half – mirror carp); bighead carp (*Hypophthalmichtys nobilis* Rich.) – 300 pcs.ha^{-1} and grass carp (*Ctenopharyngodon idella* Val.) – 100 pcs.ha^{-1}), the bighead carp reached a mean live weight of 0.766 kg, the fished in the fertilized ponds being about 13.6% heavier compared to the fishes in the unfertilized ponds. The slaughter yield of bighead carp and the relative share of the fillet were in average 54.3% and 35.4%, respectively. Pond fertilization and the amount of phytoplankton did not have a statistically significant effect on fish development. An effect on the slaughter characteristics was exerted by the pond through its area and macrophyte overgrowing. The increase of weed infestation up to 30% had a positive effect on the cleaned carcass weight, the fillet and the slaughter output.

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SHORT COMMUNICATION KISA MAKALE

EVALUATION OF FISHING VESSEL BUYBACK PROGRAM IMPLEMENTED IN TURKEY DURING EU ACCESSION PROCESS

Serpil Yılmaz, Esra E. Bilgin, M. Tunca Olguner

Akdeniz University Faculty of Fisheries, Department of Fisheries Technology, Antalya, Turkey

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Corresponding author:

M. Tunca OLGUNER, Akdeniz University Faculty of Fisheries, Department of Fisheries Technology, Antalya, Turkey

E-mail: olguner@akdeniz.edu.tr

Abstract:

There have been important developments in the number of fishing vessels, size and engine power due to low-interest loans and customs exemptions provided by the state in the 1970s and fishing vessel numbers showed a rapid increase especially after 1980 in Turkey. However, marine fisheries production has been decreasing since 1985 despite the rapid development of the fishing fleet, leading to a decline in the real income of fishermen. In Turkish seas, there are 15.680 licensed fishing vessels actively operating with different depths in 2015. When the number of fishing vessels in Turkey is compared to those of the EU countries except Italy and Spain, vessels in these countries are found to be less than in Turkey. The situation is particularly damaging the ecosystem and the fish stocks by wrong fishing techniques. One of the most important ways to solve this issue is the repurchase “buyback” programs that are commonly encouraged by regulations of the state. In fact, most of the EU countries having advanced fishing industry decided that the reduction of fishing fleet is an effective solution and they have accepted to put it into practice.

Keywords: Fishing vessels, Buyback program, Common fisheries, EU accession

Introduction

As stated in the Turkey's National Five-Year Development Plan issued in 1963, the reported fisheries production was approximately 155 thousand tons between 1963 and 1967. The production rised to 676 thousand tons in 1988 by the increase in the number of fishing vessels. One of the reasons for such growth in the fishing industry is the easy loan opportunity upon acceptance of vessels and equipment by the Ziraat Bank based on decisions taken in the Five-Year Development Plan and the other is customs exemption (DPT, 1990-1994). However, it is observed that the fish consumption per capita was about 2 kg in 1963 and about 12.2 kg in 1988. This case demonstrates the rising awareness of the Turkish people on healthy nutrition and fish products are proved to be affordable and accessible to consumers.

There has been significant increase in the size and the engine power of fishing vessels, especially after 1980. However, marine fisheries production has been decreasing since 1989 despite the rapid development of the fishing fleet, leading to a decline in the real income of fishermen. This case has resulted from an unplanned increase in fishing due to free entry system to fisheries and resulted in overfishing and excessive fishing pressure on fish stocks (Atay et al., 1995).

After the problems of existing vessel buyback program in Turkey were introduced, suggestions were presented on "what can be done?" issues on the legal basis and restructuring of the fishing fleet in terms of EU harmonization. According to these results, as similar to those in the EU, it was concluded that we must have an appropriate fisheries management in Turkey.

Materials and Methods

This research was based on literature and legislation analysis. The main material of the study consists of various research sources related to regulations and topics in the EU and Turkey fisheries. In this context, published articles, previous reports and statistic data were used. Recent developments, especially concerning the EU, were obtained from the EU study reports and web browsing. Besides, the information was collected through the mutual discussions and correspondence with relevant institutions in Turkey. In addition, this study is carried out by having face to face discussions with a number of fishermen who participated or did not participate in the buyback program to find out their opinions on the program.

Within the scope of the Common Fisheries Policy (CFP), comparisons are made among the fisheries legislations that are being implemented in Turkey, for the establishment of administrative structures and implementation mechanisms associated with the legal basis in fisheries in the EU. Regulations of vessel buyback program, which were developed for the fisherman by considering the quality and standards regulating the implementation details covered in the CFP of EU, assistance and support mechanisms have been investigated. Several comparisons have been made between the vessel buyback programs in the EU and Turkey. Positive and negative aspects have been put forward.

In this context, publications, statistics and activity reports of the European Commission's Representation in Turkey, SPO (State Planning Organization), TSI (Turkish Statistical Institute), the subunits of Food, Agriculture and Livestock Ministry organizations including FIS (Fisheries Information System – SUBIS) and GDFA (General Directorate of Fisheries and Aquaculture - BSGM) were used.

Some authorities of the mentioned institutions were interviewed face to face and information was gathered directly. In these interviews, views and expectations about the process are discussed, especially recommendations for the problems and solutions related to fisheries management in Turkey that is taking place with the EU.

Results and Discussion

Due to overfishing, pollution and ecological changes originated from fishing, the marine fisheries production dropped to 342 thousand tons in 1990 (Table 1). Since then, export of seafood products in Turkey decreased while imports increased. Turkey received 80 million US dollars of 147 milion US dollars of income from exported fisheries products from Europe in 1996. (Özdemir and Aras, 2005). In 1997, application of the European Union's non-tariff barriers to some seafood decreased the export revenue more and seafood production also decreased gradually after 1995. Due to all kinds of hygienic deficiencies in 1998, mussels, clams, fresh fish and shellfish export were strictly prohibited from Turkey to EU countries.

Table 1. Capture production and number of marine fishery vessels between 2001 and 2014.

Years	Capture Fisheries (ton)	Number of Vessels	Production per vessel (ton)
1970	170.905	6.376	26,8
1975	103.666	4.520	22,9
1980	397.321	6.764	58,7
1985	532.602	8.604	61,9
1990	342.017	8.749	39,1
1995	582.610	9.710	60,0
2000	460.521	13.381	34,4
2001	484.410	12.989	37,3
2002	522.744	17.696	29,5
2003	463.074	18.542	25,0
2004	504.897	17.953	28,1
2005	380.381	18.396	20,7
2006	488.966	17.823	27,4
2007	589.129	17.681	33,3
2008	453.113	17.161	26,4
2009	425.275	16.845	25,2
2010	445.680	16.650	26,8
2011	477.658	14.300	33,4
2012	432.442	14.324	30,2
2013	374.121	13.727	27,3
2014	302.212	14.595	20,7

Source: GTHB (2015a, b)

According to Table 1, decline and fluctuations in the production continued with the reduction of anchovy stock in 2005. The major reason for the case is that Turkey has the high fishing capacity with too many fishing vessels, causing a pressure on the fish stocks.

Comparison of number of fishing vessels of EU and Turkey

Sustainable fisheries have started to attract more attention in the world. Because of a rapid decline in the fish stocks since the early 1980s, the concept of sustainable development is very important for the world and for the products (Çevirme, 2015). The basic principles of the CFP in the European Union is to record and monitor. The area where fishing vessels can perform fishing in territorial waters was restricted to 12 nautical miles and they must have license and permission to fish. Vessels exceeding 15m in length should be equipped with remote management systems and are required to keep a record of all fishing activities. In order to establish a fleet registeration at Community level, Member States are obliged to keep a record of fishing vessels flying their flag to the Commission. Community participation in the fleet and exits from the fleet are regulated by specific rules.

In Turkey, "logbooks and vessel monitoring system" issues have been discussed by the year 2000. Application of monitoring system started in the large tuna fishing vessels in 2007 and these systems are known to have been applied in fishing of bluefin tuna in 2010. Obligations on keeping logbook have also been brought into fishing vessels which are 12 meters and longer in 2008 and after this, significant progress has been made in controlling and monitoring fishing activities.

However, due to the absence of detailed information regarding the size of fish stocks in Turkish seas , the annual amount of fishing and the size of the fishing fleet cannot be fully estimated for optimum fishing from this stock. Common Fisheries Policy legislation of EU also aims to protect the main sources. The most important tools used to achieve this goal are the total allowable catches (fishing quotas). To avoid exceeding these quotas, catches must be emptied on their specific landing points. This application has also a great significance for the collection of statistical information regarding fishing activities. Thus, locations to be used as landing points and necessary buildings with equipment and personnel should be kept ready (Balta, 2009). In this sense, there are 34 landing points known in Turkey although uncontrolled landing points are also available. Therefore, it is unlikely exceed the sustainable production that can be taken from the fishing quotas for fishing control and supply. It is still an attempt to preserve the existing stock by banning and limiting the fishing (Atay et al., 2000).

Nevertheless, the situation is particularly damaging the ecosystem and the fish stock with the wrong fishing techniques. One of the most important ways to prevent this situation is the repurchase “buyback” programs that are commonly encouraged by regulations of the state. In fact, most of the countries in the EU that have advanced fishing industry, decided that the reduction of fishing fleet is an effective solution and they have accepted to put it into practice.

Buyback programs that started in the 1970s in the world passed a variety of tests and have been implemented in different conditions. The first buyback program was introduced in the Canada salmon fishing in 1970 with the step-by-step application of four programs. Vessels and licenses were initially withdrawn, but 47% of fishermen got back to fishing again (Kurt and Muse, 1984). The reasons for evaluating repurchase of vessels by fishermen and getting back to salmon fishing in Canada are valid for Turkey. Studies have shown that 61% of fishermen participating in the buyback program in Turkey will return to fishing industry again. The reason for the high rate of interest in fishing is that, it is the only source of income for the majority of fishermen who have commonly low levels of education and are lacking other qualifications (Unal et al., 2014).

Especially in the 1970s, the amount of fishing vessel showed a rapid increase due to low-interest loans and customs exemptions provided byTurkish government . A total amount of fishing vessel was 8646 in 1991, and it has increased by 81% with 15680 fishing vessels today (GTHB, 2015a). Ministry of Food, Agriculture and Livestock in Turkey stopped the new licensing for fishing vessels since 1991. However, new vessels were added to the fleet after amnesty announcements in 1994, 1997 and 2001 and the licensing has been terminated for fishing vessels again since 2002.

When the number of Turkey's fishing vessels compared with EU countries, the closest country to the number of vessels in our fleet is Greece with 15 693 vessels. But all EU countries including Greece are successful in reducing the number of fleets (Table 3) (Eurostat, 2014).

Under the Common Fisheries Policy (CFP), reduction of fleet capacity is an essential tool for achieving a sustainable exploitation of fisheries resources. The EU's fishing fleet capacity has declined steadily since the early 1990s, in terms of both tonnage (an indicator of fish-holding capacity) and engine power (an indicator of the power available for fishing gear). The size of the EU-28 fishing fleet dropped to about 85 800 vessels in 2014 compared to 95 300 vessels for the EU-15 in 2000, although it increased by 7.2 % between 2012 and 2013 following the Croatia's EU accession (Eurostat, 2014).

The size of the fishing fleet in Turkey is a problematic issue in the EU negotiations. However, there has been some progress in sources and fleet management, inspection and control and international agreements according to 2015 progress report of Turkey. Indeed, programs supporting the removal of fishing vessels have achieved a remarkable progress in the fleet management.

Table 2. Fleet structure in the capture fisheries in Turkey (GTHB 2015b).

Fishing Type	Fishing Method	Number and Ratio (%)	Production (%)
Commercial Fisheries	Purse seiner	485 (2,8)	80
	Trawler	669 (3,9)	10
	Purse seiner- Trawler	337 (1,9)	
	Total	1491 (8,6)	90
Shore Fishermen	Traditional Method	15.674 (91,4)	10
Marine Fishing Vessel		17.165	92
Inland Fishing Vessel		3.124	8
Total		**20.289**	**100**

Table 3. Fishing fleet by country between 2000-2014

	2000	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
EU (*)	95 285	88 947	83 534	81 987	80 643	86 479	85 768
Belgium	129	120	89	86	83	80	79
Bulgaria			2 340	2 336	2 366	2 043	1 951
Czech Republic	-	-	-	-	-	-	-
Denmark	4 138	3 264	2 819	2 784	2 743	2 663	2 449
Germany	2 315	2 116	1 673	1 582	1 550	1 533	1 492
Estonia		1 044	934	923	1 360	1 445	1 515
Ireland	1 621	1 860	2 144	2 187	2 247	2 197	2 157
Greece	19 598	17 965	17 032	16 527	15 981	15 790	15 693
Spain	16 685	13 705	10 851	10 505	10 116	9 872	9 632
France (**)	8 229	8 239	7 219	7 207	7 142	7 125	7 069
Croatia						7 039	7 313
Italy	17 369	14 397	13 444	13 043	12 731	12 650	12 451
Cyprus		882	1 003	1 078	1 074	894	949
Latvia		928	786	731	715	703	700
Lithuania		267	171	151	148	146	142
Luxembourg	-	-	-	-	-	-	-
Hungary	-	-	-	-	-	-	-
Malta		1 4118	1 091	1 054	1 043	1 032	1 020
Netherlands	1 101	825	846	841	848	846	831
Austria	-	-	-	-	--	-	-
Poland		974	793	790	798	838	873
Portugal	10 677	9 113	8 440	8 346	8 269	8 216	8 172
Romania			476	502	195	194	158
Slovenia		175	182	182	174	170	169
Slovakia	-	-	-	-	-	-	-
Finland	3 664	3 268	3 366	3 332	3 241	3 211	3 179
Sweden	2 019	1 599	1 360	1 369	1 392	1 368	1 365
United Kingdom	7 740	6 788	6 475	6 431	6 427	6 424	6 409
Iceland	1 997	1 756	1 628	1 658	1 691	1 692	
Norway	13 017	7 723	6 309	6 250	6 211	6 126	

(Eurostat, 2014)

The Czech Republic, Luxembourg, Hungary, Austria and Slovakia are landlocked countries without a marine fishing fleet.

* EU-15: 2000; EU-25: 2005; EU-27: 2010; EU-25: from 2013

** French data include vessels registered in the French Overseas Department.

Table 4. Total support amount for buyback programs (GTHB 2015a, b).

Buyback programs		**Withdrawn vessels (number)**	**Support amount (TL)**	**Decrease in the fleet (%)**
1st Program 2012-2013	12 m and above	364	62 million	19,5
2nd Program 2013-2014	10 m and above	446	51 million	19,4

Table 5. Support made for buyback programs since 2013 (GTHB 2015a, b).

Year	**Mechanical and Chemical Industry Corporation (number)**	**Handed over (number)**	**Total (number)**	**Support Amount (TL)**
2013	335	29	364	62.083.850
2014	446	10	456	54.028.571
2015	180	11	191	22.515.942
Total	961	50	1011	138.628.363

Turkey has started a vessel repurchases support program based on the vessel lengths in 2012 under the Common Fisheries Chapter 13 in EU-Turkey negotiations. In 2013, 62.1 million Turkish Liras (TL) have been paid to support the withdrawal of 364 fishing vessels (19.5%) from the fleet (Olguner and Yılmaz, 2015). On the basis of decisions taken in 2012, scope of support has been progressively expanded to over 12-meters-long vessels in 2013 and to 10-meters-long vessels between 2014-2015 to remove from the fleet and the support payment of nearly 138,6 million TL has been made for 1011 fishing vessels (Table 5). Qualified fishing vessels removed from the fleet have been handed over to universities and research institutions for use in educational activities (18 fishing vessels), the Provincial Directorate of Agriculture for use in inspection purposes (12 fishing vessels) and Mechanical and Chemical Industry Corporation for the separation processes (335 fishing vessel) (GTHB 2015b).

Table 6. Support amounts for vessel length in first and second buyback programs (GTHB 2015b).

Number	Vessel length (m)	Amount per meter (TL)
1	12-20 (10-20)	10.000
2	21-30	15.000
3	31 and above	20.000

Table 7. Support amounts for vessel length in a third buyback program (GTHB 2015b).

Number	Vessel length (m)	Amount per meter (TL)
1	10-20	10.000
2	21-30	15.000
3	31-34	20.000
4	35-45	30.000
5	46 and above	35.000

The amount of support made to the owners to remove their vessel from the fishing in the 1st and 2nd Buyback (Repurchase) Program (Table 6); was 10 thousand TL (Turkish Liras) for 10-20 meters fishing vessel, 15 thousand TL for 21-30 meters fishing vessel, 20 thousand TL for 31 meters and longer fishing vessels. In the 3rd Buyback (Repurchase) Program (Table 7) by changing the amount to support longer vessels 20 thousand TL for 31-34 meters fishing vessels, 30 thousand TL for 35-45 meters fishing vessels and 35 thousand TL for 46 meters or more fishing vessels, payments made for support.

Turkey currently has no fishing laws in accordance with the EU acquis. Since the second five-year development plan (including the 1968-1972) "offshore fishing" goals have been mentioned until today. However, it is noted in the Eighth Development Plan that the lack of infrastructure results in not achieving this goal. The repurchase program initiated in 1970 in the world, however, it is mentioned in the report of 2012 in the section regarding management of resource and fleet. The competition among the fishermen in fleet in different types of fishing is the weakest spot in the fisheries sector thus it consists of the over-fishing of some fish stocks. Indeed, developed countries such as the EU have overcome these problems with scientific knowledge and the Common Fisheries Policy by assessing the developments in fishing with data. Continuously reported data of stocks is not available in Turkey and hence scientific fisheries management policy could not be established yet. Participation of fishermen into fishing vessel repurchase program is unsatisfactory in Turkey and even some of participants returned to fishing, and other fishermen disposed of their vessels. On the other hand, old licensed vessels can be sold to a new entrepreneur with a higher price with respect to the amount of support as the state has not provided any new licenses since 2002.

Conclusion

According to discussions with fishermen, it can be concluded that 24 meters and longer ships may reduce the fishing pressure and 12 meters and shorter vessels are not effective. In fact, the share of fishing with 24 meters and longer vessels was found to be 80%. These vessels are usually purse seiners especially fishing for anchovies, sardine and sprat. Therefore, the vessel buyback program undertaken for several years has not achieved a significant reduction in the number of fleets. The fishermen believed that reducing the vessel size to 10-meter after two years hindered the program's success. Thus, it is observed that the buyback program in Turkey does not reach the desired level compared to the EU. For program's success, manufacturer's awareness should be encouraged to a certain level of social and economic development with a good fisheries management and with the marine protected areas. Because of these low levels, the fisheries sector is more problematic than any other sectors. In this context, training should be given along with support mechanisms for sustainability.

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THE ROLE OF MICROECONOMIC STUDIES IN DECISION-MAKING OF FISHERY MANAGEMENT

Günay Güngör

NKU Faculty of Agriculture, Agricultural Economics, Tekirdağ, Turkey

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Corresponding author:

Günay GÜNGÖR, NKU Faculty of Agriculture, Agricultural Economics, Tekirdağ, Turkey

E-mail: **gunaygungor99@gmail.com**

Abstract:

The need for fisheries management arises as the surplus production from fish stocks is overtaken by the catching capacity of fishing fleets. In general, terms the goals in fisheries management can be divided into four subsets: biological; ecological; economic and social, where social includes political and cultural goals. Identifying such goals is important in clarifying how the fish resources are to be used to benefit society, both at the economic and policy level. Without such goals, there is no guidance on how the fishery should be operated and managed. The study was yielded some microeconomic analysis results such as value of gross output, variable and fixed costs, gross and net profit, average fishing income, non-fishing income and household income.

This research aimed at computing the income level of the fishermen, fishing of the Northern part of Turkey in the Sea of Marmara and examining the cost-profit relationship with regard to vessel size. 231 vessels sorted with respect to size and grouped under four classes. Stratified random sampling method was used to determine survey sample size. 156 vessels from the first group, 46 from the second, 15 from the third, and 14 from the fourth group were included into the survey.

Keywords: Fishing economics, Cost, Profit

Introduction

Production is a process of combining various material inputs and immaterial inputs (plans, know-how) in order to make something for consumption (the output). Economics is defined as the study of how limited resources can best be used to fulfill unlimited human wants. In a production process, all economic activities aim directly or indirectly to satisfy human needs.

So, agricultural production economics is about how to use economic principles for making agricultural production decisions.

There are three ways to use economic principles for making agricultural production decisions efficiently:

1. Input-Input Relationship-Input optimisation (Which ınputs should be preffered?)
2. Output-Output Relationship-product optimisation (Which product should be produced?)
3. Input-Output Relationship-maksimum profit at optimum cost (How much/many product must be produced at optimum (where Marginal Revenue is equal to Marginal Cost)?).

Fish and fisheries are an integral part of most societies and make important contributions to economic and social health and well-being in many countries and areas. Some 58.3 million people were engaged in the primary sector of capture fisheries and aquaculture in 2012 all over the world. Of these, 37 percent were engaged full time. It has been estimated that approximately 163 million people are directly employed in fishery activities (47.000 in Turkey). "In recent years globally production from capture fisheries has tended to vary between approximately 85 and 90 million tonnes. The total number of fishing vessels was estimated at 4.72 million in 2012. Globally, 57 percent of fishing vessels were engine-powered, but the motorization ratio was much higher (70 percent). 79 percent of the world's motorized fishing vessels were less than 12 m length overall. About 200 countries reported exports of fish and fishery products. Fishery exports reached a peak of US $129.8 billion in 2011, up 17 percent on 2010, but declined slightly to US $129.2 billion following downward pressure on international prices of selected fish and fishery products in 2012. The fishery trade is especially important for developing nations" (FAO, 2014) .

The need for fisheries management arises as the surplus production from fish stocks is overtaken by the catching capacity of fishing fleets. In general terms, as Cochrane stated in 2002, the goals in fisheries management can be divided into four subsets: biological; ecological; economic and social, where social includes political and cultural goals:

- to maintain the target species at or above the levels necessary to ensure their continued productivity (biological);
- to minimise the impacts of fishing on the physical environment and on non-target (by-catch), associated and dependent species (ecological);
- to maximise the net incomes of the participating fishers (economic); and
- to maximise employment opportunities for those dependent on the fishery for their livelihoods (social).

This research study aims at computing the income level of the fishermen in Turkey with the example of the Marmara Sea and examining the cost-profit relationship with regard to vessel size to maintain some contributions for more realistic fisheries management policies.

Identifying such goals is important in clarifying how the fish resources are to be used to benefit society, and they should be agreed upon and recorded, both at the policy level and for each fishery. Without such goals, there will be no guidance on how the fishery should be operated and managed. The study was yielded detailed analysis results of production economics such as value of gross output, variable and fixed costs, gross and net profit, average fishing income, non-fishing income and household income.

"The research area, Marmara Sea, is an important place in the fishing of especially pelagic fish that migrate, being the passage zone between the Black Sea and the Aegean through the Bosphorus and the Dardanelles straits in Turkey. It's known to be the spawning and feeding area of pelagic fish especially, due mainly to the low salinity of the surface waters flowing in through the straits and the nutrients they bring. The bluefish (*Pomatomus saltatrix* Linnaeus) is among the foremost pelagic fish species with regard to its economic contribution and traditional fishing" (Akyol et al., 2006).

Fishes such as anchovies, horse-mackerel, bonito, sardines, shrimps, red mullet and striped red mullet, turbot, sole, European hake, picarel, twait shad, European horse mackerel and mullet are fishery products of primary economic significance, whereas seafoods such as sea robin, octopus, ray, shark, needlefish, sea snail and clam secondary economic significance in Marmara Sea. Looking at the management of the fishing activities in Turkish seas, including the Sea of Marmara, it is possible to assert that there are many aspects that do not run smoothly and that it lacks an effective resource management strategy. Because both large fishing boats and small coastal fishing boats display a highly dispersed structure. The fisheries rules are continually infringed and the investments in fishing capacity constantly increase without considering the existing resources (i.e. the stock of fish that can be caught), which causes the fishing fleet to grow constantly both in quality and quantity, creating excessive pressure on fish inventory.

Using stratified random sampling method, 156 vessels from the first group, 46 from the second, 15 from the third, and 14 from the fourth group have been included into the survey. The tables include detailed economic analysis results such as value of gross output, variable and fixed costs, gross and net profit, average fishing income, non-fishing income and household income. For instance, the net annual profits are calculated to be 7,403.3€, 19,072.9€, 188,814.2€ and 360,037.5€ respectively for the first, second, third and fourth groups.

Materials and Methods

Stratified random sampling method was used to determine survey sample size. Face-to-face interviews were held with the fishermen to compute the income level of the fishermen fishing in the Sea of Marmara and to examine the cost-return relationship with regard to vessel size. The number of vessels involved in fishing activities in the region and holding a fishing permit was determined to be 2523.

Table 1. shows the distribution of the vessels with fishing permits among size groups and prov- inces. A total of 231 fishing vessels from 22 locations in 7 provinces, which pursued fishing activities in the Sea of Marmara during 2011-2012 fishing season were the main source of primary data. The vessels were sorted with respect to size and grouped under four classes as vessels under 8.9m; vessels ranging from 9m to 15.9m; from 16m to 25.9m; and over 26m in size, considering fishing methods and intensities.

Distribution of fishing vessels was taken from the official records of General Directorate of Fisheries and Aquaculture (BSÜGM). The vessels were sorted with respect to size in increasing order and grouped under four classes considering fishing methods and intensities. Table 2 shows number of samples by the size groups and provinces. 156 vessels from the first group, 46 from the second, 15 from the third, and 14 from the fourth group were included into the survey, according to sample size computations using the following formula (Yamane, 2001):

$$n = \frac{N \Sigma (Nh\, Sh^2)}{N^2 D^2 + \Sigma\, Nh\, Sh^2}$$

where;

n: Total sample size, N: Total number of enterprises, N_h: Number of enterprises in a given stratum, S_h: Standard deviation of the given stratum, S_h^2: Variance of the given stratum,

D^2: Margin of error of population mean

($D^2 = d^2/Z^2$, $d = 0.05 * X$)

Z: Z score, or standard normal deviate for 95% confidence interval (1.96)

The tables included economic analysis results such as value of gross output, variable and fixed costs, gross and net profit, average fishing income, non-fishing income and household income. The data were converted to Euro values using the offical Central Bank of Turkey exchange rate of 1€ =2.4TL on 1st January, 2012, pertaining to the fishing season where the survey was carried out.

Table 1. Fishing Vessels in Marmara Region by the Size Groups and Provinces (2012)

Provinces	1	2	3	4	Total	%
	<8.9 m	9-15.9 m	16-25.9 m	>26 m		
Çanakkale	472	87	12	4	**575**	**22.8**
Istanbul	432	103	15	12	**562**	**22.3**
Balıkesir	205	161	119	45	**530**	**21.0**
Kocaeli	335	8	3	2	**348**	**13.8**
Yalova	137	50	5	6	**198**	**7.8**
Tekirdağ	119	68	4	4	**194**	**7.7**
Bursa	71	28	9	7	**115**	**4.6**
TOTAL	**1770**	**506**	**167**	**80**	**2523**	**100.0**
%	**70.2**	**20.1**	**6.6**	**3.2**	**100.0**	**-**

Reference: TÜIK, 2013.

Table 2. Number of Samples by the Size Groups and Provinces

Provinces	1	2	3	4	Total
	<8.9 m	9-15.9 m	16-25.9 m	>26 m	
Çanakkale	34	10	3	3	51
Istanbul	36	10	3	3	53
Balıkesir	33	10	3	3	49
Kocaeli	22	6	2	2	32
Yalova	12	4	1	1	18
Tekirdağ	12	4	1	1	18
Bursa	7	2	1	1	11
TOTAL	156	46	15	14	231

Reference: TÜIK, 2013.

Results and Discussion

It is important for the management authority to consider the broad economic context of fishery, including relevant macroeconomic factors. Realistic goals and objectives must be established across ecosystems, so as to manage for species and fisheries interactions. The potential yield and profits according to vessel size needs to be estimated to maximise the net incomes of the participating fishers. The ability of fishery economics to provide a consistent framework for the analysis of policy problems thus enables it to make a key contribution to development of fishing people. Development of fishing people is very important for sustainability and scarcity of naturel resources.

It is possible to group professional fishing in Turkey under two main categories:

1. Coastal fishing (small size vessels ranging between 10 to 29 meters)
2. Long-range fishing (vessels larger than 30 meters; (sweep-nets, trawls and sweep-trawls)

Table 3 shows, number of fishing vessels by size groups in Turkey. According to the statistics, there are currently about 14.500 vessels in Turkey. 24% of which are active in the research area. 82% of the vessels consist of small fishing boats under the size of 10 meters same as in Turkey (Table 4). The vessels shorter than 20 m are income tax free in Turkey according to general support policy for agricultural products. So then total income level directly increases at least 20-25% yearly. Because the income tax rates are between 15-35% according to income level.

Costs of Fishery Products

All the costs faced by companies can be divided into two main categories: fixed costs and variable costs. These categorisation is also true for fishery activities. Variable costs are costs that vary with output while fixed costs are costs that are independent of output. Variable costs are also the sum of marginal costs over all units produced. Variable and fix costs can be defined for fishery activities as:

Variable costs are costs that change in proportion to the fish amount that caught by a vessel. But fixed costs are independent of seafood amount caught. Fixed costs and variable costs make up the two components of total cost.

The distribution of fishery costs in Turkey announced by the Turkish Statistical Institute showed in table 6. As it could be seen in the table, the biggest cost item is fuel and the second one is crew costs. The second support policy for fishermen is tax free fuel oil application. In 2012, 5513 recorded fishermen benefited this support in Turkey (Ubak 2016).

Finally, the distribution of fishery costs in research region was shown in table 5. As it could be seen the differences between the table 5 and 6. The middlemen and marketing costs determined approximately 23% in Marmara Sea while about 5% in General. Therefore, the fishery managers could be aware of the differences and reasons of this difference among regions and between the vessels sizes.

Total Gross Product of Fishery Activities

Coastal fishing vessels, are those that usually exploit local areas in nearshore waters for daily fishing trips using various fishing instruments such as lines, setlines, seines (pelagic seine-nets), drive-in nets, beam trawls, and dredges in Marmara Sea. These vessels are smaller than 12 meters in size generally.

A variety of pelagic, demersal and benthic fish and marine species such as bonito, bluefish, turbot, whiting, red mullet, twait shad, grey mullet, needlefish, horse mackerel, hake, sole, shrimps, sea snail, and mussels can be caught with these nets.

Table 7 shows a hypothetical sample for calculating net profit of a vessel. At the table; the amounts caught and prices obtained for different fish species are given to calculate gross product or profit of vessels.

At last, economic indicators calculated for the vessel groups showed at the table 8. The values of gross product (Value of Gross Output-Variable Costs) with regard to fish species for different vessel groups were calculated as €8.065, €20.849, €205.975 and €401.211 for Groups 1, 2, 3, and 4 respectively.

As it can be seen on the table 9, a satisfactory net profit is realized by fishermen especially 3 and 4th groups. Total household income was calculated by adding fishery income from other activities than fishing (net repair, retail fish sales on stalls, fish restaurants etc.) and non-fishery income (retirement salary, income from rented properties, wages for other jobs, agricultural production income, etc.) to net profit. Total monthly household income is seen to be €831.3, €1.780, €16.241, and €30.515 for Groups 1, 2, 3, 4 respectively, which makes fisheries a more lucrative business segment compared to other agricultural segments, although it is also riskier and more intensive.

In this study, it was founded that there was a positive economic return to fishermen in Marmara Region. According to data from the Federation of European Employers, Minimum wage is 310.92 monthly in Turkey. Compared to the minimum wage, the first group's vessels gained almost twice monthly (€831). The profits tend to increase because of scarcity of resources and seasonal increases in fish prices. But there are considerable variations in activities, revenues and costs among regions and vessels in terms of vessel size. Politicians and fishery managers have to take into considiration these variations for more effective and realistic management.

Some suggestions was given below in determining an appropriate fishery management strategy to achieve specified operational objectives.

However, the income of the fishermen in Marmara region fails to create the expected level of welfare, mainly due to the fact that the fishermen have long been economically dependent on loans and middlemen systems. They borrow money during the closed season and at the beginning of the fishing season from the fishermen to whom they will be selling their catch (for instance, it's estimated that it takes around €62.500 to prepare a 25 meter purse-seine vessel to the season) (Uras, 2014). Therefore the fishermen sail under the pressure of heavy debts in the fist place; and in a market dominated by middlemen rather than by cooperatives, they have to settle for low prices while the consumers will have to accept to pay high prices.

Table 3. Number of Fishing Vessels in Turkey by Size Groups (m) (TUIK, 2014)

Years	(5 - 7.9)	(8 - 9.9)	(10-11.9)	(12-14.9)	(15-19.9)	(20-29.9)	(30-49.9)	(50+)	Total
2010	9196	4871	728	603	420	609	215	8	**16650**
2011	7293	4512	662	607	400	593	223	10	**14300**
2012	7377	4409	680	633	396	595	225	9	**14324**
2013	7166	4264	632	534	358	534	230	9	**13727**
2014	9508	3064	621	392	286	489	227	8	**14595**

Table 4. Some Characteristics of Fishery in Turkey (TUIK, 2014)

Years	Shorter than 10 m		Shorter than 20 m (Tax Free)	
	Number	%	Number	%
2010	14067	84.5	15818	95.0
2011	11805	82.6	13474	94.2
2012	11786	82.3	13495	94.2
2013	11430	83.3	12954	94.4
2014	12572	86,1	13871	95.0

Table 5. Variable and Fixed Cost Items of the Fishing Activities

Total Costs=TVC+TFC	
Variable Cost Items	**Fixed Cost Items**
Fuel	General Administrative Expenses (VC*%3)
Temporary Crew costs	Interest of debts/loans (annual)
Victuals	Labour (wages of permanent labourers)
Apparel (boots, raincoats)	Mooring fees
Packaging, crates etc.	Telephone bills (annual)
Ice	Vessel insurance (annual)
Marketing	Labor insurance (annual)
Cleaning	Vessel depreciation+interest
Fines	Other depreciation+interest
Vessel lease/rent	Warehouse/Vessel refuge rent (annual)
Ves. repair and maintenance	Vessel tax (annual)
Net maintenance+Purchasing	Diesel fuel card (annual)
Middleman share	Certificate of seaworthiness
Variable Costs (VC)	Green licence (semi-annual)
Interest on operating capital (VC*0.7)	Fishing licences (annual)
	Cooperative fees (annual)
Total Variable Costs (TVC)	**Total Fixed Costs (TFC)**

Table 6. The Distribution of Fishery Costs in Turkey During 2010-2014 Fishing Season (%) (TUIK, 2014)

Cost Items	2010	2011	2012	2013	2014
Fuel	46.9	49.8	49.3	47.5	45.3
Crew costs	26.6	24.9	25.6	26.8	26.6
Victuals	8.0	6.4	6.2	6.1	8.0
Middleman share, payments in fish markets, taxes etc.	5.1	5.0	5.5	5.4	5.1
İnterests	3.2	2.8	2.1	2.5	3.2
Net maintenance+Purchasing	1.7	1.7	1.5	1.2	1.7
Apparel (boots, raincoats)	0.9	0.7	0.8	0.9	0.9
Vessel, frozen deposit lease/rent	0.8	1.0	1.0	0.8	0.8
Packaging, crates, ıce etc.	1.0	0.8	5.4	5.5	5.5
Other costs (water, electricity, telephone etc.)	5.8	6.9	0.6	3.3	2.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 7. The Distribution of Fishery Costs Due to the Various Items in Marmara Sea (%) (TUIK, 2014)

Cost Items	2011-2012
Fuel	32,7
Crew costs	24,4
Middleman share and marketing	22,6
Vessel repair and maintenance	5,8
Net maintenance+Purchasing	5,8
Victuals	4,4
Packaging, crates etc.	2,5
Apparel (boots, raincoats)	0,9
Ice	0,6
Vessel lease/rent	0,1
Cleaning	0,1
Total	**100**

Table 8. Hypothetical Sample For Calculating Profit of Each Vessels

Fish Species	Amount				Prices (€)			
	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4
Anchovies (kg)	0	0	29250	47500	0.0	0.0	1.1	1.0
Small Bluefish (kg)	284	1220	17750	28750	3.5	4.3	3.4	3.3
Horse Mackerel (kg)	934	1627	48750	61250	1.8	1.8	1.6	1.5
Picarel (kg)	25	0	0	0	2.9	0.0	0.0	0.0
Grey Mullet (kg)	0	0	0	3750	0.0	0.0	0.0	3.0
Chub Mackerel (kg)	0	0	0	650	0.0	0.0	0.0	1.5
Seabass (nr)	14	0	0	1750	0.0	0.0	0.0	6.5
Bluefish (nr)	349	805	30225	55750	3.8	4.1	3.8	3.7
Bonito (nr)	646	2880	24330	53375	2.6	2.8	2.6	2.6
Sardines (kg)	792	1180	0	0	1.4	1.1	1.3	1.1
Garfish (kg)	21	50	0	0	3.6	3.4	0.0	0.0
Red Mullet (kg)	104	517	0	0	6.1	6.0	0.0	0.0
Sole (kg)	25	0	0	0	8.0	8.3	0.0	0.0
Turbot (kg)	54	230	0	0	11.1	12.0	0.0	0.0
Red Mullet (kg)	22	0	0	0	6.4	0.0	0.0	0.0
Whiting+hake (kg)	144	240	0	0	4.4	4.3	0.0	0.0
Red Gurnard(kg)	31	0	0	5270	2.8	0.0	0.0	3.3
Shrimps (kg)	1110	2770	0	0	1.8	2.0	0.0	0.0

Table 9. Calculation of Gross and Net Profit for Each Vessels (€)

Indıcators	Group 1	Group 2	Group 3	Group 4
Gross Output	**11310.8**	**33215.8**	**351868.3**	**623355.8**
Varıable Costs	3246.3	12367.1	145893.3	222145.0
Fıxed Costs	661.1	1776.0	15858.5	35641.4
Income Tax	0.0	0.0	1302.1	5531.7
Gross Profıt	8064.6	20848.8	205975.0	401210.8
Net Profıt	**7403.3**	**19072.9**	**188814.2**	**360037.5**
Other Fishing İncome	293.8	1052.1	2552.1	1320.8
Total (Annual)	**7697.1**	**20125.0**	**191366.3**	**361358.3**
Total (Monthly)	**641.3**	**1677.1**	**15947.1**	**30113.3**
Non-fishery income	2279.2	1229.2	3530.0	5142.9
Total Household Income (Annual)	9976.3	21354.2	194896.3	366501.3
Total Household Income (Monthly)	831.3	1779.6	16241.3	30541.7
Minimum Wage in Turkey (Monthly) (2012)			€311	

Table 10. Some Suggestions in Determining an Appropriate Fishery management

Strategy Steps	Importance of Microeconomic Information
1. While determining fisheries policy	- Guides to managers critical information on cost and profit items of fisheries, social and economic characteristics and importance of sector.
2. While setting goals	- Draws an historical performance view including costs, yields, economic and social contribution. - Considers a lot of existing problems as living conditions/quality of fishermen and crews - May give some idea for decision-making techniques and policy opportunities.
3. While determining operational objectives and setting reference points	- Gives opportunity to test, refine and quantify the objectives and models used. - Requires iterative consultation between decision-makers and scientists.
4. While determining management strategy	- Uses analyses, models, and expert knowledge of interested areas to test performance of management measures against operational objectives. - Determines suite of management measures best able to achieve operational objectives. - Considers realities of fishing operations in main and the sub-sectors at the same time.

The issues determine these requirements and operational objectives the manager needs to consider. They have to benefit the biological, ecological, economic, social and institutional information as a chain.

Conclusion

Different perspectives will give some chances by finding easy and more realistic answers for the following simple questions:

- Are current catches in the fishery sustainable and making good use of the resource?
- Is the fishery being conducted in an economically responsible and efficient manner consistent with the economic goals and priorities of the country or local area?
- Are those dependent on the fishery for income and livelihoods receiving appro-

priate, beneficial returns from their fish- ery-related activities?

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FULL PAPER TAM MAKALE

FECUNDITY, GROWTH PARAMETERS AND SURVIVAL RATE OF THREE AFRICAN CATFISH (*Clarias gariepinus*) STRAINS UNDER HATCHERY CONDITIONS

Mary A. Opiyo[1], Paul Orina[1], Harrison Charo-Karisa[2]

[1] Kenya Marine and Fisheries Research Institute, National Aquaculture Research Development and Training Center, Sagana, Kenya

[2] State Department of Fisheries and the Blue Economy, Ministry of Agriculture, Livestock and Fisheries, Nairobi, Kenya

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Corresponding author:

Mary A. APIYO, Kenya Marine and Fisheries Research Institute, National Aquaculture Research Development and Training Center, P.O. Box 451-10230, Sagana, Kenya

E-mail: marybede@gmail.com

Abstract:

Three strains of African catfish (*Clarias gariepinus*) from the Netherlands (Dutch), Indonesia and Kenya (Lake Victoria) were studied in hatchery conditions to compare their fecundity, growth performance and survival rates. The results indicated that fecundity was significantly higher (P < 0.05) in the Kenyan strain (145715.17 eggs Kg^{-1}) and lower in the Indonesian strain (86354.55 eggs Kg^{-1}). The Indonesian strain had significantly (P< 0.05) higher final mean body weight, specific growth rate and food conversion ratio. Survival rate was significantly different among the strains (P <0.05); with the Indonesian strain having the highest survival rate (68.13 ±4.50%) and the Kenyan strain the lowest survival of 23.28 ±0.40%. It was concluded that significant variations existed in the three strains of *C. gariepinus* available in Kenya and development of a population involving the three strains is ideal, but should be accompanied by further studies over a wide range of culture systems and conditions. Meanwhile, the Indonesian strain is recommended for aquaculture in Kenya.

Keywords: Growth, *Clarias gariepinus*, Strains, Fecundity

Introduction

The African catfish (*Clarias gariepinus*) is cultured in several countries throughout Africa as well as in Europe, Asia and South America (de Graaf and Janssen, 1996; Brummett, 2008). It is the second most important freshwater fish cultured in Africa. In Kenya, *C. gariepinus* is second most cultured fish species and it represents over 21% of the total aquaculture production in the country (Ogello and Opiyo, 2011; Otieno, 2011). Interest in the culture of *C. gariepinus* is increasing in areas that are not predominantly fish eating; due to the high flesh to bone ratio (Charo-Karisa *et al*., 2008; Obiero *et al*., 2014). One of the critical limiting factors in *C. gariepinus* culture in Kenya has been lack of good quality seed (Macharia *et al*., 2005). This has been attributed to lack of appropriate breed improvement programs based on local species or absence of imported genetically improved strains (Ponzoni and Nguyen, 2008). Development of a genetically improved strain of *C. gariepinus* that can adapt to a wide range of production environments and exhibiting higher fillet yield is a priority by researchers in Africa (Ponzoni and Nguyen, 2008).

Kenya is endowed with both local and imported strains of *C. gariepinus* including Indonesian, Dutch and several local strains majorly from Lake Victoria. Although *C. gariepinus* originated from Africa, the different stocks exported to other countries have been isolated for several generations and genetically divergent strains may have developed through natural selection and selective breeding under domestic conditions (Broussard and Stickney, 1981). It has been established that the development and effective use of genetically improved strains is one of the most powerful technologies to achieve the fast growing strain of catfish for aquaculture development in Africa (Ponzoni and Nguyen, 2008).

Selection of the best strains is crucial for efficient breeding program not only to reach the production goal but also to reduce production costs, improve disease resistance, utilization of feed resources and product quality (Gjedrem, 1997; Ibrahim *et al*., 2013). Few studies have included reproductive performance of catfish brood-stock as a selection criterion (Prinsloo *et al*., 1990; Legendre *et al*., 1992; Grobler *et al*., 1992). Currently, there is no research on fecundity, comparative growth and feed utilization of the different *C. gariepinus* strains in Kenya. The results from this study would guide decisions on implementation of *C. gariepinus* genetic improvement programs and enable hatcheries and farmers decide the best strains suitable for local conditions.

Materials and Methods

Origin of stocks

Three *C. gariepinus* strains of different origins were used for this study: 1) Dutch strain obtained from Fleuren and Nooijen Fish farms Ltd, in the Netherlands and were bought from Jambo fish Ltd in Kenya; 2) Indonesian strain obtained from Main Center for Freshwater Aquaculture Development in Indonesia; 3) Kenyan strain obtained from Lake Victoria in 2011. All the exotic strains of *C. gariepinus* were imported to Kenya in 2011 from the Netherlands and Indonesia respectively and domesticated in ponds at National Aquaculture Research Development and Training Centre (NARDTC), Sagana. All the strains consisted of breeders hatched under artificial conditions and matured in captivity. Brood-fish from each of the different populations were kept in different tanks and fed on formulated diet containing 35% crude protein. The fish were reared under the same culture environment in a hatchery at the Emmick Fish Farm in Kirinyaga County, Kenya (0.603° N, 37.227° E), North East of Nairobi). Four pure *C. gariepinus* from each strain were used for spawning according to de Graaf & Janssen (1996). Fry were reared in nursery tanks in the hatchery for 13 days.

Determination of fecundity

From each strain, a female *C. gariepinus* previously induced with OVAPRIM (sGnRHa) at 0.5ml Kg^{-1} was weighed using an electronic weighing balance to nearest gram, stripped into a dry plastic bowl and the eggs weighed to calculate the number of eggs from each egg mass of the female. A sample of 1 g was collected from each egg mass and fixed in buffered 10% formalin for 12 hours then transferred to 70% ethanol for storage before counting. The samples were counted in a calibrated petri dish using a tally counter under a dissecting microscope at ×20 magnifications. The number of eggs spawned was calculated by multiplying the weight of the egg mass (from each female) by the number of the eggs present in 1 g of the respective egg mass. Fecundity (the number of eggs per kilogram female) was determined by number of eggs spawned divided by the ovulated female's body weight.

Experimental set up

C. gariepinus fry of an average weight of 0.04g were stocked at 200 fish m^{-3} in triplicates in 2.0 m×2.5 m×1.5 m raised liner tanks of 1 m water depth ($5m^3$). Each rearing tank was covered with a black polyethylene sheet to provide darkness in the tank. The fish were fed at 10% body weight, three times a day (0900 h, 0100 h and 1600 h) on commercial catfish starter feed 45 % crude protein (Skretting Fish Feed Ltd). The tanks were cleaned by siphoning out the bottom debris (faecal matter and uneaten food) twice a day and 10% of the culture water was replaced daily with fresh well water. Dissolved oxygen (DO) concentrations, temperature and pH were measured daily using multi-parameter water quality meter, model H19828 (Hanna Instruments Ltd., Chicago, IL., USA). Ammonium nitrogen and (NH_4^+- N), nitrate nitrogen (NO^{3}- N) and total alkalinity were determined weekly using standard methods (APHA, 1999). The fish were reared in the experimental tanks for 42 days.

Fish sampling

Sampling was done every 7 days to determine the weight of the fish and to adjust feeding. Growth was monitored by taking individual weight of 40 larvae collected randomly from each liner tank. The fish were caught by fine mesh net, gently placed on absorbent paper for approximately 5 seconds and weighed in a plastic bowl containing water using an electronic weighing balance (readability 0.01g) (model KERN 572-33, Germany). They were then returned to their respective tanks. After the 42 days period, the surviving juveniles were counted and all fish from each tank were weighed by taking the individual weights. The performances of the different strains were evaluated based on final weight (g), weight gain (%) $=100^* (W_t - W_0)/W_0$, specific growth rate [SGR, % $day^{-1} = 100^*(\ln W_t - \ln W_0 / t)$], where ln = Natural logarithm, W_0 = initial weight (g), W_t = final weight (g) and t = time in days from stocking to harvesting. Survival (%) = number of fish harvested/number of fish stocked) ×100 and feed conversion ratio (FCR) = feed given (g)/body weight gain (g). The coefficient of variation (CV) of the final weight of the fish was also calculated to determine heterogeneity in sizes of the fish.

Data Analysis

All the experimental data including final mean weight, weight gain, SGR, FCR and survival rate, were compared using analysis of variance (one-way ANOVA) followed by Fisher's LSD tests to determine the significant difference among means. Significance level was declared at ($P < 0.05$). SPSS (version 20) for windows was used for all statistical analysis.

Results and Discussion

Growth performance of different *C. gariepinus* strains are presented in Table 1. After 42 days growth period, differences were observed in final body weight of the three strains. The final mean weight of Indonesian strain was significantly ($P < 0.05$) higher compared to the Dutch and Kenyan strains. The SGR of Indonesian strain (8.98 ± 0.09%) was higher compared to the other strains, the FCR of 1.54 ± 0.04 was observed in the Indonesian strain but no significant difference ($P > 0.05$) was recorded in FCR between the Dutch and the Kenyan strains. The survival was 68.13%, 36.22% and 23.28% for the Indonesian, Dutch and Kenyan strains respectively. The Indonesian strain exhibited significantly ($P < 0.05$) higher survival rate while the Kenyan strain had the lowest survival rate. The Indonesian strain which exhibited the lowest CV of 20.60 indicating highest level of uniformity in sizes while the Kenyan strain exhibited the highest CV of 52.19 and Dutch strain 39.97.

Table 1. Growth parameters, feed conversion ratio, coefficient of variation and survival rate of three *C. gariepinus* strains during 42 days experimental period.

Parameter	Indonesian	Dutch	Kenyan
Initial body weight (g fish $^{-1}$)	0.04 ± 0.00^a	0.04 ± 0.00^a	0.04 ± 0.00^a
Final body weight (g fish $^{-1}$)	1.76 ± 0.02^a	0.69 ± 0.04^b	0.45 ± 0.02^c
SGR (% day $^{-1}$)	8.98 ± 0.09^a	6.50 ± 0.15^a	5.62 ± 0.12^c
FCR	1.54 ± 0.04^a	2.05 ± 0.24^b	2.09 ± 0.01^b
Weight gain (%)	4513.51 ± 174.51^a	1751.58 ± 133.81^b	1080.38 ± 56.98^c
Survival rate (%)	68.13 ± 4.50^a	36.22 ± 1.17^b	23.28 ± 0.40^c

*Values are expressed as mean± SE. Mean values in the same row having the same letters are not significantly different ($P > 0.05$).

Table 2: Fecundity of three *C. gariepinus* strains

	Indonesian	Dutch	Kenyan
Female weight (Kg)	0.45 [a]	1.13 [b]	0.84 [c]
No. of eggs (eggs g^{-1})	650 [a]	700[b]	845[c]
Fecundity (Eggs Kg^{-1} fish)	86354.55±2074.87[a]	93672.50±477.92[a]	145715.17±1283.51[b]

* Values are expressed as mean± SE. Mean values in the same row having the same letters are not significantly different ($P > 0.05$).

The fecundity of the three *C. gariepinus* strains are presented in Table 2. Fecundity varied significantly among the three strains ($P < 0.05$) of which the Kenyan strain was most fecund (145,715.17 eggs Kg^{-1}) and Indonesian strain least fecund (86,354.55 eggs Kg^{-1}). The number of eggs per g of egg mass was significantly higher in the Kenyan strain compared to the Dutch and the Indonesian strain.

The ranges of values of the water quality parameters during the experimental period were: pH 7.67 - 7.69; dissolved oxygen 4.79 - 4.81 mg L^{-1}; temperature 24.12 - 24.18 °C; total alkalinity 371.72 - 372.75 mg L^{-1}; Ammonium nitrogen 0.02 - 0.03 mg L^{-1} and nitrate nitrogen; 0.20 - 0.21 mg L^{-1}. All recorded mean values of the water quality parameters were within the acceptable ranges for *C. gariepinus* culture and were not affected ($P > 0.05$) by the different strains.

Growth in fish differs between species, strains or populations within the same species and even between individuals within the same population (Martins, 2005). The current study indicates that Indonesian strain outperformed the Dutch and the Kenyan strain in all the aspects of growth. This finding is in line with Giddelo *et al.* (2002) who indicated considerable variation in growth in different populations of *C. gariepinus* from Western Rift, Lake Baringo and Rufiji River in the East African region due to geographical separation. Significant morphometric differences have also been established between strains of *C. gariepinus* in the Nile and Lake Victoria (Teugels, 1998) and Lake Kanyaboli (Barasa *et al*., 2014). The differences in growth among strains have been reported to result from either competition favoring one of the strains or a particular strain's inherent capacity to grow (Ibrahim *et al*., 2013). The difference in final weight among the different strains observed in this study is similar to findings of Nguenga *et al*. (2000) on African catfish (*Heterobranchus longifilis*) in Cameroon where the final body weight of the Noun strain was lower than Layo strain and the crosses of the two strains when reared in controlled hatchery conditions.

Difference in final weight among the different strains in this study seem not to be of a direct consequence of social hierarchies in each group where the larger fish suppress the growth of smaller fish but could be as a result of the feeding behavior with the heavier fish exhibiting feeding behavior that may give advantage when feed is limited (Martin *et al*., 2005). The survival of the different strains in the present study is in line with the work of Nguenga *et al*., (2000) who observed that the survival of juvenile *H. longifilis* was high in Layo and reciprocal crosses of Layo and Noun strains but lower in Noun strain cultured in tanks in controlled hatchery conditions. The lower survival rate in the Kenyan strain could be as a result of high incidences of cannibalism due to heterogeneity in sizes evidenced by the high value of the coefficient of variation (CV) indicating that the prey was smaller than the cannibal. It has been established that cannibalism occurs more severely when there is larger size differences between the prey and predator (Hecht and Appelbaum, 1988; Baras and Almeida, 2001).

The differences in growth performance of the fish indicate differences in the adaptability of the strains to local farming conditions. In Indonesia, the farming of the *C. gariepinus* has been largely based on freshwater systems mainly in raised liner ponds and earthen ponds where fish are stocked at high stocking densities of 150 fish m^{-2}, while in Kenya the widespread culture system are earthen ponds with low stocking densities of 3 fish m^{-2}. By contrast, culture systems in the Netherlands are mainly closed recirculating system with stocking densities of between 25 - 30 fish m^{-3}. There are also possibilities that the degree of improvement of the *C. gariepinus* through selective breeding may have occurred to a greater extent in Indonesia compared to the Netherlands and Kenya (Fleuren, 2008; Sunarma, 2008). Selective breeding has been used to increase growth from one generation to another in channel catfish (*Ictalurus punctatus*) whereby 55% of intraspecific crosses resulted in an average increase of 10% body weight above the parental strain (Tucker and Stickeny, 1987; Dunham *et al*., 1987). Hence, the fish from Indonesia could be having a higher tolerance level of the culture environment as a result of selection (Sunarma, 2008). The difference in growth performance could also be linked to the history of domestication of the different strains. Smitherman *et al*., (1984) defines a strain as a fish having a common geographic origin and history and is considered domesticated if propagated in a hatchery environment for at least 2 generations. Considering the domestication history of each of the strains, the Kenyan strain could be considered more of a wild strain. On the other hand, the Indonesian and Dutch strain have been used for years under captivity and have been propagated for several generations and could hence be considered domesticated (Fleuren, 2008; Sunarma, 2008). Burnside *et al.* (1975) compared wild and domesticated strain of channel catfish grown in brackish water and found out that the domestic strain grew faster than the wild strain. The slow growth of the Kenyan strain was similar to the growth recorded for Noun strain of *H. longifilis* which was captured from the wild and reared in a pond environment before use (Nguenga *et al*., 2000).

The high fecundity in The Kenyan strain could also be an indicator of natural selection favoring more eggs. In most species of catfish, the total number and weight of eggs spawned are positively correlated with female weight (Broussard and Stickney, 1981; Nguenga *et al*., 2000). The difference in the number of eggs per Kg of fish in the present study is in line with other studies on Channel catfish where large strain differences were observed for various reproductive traits; in the production of eggs and eventually in the fry per Kg of different strain of channel catfish (Broussard and Stickney, 1981; Dunham *et al*., 1983; Ballenger, 2006). The number of eggs per Kg of fish for all the strains of *C. gariepinus* in this study were higher than the number of eggs per Kg of fish reported in reciprocal pairing of two strains of Channel catfish (Smitherman *et al*., 1984). The differences in egg number per Kg among the three strains in this study may indicate presence of variation that can be utilized in selection for increased production of eggs for improved reproductive output of the *C. gariepinus* in aquaculture in Kenya. However, studies should be undertaken to determine the genetic correlation between reproductive traits and growth in African catfish.

Conclusion

We conclude that the Indonesian strain is suitable for grow out aquaculture in Kenya and is ready for release to the aquaculture industry. Further research is needed to evaluate the growth; survival and reproductive performance of the reciprocal crosses between the different strains of *C. gariepinus* in Kenya to establish a fast growing fish with reduced heterogeneity. The growth performance of the three different strains may be used as a guideline to form a base population for genetic selection to improve performance of *C. gariepinus* in Kenya. If the genetic improvement is targeted at the development of a fast growing fish with reduced heterogeneity then the Indonesian strain is appropriate to be included in the population for selective breeding program. However, the genetic correlation between reproductive traits and growth should be determined.

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SHORT COMMUNICATION **KISA MAKALE**

MUĞLA İLİ ULA GÖLETİ'NDE BIR TATLISU DENİZANASI: *Craspedacusta sowerbii* LANKESTER, 1880

Nurçin Gülşahin

Muğla Sıtkı Koçman Üniversitesi Su Ürünleri Fakültesi Su Ürünleri Temel Bilimleri Bölümü, Muğla

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Corresponding author:

Nurçin GÜLŞAHİN, Muğla Sıtkı Koçman University, Faculty of Fisheries, Department of Basic Sciences, Mıuğla, Turkey

E-mail: ngulsahin@mu.edu.tr

Öz:

Bir tatlısu hydrozoan olan *Craspedacusta sowerbii* Lankester, 1880 Muğla ili sınırları içerisinde yer alan Ula Göleti'nde tespit edilmiştir. Göletin üç farklı bölgesinden örneklenen bu türün bolluk değerleri sırası ile 1,8 birey/m^3, 2,3 birey/m^3 ve 3 birey/m^3 olarak belirlenmiştir. *C. sowerbii* genellikle insan yapımı göl, gölet ve rezervuarlarda daha çok dağılım göstermektedir. *C. sowerbii*'nin Ula Göleti'nde daha önceleri var olup olmadığına dair bir veriye rastlanmamıştır. Gölette zaman zaman balıklandırma çalışmaları yapılmaktadır. Bu türün Ula Göleti'ne balıklandırma çalışmaları sırasında gelmiş olabileceği düşünülmektedir. Fakat bu konuda kesin bir bilgi bulunmamaktadır.

Keywords: Hydrozoan, Ula Göleti, Muğla

Abstract:

A FRESHWATER JELLYFISH İN POND ULA, MUĞLA: Craspedacusta sowerbii LANKESTER, 1880

Craspedacusta sowerbii Lankester, 1880 is a freshwater hydrozoan, was determined in Pond Ula, which is located in Muğla province. This species was sampled from three different areas with 1,8 ind./m^3, 2,3 ind./m^3 and 3 ind./m^3 abundances, respectively. *C. sowerbii* generally distributes in man-made ponds and reservoirs. There is no data about *C. sowerbii* is previously existed in this pond. Stockings are performed from time to time in the Pond Ula. Therefore, it is thought that this species could have come to the pond with stocking. But there is no precise information on this subject.

Keywords: Hydrozoan, Pond Ula, Mugla

Giriş

Craspedacusta sowerbii Lankester, 1880 Cnidaria şubesinin Hydrozoa sınıfının Limnomedusae takımına dahil olan bir tatlısu denizanasıdır. Bu tür doğal göllerde bulunmakla birlikte (Fantham ve Porter, 1938; Deevey ve Brooks, 1943; Dexter vd., 1949) insan yapımı göl, gölet ve rezervuarlarda daha çok dağılım göstermektedir (Pennak, 1956; Augustin vd., 1987). Kozmopolit dağılım gösteren bu tür Kuzey ve Güney Amerika, Asya, Avrupa ve Avustralya'da yaygın olarak bulunmaktadır (Pennak, 1956; Acker ve Muscat, 1976). Polip ve früstül yapılarından tomurcuklanma ile yeni poliplerin oluşumu ve olumsuz koşulları kitin kabukla kaplı dinlenme safhasında (resting eggs) geçirebilmesi bu türün farklı tatlısu habitatlarında yerleşme başarısını arttırmaktadır (Dejdar, 1934; Reisinger, 1957; Acker ve Muscat, 1976; Bouillon ve Boero, 2000).

C. sowerbii'nin ülkemizdeki varlığı ilk kez Dumont (1994) tarafından İstanbul ve Keban Baraj Gölü'nden rapor edilmiştir. Daha sonra Balık vd. (2001) tarafından Topçam Baraj Gölü'nde (Aydın), 2002 yılında Bozkurt (2004) tarafından Kozan Baraj Gölü'nde (Adana) bulunmuştur. Ayrıca bu tür 2008 yılında Bekleyen vd. (2011) tarafından Kıralkızı Baraj Gölü'nden (Diyarbakır) ve 2009 yılında Akçaalan vd. (2011) tarafından Sapanca Gölü'nden rapor edilmiştir. *C. sowerbii*'nin yaşam şeklinde polip ve medüz evreleri bulunmakla birlikte polip evresi baskındır (Acker ve Muscat, 1976). Bu çalışmada, *C. sowerbii*'nin Ula Göleti'ndeki varlığı ilk kez tespit edilmiştir.

Materyal ve Metot

Ula Göleti Muğla ili sınırları içerisinde olup, 1987 yılında sulama amaçlı olarak yapılmıştır. 645 m rakımlı göletin havzası 9.750 km^2, çevresi 2,5 km ve en derin yeri 20 m'dir (Küçükçe, 1999; Önsoy vd., 2011). Ula Göleti Akarca Çayı adı verilen küçük bir dereden beslenir. Gölet aynı zamanda yangın helikopterleri için de su kaynağı olarak kullanılmaktadır (Önsoy vd., 2011).

Şekil 1. Ula Göleti (Örnekleme bölgeleri numaralandırılmış beyaz çizgilerle gösterilmiştir) (https://earth.google.com/).

Figure 1. Pond Ula (Sampling areas are shown by numbered white lines) (https://earth.google.com/).

C. sowerbii Eylül 2016 tarihinde Ula Göleti'nde tespit edilmiş ve üç bölgeden örneklenmiştir (Şekil 1). Örneklemeler 200 mikrometre göz açıklığındaki WP2 Unesco standart plankton ağı ile horizontal olarak yapılmıştır. *C. sowerbii* örnekleri Olympus marka SZX16 model stereomikroskopta incelenerek tayin edilmiş ve fotoğraflanmıştır. Plankton çekimlerinde örneklenen birey sayısından yola çıkılarak *C. sowerbii*'nin metreküpteki bolluk değeri hesaplanmıştır. Ayrıca göletin fizikokimyasal değerleri YSI marka multiparametre cihazı ile ölçülmüştür.

Bulgular ve Tartışma

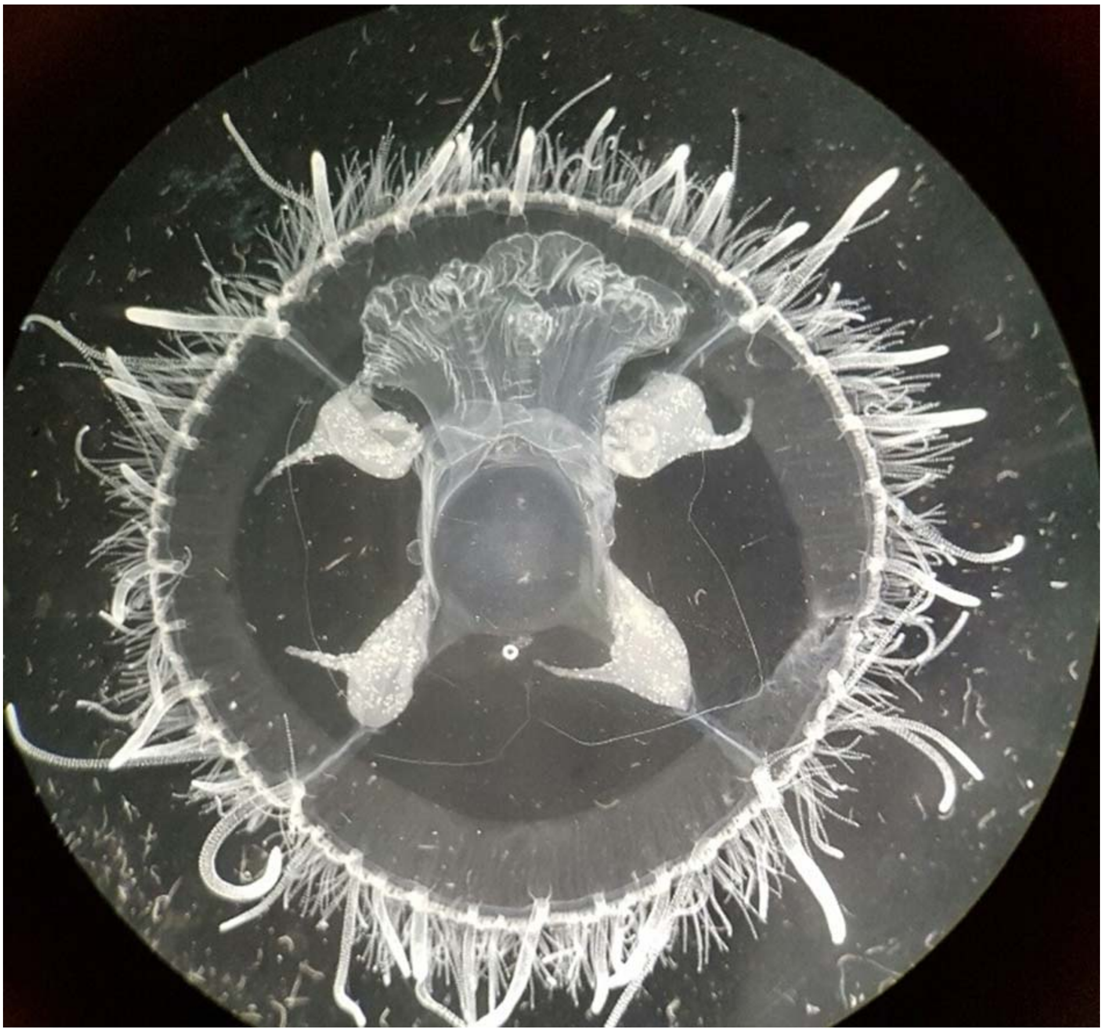
C. sowerbii Ula Göleti'nde Şekil 1'deki numaralandırılmış bölgelerde tespit edilmiştir. Dere girişine yakın bölgelerde ise bulunamamıştır. Türün bolluk değeri bir numaralı bölgede 1,8 birey/m^3, iki numaralı bölgede 2,3 birey/m^3 ve üç numaralı bölgede ise 3 birey/m^3 olarak belirlenmiştir. *C. sowerbii*'nin göletteki dağılımının düzenli olmadığı belirlenmiştir. Balık vd. (2001) ve Bekleyen vd. (2011) Topçam ve Kıralkızı baraj göllerinde bu türün dağılımlarının bölgesel olduğunu belirtmektedir.

C. sowerbii 20-25 mm çaplı, şeffaf, beyazımsı çan şeklindeki medüzleriyle kolayca ayırt edilmektedir (Peard, 2002; Pennak, 1989). Mikroskop altında yapılan incelemelerde gastrovasküler boşluğu oluşturan 4 adet radyal kanal, bu kanallara paralel olarak çıkan 4 adet uzun tentakül ve çok sayıdaki kısa tentaküller ile radyal kanalların alt tarafında yer alan 4 adet gonad ayırt edilmiştir (Şekil 1). Bu özellikler ışığında tür tayini Acker ve Muscat (1976)'a göre yapılmıştır. Gölette poliplerin varlığı ile ilgili bir çalışma yapılmamıştır. Örneklediğimiz bireylerin çapları 16-22 mm arasında ölçülmüştür. Acker ve Muscat (1976) ergin medüzlerin çaplarının 20-25 mm olduğunu belirtmektedir.

Yapılan araştırmalarda bu türün medüzlerinin yaz ve sonbahar aylarında 19-30°C aralığında görüldüğü bildirilmektedir. (Moser, 1930; Dunham, 1941; Reisinger, 1957; McClary, 1959; Lytle, 1959; Acker ve Muscat, 1976). Fakat Milne (1938) 15-30°C aralığında da medüz oluşumu görüldüğünü rapor etmektedir. Dunham (1941) medüzlerin 15°C'nin altında yaşamadığını belirtmektedir. Matthews (1966)'a göre besin bulunurluğu ve sıcaklık değişimleri medüz oluşumunu etkilemektedir. Bu çalışmada gölette su sıcaklığı 25,5-25,9°C arasında, tuzluluğu ise 0,18 ppt olarak ölçülmüştür. Dolayısıyla, göletin sıcaklık değerlerinin *C. sowerbii* medüzlerinin yaşaması için uygun olduğu düşünülmektedir. *C. sowerbii*'nin diğer bölgelerde de Haziran, Ağustos, Eylül ve Ekim aylarında yoğun olarak gözlendiği belirtilmektedir (Balık vd., 2001; Bozkurt, 2004; Bekleyen vd., 2011; Akçaalan vd. 2011). Ula Göleti'nde Ekim ayında yapılan gözlemlerde *C. sowerbii* bireylerine rastlanmamıştır. Ayrıca zooplankton örnekleri ile yapılan mikroskobik incelemelerde Cladocera türlerinin aşırı üreme yaptığı tespit edilmiştir. Dunham (1941)'a göre *C. sowerbii*'nin yoğunluğu zooplankton yoğunluğunun artışına paralel olarak artmaktadır. Özellikle *Bosmina* türlerinin *C. sowerbii*'nin bolluğunu etkilediği bildirilmektedir. Ula Göleti'nden alınan zooplankton örneklerinde *Bosmina sp.* türünün baskın tür olduğu, bu türün toplam zooplankton miktarının %80'ini oluşturduğu belirlenmiştir.

Sonuç

C. sowerbii'nin Ula Göleti'nde daha önceki yıllarda var olup olmadığına dair bir çalışma bulunmamaktadır. Ula Göleti'nde 2009 yılında yapılan bir çalışmada bu türe rastlanmamıştır (Prof. Dr. Ali Serhan TARKAN ile görüşme). Fakat bu çalışma Nisan, Mayıs, Haziran aylarında yapılmış olduğundan söz konusu türe ait medüzlere rastlanılmadığı düşünülmektedir. Öte yandan Balık vd. (2001) ve Bekleyen vd. (2011) tarafından yapılan çalışmalarda kesin olmamakla birlikte bu türün balıklandırma çalışmaları ile gelmiş olabileceği belirtilmektedir. Ula Göleti zaman zaman balıklandırma çalışmalarının yapıldığı bir bölge olup, *C. sowerbii*'nin balıklarla birlikte gelmiş olabileceği düşünülmektedir. Fakat bu konuda kesin bir bilgi bulunmamaktadır. Ayrıca bu türün poliplerinin göle yerleşme başarısı gösterip göstermediği bilinmemektedir. Bu nedenle gerek iç sularımızda gerekse denizlerimizde tür izleme çalışmalarının yapılması büyük önem arz etmektedir. Ula Göleti'nde de uzun süreli çalışmalarla mevcut türlerin korunması ve yeni türlerin tespit edilmesi göletin sürdürülebilir kullanımı için gereklidir.



Şekil 2. *C. sowerbii* üstten görünüş.

Figure 2. Upper view of *C. sowerbii*.

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FULL PAPER TAM MAKALE

THE INVESTIGATION OF HEAVY METAL LEVELS IN WATER AND SEDIMENT FROM IŞIKLI LAKE (TURKEY) IN RELATION TO SEASONS AND PHYSICO-CHEMICAL PARAMETERS

Belma Gülcü-Gür, Selda Tekin-Özan

Süleyman Demirel University, Faculty of Science and Art, Department of Biology, Isparta-Turkey

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Corresponding author:

Selda TEKİN-ÖZAN, Süleyman Demirel University, Faculty of Science and Art, Department of Biology, Isparta-Turkey

E-mail: seldaozan@sdu.edu.tr

Abstract:

This paper presents data on the concentrations of ten heavy metal levels in water and sediment sampled from Işıklı Lake (Turkey) as seasonally (October-2012, January-2013, April-2013, July-2013) and shows relationships between physico-chemical parameters and levels of heavy metals. Temperature, pH, dissolved oxygen and electrical conductivity were measured. In water, Pb was below detection limit (<0.005) in all seasons, while Cu (<0.0005) was in autumn and winter. Fe had the highest level and Cd had the lowest level among the analyzed metals. Cr, Cu, Fe, Mn, Ni and Se reached the highest levels in summer, while Cd, Mo and Zn were in spring. Cd, Cr, Mo and Zn in autumn, Cu and Se in spring, and Fe, Mn, and Ni in winter were the lowest. Cd, Cu and Mo levels varied significantly ($p<0.05$) from season to season. There were positive relationships among temperature, pH value ($p<0.05$) and EC. Significant negative correlation (<0.01) was determined between temperature and dissolved oxygen. Significant (Cr, Cu, Mn and Zn) and non-significant (Cd, Fe, Mo, Ni and Se) positive correlations were detected between content in water and temperature. There were positive correlations between pH and dissolved oxygen, while negative correlation with EC. When the pH value increased, only Mo level decreased. Dissolved oxygen levels had a positive relationship with EC and all studied metals except Cu. There were positive relationships between EC and Cd, Cr, Mn, Mo and Zn, the others were significant negative (<0.01). In sediment, Se was below detection limit in winter, other metals were detected in all seasons. Fe was the highest while Cd was the lowest in sediment. Cd, Cr, Mn, Mo, Ni and Zn reached the highest levels in spring, while Fe in winter, Cu in autumn, Pb in summer. Cr, Mn, Mo, Ni, Pb and Zn in winter, Cd and Se in autumn, Cu in summer and Fe in spring were the lowest. Cd, Cu and Mo levels varied significantly ($p<0.05$) from season to season.

Keywords: Heavy metal, Pollution, Water, Sediment, Işıklı Lake, Turkey

Introduction

Pollution of the wetlands is one of the world's most serious problems. Different materials like heavy metals, acids, pesticids, fossil fuels, nitrates, sulfates, microorganisms, hot water, radioactive subtances are cause water pollution (Göksu et al., 2003). From these, heavy metals are seem to be one of the most important pollutants of the lakes and these metals may cause a serious hazard to aquatic life because of their long persistence, bioaccumulation, biomagnification and toxicity (Harte et al., 1991; Schüürmann and Markert, 1998; Iqbal and Shah, 2014). Heavy metals are produced from different anthropogenic and natural sources like industrial effluents, mining activities, agricultural runoffs, transport, geological structure, burning of fossil fuels and atmospheric deposition (Adnano, 1986; Dawson and Macklin, 1998; Kalay and Canli, 2000). Low levels of some heavy metals are essential for the development of living organisms, but some of them such as Pb, Hg and Cd are non-essential and very toxic. And also, essential metals may be toxic when they are present above the permissible concentration (Puttaiah and Kiran, 2008).

Heavy metal concentration in the lakes can be verified in aquatic organisms, water and sediment (Förstner and Wittman, 1983). Metals don't subsist in solvable forms in water for a long time, generally exist as suspended colloids or are stable as organic and mineral substances (Kabata-Pendias and Pendias, 2001). Dissolved metal can generate dissolved organic or inorganic complexes, depending on physico-chemical conditions (Petronio et al., 2012). Sediments are important sinks for heavy metals and can be used to detected pollution of heavy metal in aquatic systems (Gangaiya et al., 2004). Some factors such as pH and the property of metal affects the release of heavy metals from sediment into the water (Dean, 2012).

The aim of this study are to determine relationships between the metal levels in water and physico-chemical parameters and to show seasonal variations of heavy metal levels in water and sediment.

Materials and Methods

Işıklı Lake (29º 92´ E, 38º 22´ N), situated on south west of Turkey (Figure 1). Lake water is mainly used for irrigation. The lake is approximately 7 m depth, its area is 9749 ha and fed by Büyük Menderes Stream, Karanlık Stream and Kufi Stream. There are small rush islands in the lake (Aygen and Balık, 2005; Akarsu et al., 2006). During the study period (October-2012, January-2013, April-2013, July-2013) as seasonally water and sediment sampled were collected at the three sampling stations from the Işıklı Lake. Using with YSI multiparameter equipment, the temperature, dissolved oxygen, electrical conductivity (EC) and pH values were measured from these same stations. Surface water samples were taken by using 500 ml polypropylene bottle, added 5 ml of concentrated HNO_3 to keep the pH value less than 2.0. Water samples filtered with a 0.45 µm Whatman glassfiber filter, stored at 4 ºC and were analyzed directly (APHA, 2005).

Figure 1. Map of Işıklı Lake (Turkey) (Taken from googleearth)

The sediment samples were collected by a Ekman grab from a depth of 5-15 cm and were put the oven and the samples dried in it at 50 ºC for 48 h, sieved to obtain the <63 µm fraction (Bryan and Langston, 1992; Buchanan, 1984) and homogenized. 0.5 g sediment was weight, placed in autoclavable bottles and 5 ml HNO_3 (65%) added to each, were kept at room temperature for 24-h. The samples were heated for 2 hours at 120 ºC on hot plate, until the solution evaporate slowly to near dryness. 1 ml H_2SO_4 (30%) added the bottles after cooling, and solvented to 25 ml with deionized water, then 1-2 drop HNO_3 was added (UNEP, 1984).

All samples were analyzed for three times for heavy metals (Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se and Zn) by using for ICP-AES Vista. The digestion and analytical procedures were checked by using standard materials DORM-3, DOLT-4 and HISS-1 (National Research Council Canada). The absorption wavelength were 228.802 nm for Cd, 267.716 nm for Cr, 324.754 nm for Cu, 259.940 nm for Fe, 257.61 nm for Mn, 202.03 nm for Mo, 352.454 nm for Ni, 220.353 nm for Se, 196.026 nm for Pb and 213.856 nm for Zn, respectively. The analysis limits were 0.4 µg/L for Cd, 0.5 µg/L for Cr, 0.3 µg/L for Cu, 0.35 µg/L for Fe, 0.05 µg/L for Mn, 0.8 µg/L for Mo, 1.3 µg/L for Ni, 3 µg/L for Pb, 5 µg/L for Se and 0.3 µg/L for Zn.

SPSS 18 Statistical package programs was used for statistical analysis. To compare the data among seasons at the level of 0.05 and to test for significant associations between heavy metal levels in water and physico-chemical parameters One-Way ANOVA, Duncan's Multiple Comparison Test and Pearson rank correlation coefficient were used (Duncan, 1955; Muller and Bethel, 2002; Gravetter and Wallnau, 2007).

Results and Discussion

The same heavy metals were analyzed under the same conditions from reference materials (DORM-3, DOLT-4, HISS-1) to check the certainty and accuracy (Table 1). Replicate analysis of DORM-3, DOLT-4, HISS-1 showed good precision, with recovery rates for metals between 82% and 115% for DORM 3, 92% and 112% for DOLT 4, 86% and 116% for HISS 1.

Physico-chemical parameters of water samples as seasonally are given in Table 2. According to the table, water temperature varied between 4.17 °C (in winter) and 28.83 °C (in summer), respectively. Mean pH varied between 8.65 (in spring) and 9.13 (in summer). Dissolved oxygen was the highest in spring (9.37 mg/lt) and lowest in summer (4.99 mg/lt). EC measurement ranged between 385.2 µs/cm (in spring) and 262.33 µs/cm (in winter). Important positive relations were found between temperature and pH ($p<0.05$), and dissolved oxygen and EC ($p<0.05$). Negative significant relationships were determined temperature and dissolved oxygen ($p<0.01$). Başyiğit and Tekin-Özan (2013), found that in Karataş Lake, pH and EC values were highest in summer and lowest in winter. Dissolved oxygen decreases in summer and increases in winter. The pH value in water decrease with increasing CO_2. In summer, the pH value increase when CO_2 decrease owing to photosynthesis (Tanyolaç, 2006). Dissolved oxygen was the highest in spring. This can be related to with photosynthesis because there are a lot of macropyhte in the lake and in spring, they produce oxygen via photosynthesis. And the rivers carry too much water with oxygen to the lake. EC level was the highest in summer. In warm seasons, too much water evaporate, so that inorganic substances concentrate increase in water body.

In Table 3, the heavy metal concentrations in water were given. As seen Table 3, Pb was below detection limit (<0.005) in all seasons, while Cu (<0.0005) was in autumn and winter. The heavy metals predominantly determined in the water of Işıklı Lake. Among the analyzed metals, the highest and lowest metals were Fe and Cd. Similar results were reported in Beyler Reservoir (Fındık, 2013), Hazar Lake (Karadede-Akın, 2009), Karataş Lake (Başyiğit and Tekin-Özan, 2013), Kızılırmak River (Akbulut and Akbulut, 2010), Beyşehir Lake (Tekin-Özan, 2008). Ghaffar et al. (2008), reported that Fe facilities the precipitation of other metals and found at low levels when precipitation occurs.

Seasonal variations of heavy metals also can be seen in Table 3. Cr, Cu, Fe, Mn, Ni and Se reached the highest levels in summer, while Cd, Mo and Zn were in spring. Cd, Cr, Mo and Zn in autumn, Cu and Se in spring, and Fe, Mn, and Ni in winter were the lowest. Cd, Cu and Mo levels varied significantly ($p<0.05$) from season to season. Physico-chemical parameters of water like pH, EC, salinity, dissolved oxygen effect the metal levels in water (Wong et al., 2000). The reason of increasing metal levels in summer can be caused by increasing the air temperature and evaporation. The decrease of heavy metals in warm seasons and winter in maybe cause by heavy rain, snow and melting snow. Similar results are also found in Hazar Lake (Karadede-Akın, 2009), Karataş Lake (Başyiğit and Tekin-Özan, 2013), Kızılırmak River Basin (Akbulut and Akbulut, 2010).

Relationships of metal in water with some physico-chemical parameters were measured using the pearson test and given in Table 4. According to the table, there were positive relationships among temperature, pH value ($p<0.05$) and EC. Significant negative correlation ($p<0.01$) was determined between temperature and dissolved oxygen. Significant (Cr, Cu, Mn and Zn) and non-significant (Cd, Fe, Mo, Ni and Se) positive correlations were detected between content in water and temperature. There were positive correlations between pH and dissolved oxygen, while negative correlation with EC. When the pH value increased, only Mo level decreased. Dissolved oxygen levels had a positive relationship with EC and all studied metals except Cu. There were positive relationships between EC and Cd, Cr, Mn, Mo and Zn, the others were significant negative ($p<0.01$). Başyiğit and Tekin-Özan (2013) found negative relationships between temperature and Cu and Se, between pH and Se, Zn, between dissolved oxygen and Mn, Mo, Cu, Fe, Cd, Cr, Pb and Zn, between EC and Cd, Cu, Fe, Mn, Pb, Se. Fındık (2013) determined negative correlations between temperature and Fe, Mn, Pb, between dissolved oxygen and Zn, Cu, B, Cr, Ni and Al, between pH and Fe, Al. Witeska and Jezierska (2003) explained that most metals seem to be more toxic in acidic in neutral and alkaline water and showed that an increase in water hardness reduces metal toxicity.

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Table 1. Concentrations of metals found in certificied reference material DORM-3, DOLT-4 and HISS-1 from National Research Council, Canada.

Metals	DORM 3 Certified	DORM 3 Observed	Recovery (%)	DOLT 4 Certified	DOLT 4 Observed	Recovery (%)	HISS 1 Certified	HISS 1 Observed	Recovery (%)
Cd	0.290 ±0.020	0.24 ±0.01	82	24.3 ±0.8	22.45 ±0.12	92	0.024 ±0.009	0.021 ±0.02	87
Cr	1.89 ±0.17	1.72 ±0.11	91	-	-	-	30.0 ±6.8	28.45 ±2.25	94
Cu	15.5 ±0.63	13.21 ±1.69	85	31.2 ±1.1	35.12 ±2.36	112	2.29 ±0.37	1.99 ±0.25	86
Fe	347 ±20	400.78 ±8.25	115	1833 ±75	1698 ±22.1	92	-		-
Mn	-	-	-	-	-	-	66.1 ±4.2	54.95 ±1.45	89
Mo	-	-	-	-	-	-	-		-
Ni	1.28 ±0.24	1.12 ±0.47	87	0.97 ±0.11	0.99 ±0.05	102	2.16 ±0.29	2.45 ±0.15	116
Pb	0.395 ±0.05	0.41 ±0.09	-	8.3 ±1.3	7.97 ±1.12	96	3.13 ±0.40	2.98 ±0.01	95
Se	-	-	105	-	-	-	0.050 ±0.007	0.048 ±0.11	96
Zn	51.3 ±3.1	57.14 ±8.47	111	116 ±6	125.78 ±4.54	108	4.94 ±0.79	5.12 ±1.002	103

Table 2. Some physical parameters of Işıklı Lake's water

Season	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Electrical Conductivity (µg/cm)
Autumn	11.57-13.12 12.55 ±0.855	7.7-7.83 7.78 ±0.07	4.45-6.04 5.49 ±0.901	265-357 320.33 ±48.75
Winter	3.76-4.63 4.17 ±0.43	7.45-7.57 7.51 ±0.06	7.99-8.41 8.20 ±0.21	247-289 262.33 ±23.18
Spring	16.50-18.98 18.04 ±1.34	7.24-7.29 7.26 ±0.025	8.89-9.95 9.37 ±0.53	355-428 385.2 ±38.17
Summer	27.94-30.05 28.83 ±1.09	9.01-9.35 9.13 ±0.18	4.08-5.81 4.99 ±0.86	300.9-334.5 311.6 ±17.25

Table 3. The concentrations (ppb) of some heavy metals in Işıklı Lake's water

Season	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Autumn	0.03-0.19 0.11±0.08 [a**]	0.01-1.66 0.77±0.83 [a]	BDL*	56.65-829.44 421.37±388.2 [a]	8.97-47.91 26.53±19.75 [a]	0.44-1.11 0.78±0.47 [a]	1.89-5.33 3.61±2.43 [a]	BDL	4.68-4.70 4.69±0.01 [a]	3.96-6.61 5.02±1.40 [a]
Winter	0.16-0.27 0.21±0.08 [a]	0.72-1.09 0.88±0.19 [a]	BDL	35.19-51.66 43.27±8.24 [a]	4.69-7.63 6.13±1.47 [a]	1.49-1.64 1.57±0.08 [ab]	0.13-0.14 0.135±0.007 [a]	BDL	3.41-5.35 4.4±1.37 [a]	3.68-10.26 5.9±3.79 [a]
Spring	1.60-7.00 3.50±3.04 [b]	2.70-5.80 3.87±1.69 [a]	1.80-6.50 4.67±2.51 [b]	140.00-260.00 210.00±62.45 [a]	27.00-97.0 65.33±35.47 [a]	2.10-4.50 3.27±1.20 [c]	0.57-13.40 6.46±6.48 [a]	BDL	1.40-5.00 2.90±1.87 [a]	340.00-460.00 393.33±61.10 [a]
Summer	2.18-270 2.37±0.28 [ab]	14.69-14.70 14.696±0.002 [a]	9.74-14.31 12.68±2.55 [c]	55.41-8569.09 3206.97±4667.51 [a]	20.97-251.39 116.84±119.98 [a]	2.01-2.44 2.26±0.22 [bc]	10.21-106.33 43.40±54.53 [a]	BDL	2.41-51.39 30.26±25.18 [b]	120.60-373.68 281.63±139.93 [a]

* Below Detection Limit

** Means with the same superscript in the same row are not significant different according to Duncan's multiple range test ($p<0.05$)

Table 4. Pearson correlation matrix showing the relationships of metals in water and some physico-chemical parameters in water

	Temperature (ºC)	pH	Dissolved Oxygen (mg/L)	Conductivity (µg/cm)	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Se	Zn
Temperature (ºC)	1	0,755*	-0,644**	0,376	0,493	0,823**	0,884*	0,466	0,600*	0,415	0,517	0,605	0,686*
pH		1	0,161	-0,186	0,051	0,723	0,850	0,486	0,414	-0,057	0,497	0,725	0,174
Dissolved Oxygen (mg/L)			1	0,587*	0,704*	0,465	-0,969**	0,150	0,417	0,777**	0,114	0,107	0,890**
Conductivity (µg/cm)				1	0,676*	0,129	-0,791	-0,079	0,238	0,532	-0,369	-0,236	0,618
Cd					1	0,290	-0,162	0,098	0,426	0,885**	0,074	-0,004	0,679*
Cr						1	0,961*	0,922**	0,916**	0,244	0,966**	0,936**	0,327
Cu							1	0,610	0,488	-0,340	0,638	0,575	-0,540
Fe								1	0,920**	-0,046	0,986**	0,764*	-0,068
Mn									1	0,225	0,911**	0,624	0,202
Mo										1	0,011	-0,094	0,790**
Ni											1	0,807*	-0,111
Se												1	-0,037
Zn													1

* and ** indicate the correlation coefficients were significant at 0.05 and 0.01 probability levels, using two-tailed test

Table 5. The concentrations (mg kg^{-1}) of some heavy metals in Işıklı Lake's sediment

Season	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Autumn	0.09-0.11 0.10±0.01 [a**]	9.15-11.92 10.79±1.45 [ab]	13.05-16.31 14.43-1.69 [a]	2677.23-2891.61 2756.83±117.36 [a]	168.10-235.62 200.3±33.87 [ab]	0.14-0.17 0.15±0.02 [a]	18.37-23.90 21.49±2.83 [ab]	1.15-2.46 1.75±0.66 [ab]	0.20-1.01 0.66±0.42 [ab]	14.87-18.45 16.14±2.002 [ab]
Winter	0.10-0.11 0.104±0.01 [a]	5.12-7.80 6.40±1.35 [a]	10.64-13.22 11.90±1.30 [a]	2015.35-2616.19 2297.85±302.02 [a]	135.98-150.95 145.03±7.96 [a]	0.08-0.19 0.13±0.06 [a]	11.55-18.95 15.60±3.75 [a]	0.91-1.77 1.32±0.44 [a]	BDL*	12.01-13.43 12.85 ±0.74 [a]
Spring	0.27-0.30 0.28±0.02 [c]	11.75-16.48 13.65±2.50 [b]	11.11-14.55 12.74±1.73 [a]	5904.89-7700.27 6614.28±955.10 [b]	264.03-556.95 361.94±168.88 [b]	0.60-0.67 0.63±0.03 [c]	25.78-38.93 30.81±7.10 [b]	2.13-4.48 3.32±1.18 [ab]	0.16-1.92 1.05±0.88 [b]	21.70-28.87 24.47±3.85 [c]
Summer	0.21-0.27 0.25±0.03 [b]	6.74-14.69 11.65±4.29 [b]	7.18-16.32 11.62±4.58 [a]	4336.97-7567.02 6295.71±1721.26 [b]	189.07-332.70 248.83±74.79 [ab]	0.46-0.52 0.49±0.03 [b]	16.70-34.30 27.68±9.57 [ab]	2.52-5.50 3.68±1.60 [b]	0.75-1.09 0.94±0.17 [ab]	15.49-24.44 20.66±4.63 [b]

* Below Detection Limit

** Means with the same superscript in the same row are not significant different according to Duncan's multiple range test (*p*<0.05)

The metal concentrations in sediment are summarized in Table 5. Se was below detection limit in winter, other metals were determined in all seasons. The total levels of metal concentrations in sediment samples were in order Fe> Mn> Ni> Zn> Cu> Cr> Pb> Se> Mo> Cd. Fe levels were the highest while Cd lowest in Karataş Lake (Başyiğit and Tekin-Özan, 2013), Beyler Reservoir (Fındık and Turan, 2012), Uluabat Lake (Barlas et al., 2005), Hazar Lake (Özmen et al., 2004). Iron is generally the most abundant metal in all of the reservoirs it is one of the most common elements in the Earth's crust (Usero et al., 2014). Pyrite oxidation produced sulphate and the Fe^{2+} ion, which is oxidised to Fe^{3+} by microorganisms such as *Thiobacillus ferrooxidans* (Cabrera et al., 1999). Kerrison et al. (1988), reported that Cd accumulates slowly in the sediment. Cadmium is not found in the organic fraction for low adsorption constant and labile complexion with organic matter (Baron et al., 1990). The Fe, Mn, Zn, Cr, Cu and Cd levels are lower than the values in Beyler Dam Lake (Fındık and Turan, 2012), Kovada Lake (Kır et al., 2007) and Seyhan Dam Lake (Çevik et al., 2009). Cd, Cr, Mn, Mo, Ni and Zn reached the highest levels in spring, while Fe in winter, Cu in autumn, Pb in summer. Cr, Mn, Mo, Ni, Pb and Zn in winter, Cd and Se in autumn, Cu in summer and Fe in spring were the lowest. Cd, Cu and Mo levels varied significantly ($p<0.05$) from season to season. Tekin-Özan (2008) reported that the Cu and Zn levels were highest in spring, while Fe and Mn were in autumn in Beyşehir Lake's sediment. In Beyler reservoir sediment, Fe, Al, Zn, Cu, Mn and B were highest in summer, while Cr, Ni, Cd and Pb were in spring (Fındık and Turan, 2012). In Hazar Lake, heavy metals concentrations were highest in spring and autumn (Karadede-Akın, 2009). Kankılıç et al. (2013) showed Fe, Mn, Cu, As, Pb and Hg levels were highest in summer and lowest in autumn. In aquatic systems, metals are transported either in solution or on the surface of suspended sediments (Dawson and Macklin, 1998). Due to their strong affinity for particles (Luorna, 1990), metals tend to be accumulated by suspended matter or trapped immediately by bottom sediments (Dauvalter, 1998). The heavy metals may be in sediment through indirect discharge or from atmospheric deposition at the power plant (Demirak et al., 2006).

This study showed that Işıklı Lake's sediment contains higher amounts of heavy metals as compared with the quantity of water. Sediments behave as the most important sink or reservoir of metals and other pollutants in the aquatic environment (Abdel-Baki, 2011).

Conclusion

Işıklı Lake is one of the most important water sources of the region because of its use for irrigation and having great potential fisheries activity. In this study, we also compared our results with permissible levels in water for heavy metals given by some different institutes. Based on the heavy metals level, the water of Lake Işıklı was classified as category I according to the standards of Republic of Turkey Ministry of Environment and Forest (Republic of Turkey Ministry of Environment and Forest, 2004). The levels of Zn and Fe in the lake water higher than permissible levels given by Republic of Turkey Ministry of Food, Agriculture and Livestock (Republic of Turkey Ministry of Food, Agriculture and Livestock., 2002). The levels of analyzed metals were lower than the WHO, EC and EPA (WHO, 1998; 2011; EC, 1998; US EPA, 1999).

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