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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Sığacık Körfezi'ndeki (Ege Denizi) *Plesionika heterocarpus*'un (Decapoda: Pandalidae) bazı morfometrik özellikleri

Some morphometric features of *Plesionika heterocarpus* (Decapoda: Pandalidae) in Sığacık Bay, Aegean Sea

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Öz: Ege Denizi (Doğu Akdeniz)'de, derin su pandalid karidesi *Plesionika heterocarpus* (A. Costa, l871)'un üreme, büyüme ve populasyon dinamikleri çalışılmıştır. Bireyler aylık olarak, Mayıs 2008 ve Nisan 2009 arasında Sığacık Körfezi'nden 128-550 m derinlikler arasından toplanmıştır. Araştırma sürecinde, toplam 2749 *P. heterocarpus* bireyi (1112 erkek ve 1637 dişi) toplanmıştır. Karapaks boyu (CL), erkek bireyler için 11,30 mm ve 12,30 mm arasında dişi bireyler için 11,50 mm ve 13,00 mm arasında ölçülmüştür. Yıl boyunca, dişilerin ortalama boy (CL) ve ağırlığı (W) erkeklerin ortalama boy ve ağırlığından sürekli olarak yüksek çıkmıştır. Yumurtalı dişiler yıl boyunca gözlenmiştir. Ana üreme dönemleri Mart ve Ağustos ayları olarak belirlenmiştir. Mevsimsel olarak incelenen tüm gruplarda allometrik katsayısı (b) 3'ten az bulunmuştur. Von Bertalanffy büyüme parametreleri dişilerde L_∞: 26,25 mm, k: 0,38 yıl^{-1}, erkeklerde L_∞: 23,63 mm, k:0,49 yıl^{-1} olarak hesaplanmıştır.

Anahtar kelimeler: *Pandalidae, Plesionika heterocarpus, Decapoda, Ege Denizi, Doğu Akdeniz*

Abstract: Reproduction growth and population dynamics of the deep-water pandalid shrimp *Plesionika heterocarpus* (A. Costa, 1871) were studied in the Aegean Sea (Eastern Mediterranean). Individuals were collected monthly between May 2008 and April 2009 from 128 to 550 m of depth in Sığacık Bay. A total of 2749 individuals (1112 males and 1637 females) of *P. heterocarpus* were collected during the surveys. Males ranged from 11.30 mm to 12.30 mm CL, and females ranged between 11.50 mm and 13.00 mm CL. The mean size (CL) and weight (W) values of females were consistently exceeding that of males throughout the year. Ovigerous females were observed throughout the year. Main reproductive months can be defined in March and August. In all the groups examined seasonally, the values of allometric coefficient b were less than 3. Estimates of the Von Bertalanffy growth parameters are: L_∞: 26.25 mm, k: 0.38 year^{-1} in females, L_∞: 23.63 mm, k: 0.49 year^{-1} in males.

Keywords: *Pandalidae, Plesionika heterocarpus, Decapoda, Aegean Sea, Eastern Mediterranean*

GİRİŞ

Plesionika heterocarpus (A. Costa, 1871)'un hem ılıman hem de tropikal sularda dağılımı vardır (Holthuis, 1980). Akdeniz boyunca 80-700 metre arasında bulunur ve çeşitli Akdeniz bölgelerinde derin su trol balıkçılığının hedef dışı avların (by-catch) önemli bir kısmını oluşturur (Company ve Sardà, 1997, 2000; Fanelli vd, 2004). Türkiye'nin Marmara, Ege ve Akdeniz sahillerinden bilinen *P. heterocarpus*, Akdeniz dışında Batı ve Doğu Atlantik ile Doğu Afrika'dan Japonya'ya kadar olan kıyılarda dağılım gösterir (Holthius, 1980). Akdeniz'de, *P. heterocarpus* kıta sahanlığının sınırı boyunca, doğu kısmına göre daha yaygın olduğu batı kısmında avlanır. Kuzey ve Orta Adriyatik Denizi'nde bulunmaz (Holthuis, 1980).

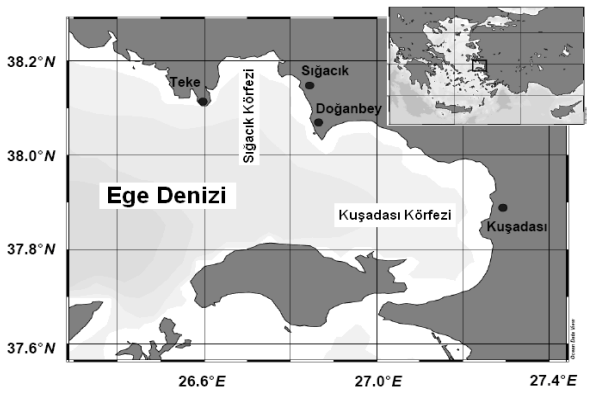
Plesionika türleri (*P. heterocarpus* ve *P. martia*) her ne kadar derin su trol balıkçılığının hedef dışı avların önemli bir kısmını oluştursa da, çok az çalışma Akdeniz'deki türlerin biyolojisi ve ekolojisi üzerinde odaklanmıştır. Bu çalışmalar genelde üreme biyolojisi (Company ve Sardà, 1997; Campisi vd. 1998; Marsan vd., 2000; Maiorano vd., 2002; Company vd., 2003), büyüme (Company ve Sardà, 2000; Maiorano vd., 2002) ve beslenme alışkanlıkları (Cartes 1993a; 1993b) üzerine olup Akdeniz'in batı ve orta bölgelerine odaklanmıştır. Akdeniz'in doğu kısmına ilişkin, *P. heterocarpus*'un biyoekolojisi hakkında bilgiler oldukça yetersizdir ve genelde mevcudiyet, derinlik dağılımı ve bolluk hakkındadır (Katağan vd., 1988; Koukouras vd., 1998; Politou vd., 1998, 2000; Kallianiotis vd., 2000; D'onghia vd., 2003; Ateş vd., 2015; Özcan ve Katağan, 2009, 2011). Bölgedeki türlerin biyolojisi üzerine detaylı bir çalışma olan Chilari vd. (2005), Doğu İyonya Denizindeki *P. heterocarpus*'un populasyon yapısı, büyümesi, cinsiyet oranı,

üremesi, ilk olgunlaşma büyüklüğü ve fekonditesi hakkında bilgi sağlamaktadır.

Bu çalışmanın amacı, Sığacık Körfezi'nde dağılım gösteren *P. heterocarpus*'un bazı biyolojik özellikleri hakkında bilgi sahibi olmak ve tür hakkındaki mevcut bilgilere katkı sağlamaktır.

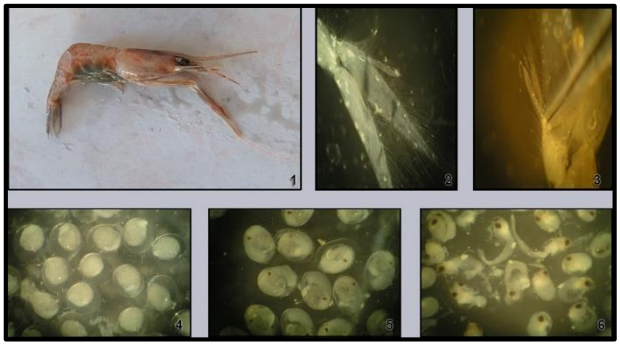
MATERYAL VE METOT

P. heterocarpus örnekleri Mayıs 2008 ve Nisan 2009 arasında aylık olarak Ege Denizi Sığacık Körfezi'nden (38°05'13"K–26°35'08"D ile 37°59'27"K–26°54'47"D) toplanmıştır. Örnekler sıfır ya da düşük seçicilikte değiştirilmiş trol ağı örnekleme torbasında ticari bir trol teknesi ile toplanmışlardır. Tarama hızı, substrat durumuna bağlı olarak, 2,3 ile 2,7 deniz mili arasında değişmiştir. 128 ile 550 m arasındaki derinliklerden toplam 36 çekim yapılmıştır. Tüm çekimler gün ışığında gerçekleşmiştir. Yakalanan bireylerden toplam 2749 adet *P. heterocarpus* numunesi laboratuar analizi için dondurularak saklanmıştır (Şekil 1).



Şekil 1. Örnekleme bölgesi ve Sığacık Körfezi'nin coğrafik konumu
Figure 1. Sampling area and geographical position of Sığacık Bay

Çözülen hasar görmemiş her bir *P. heterocarpus* numunesinin karapaks boyu (CL) gözün arka sınırından karapaksın dorsal arka sınırına kadar dijital kumpas ile en yakın 0,01 mm'ye kadar ölçülmüştür. Bu çalışmada toplam boy yerine karapaks boyu kullanılmıştır. Bunun temel nedeni, bireylerin rostrum veya telson kısımlarında meydana gelmiş veya gelebilecek kopmalardan analizin etkilenmesini engellemektir. Karapaks boyu ve ağırlıkları arasında lineer bağlantılar sağlayabilmek için numunelerin yaş ağırlıkları (W) (Kurutma kâğıdı ile kurutulmamış) 0,01 gram hassasiyetli dijital terazi yardımıyla belirlenmiştir. Yumurtalı dişilerden yumurtalar alınıp incelenmiştir ve numunelerde parazit oluşumu gözlenmemiştir. Cinsiyet tayini için erkek ve dişi bireylerin ikinci pleopodları incelenmiştir. Erkek bireyler ikinci pleopod çiftinin endopodunda Appendix masculina (Zariquiey Alvarez, 1968) bulunup bulunmadığına bağlı olarak bir stereomikroskop altında belirlenmiştir (Şekil 2).



Şekil 2. *P. heterocarpus*'un genel görünüşü (1), ikinci pleopod, dişi birey, (2), ikinci pleopod, erkek birey (3), birinci evre yumurta (4), ikinci evre yumurta (5), üçüncü evre yumurta (6). (Foto: M. Özbek)
Figure 2. Lateral view of *P. heterocarpus* (1), second pleopod, female (2), second pleopod, male (3), first stage eggs (4), second stage eggs (5), third stage eggs (6). (Photo: M. Özbek)

Populasyon parametrelerinden L∞ ve k'nın tahmininde von Bertalanffy büyüme denkleminden ($L_t = L_\infty(1 - e^{-k(t - t_0)})$) faydalanılmıştır. Örneklenen dişi ve erkek bireylerde mevsimlere bağlı karapaks boyu-ağırlık ilişkilerini tespit etmek için hesaplamalar yapılmıştır. Boy (CL) – Ağırlık (W) ilişkilerini hesaplamak için üssel regresyon eşitliği kullanılmıştır (Ricker, 1975):

$$W = aCL^b$$

Bu eşitlikte; W yaş ağırlık (g), CL karapaks boyu (mm), a kesim ve b allometrik katsayısını ifade etmektedir.

Yumurtalı dişilerde yumurtalar alınıp incelenmiş ve yumurta gelişiminin evreleri aşağıdaki üç aşamalı ölçeğe (Company ve Sardà, 1997) göre değerlendirilmiştir.

Birinci evre: Yoğun gök mavisi renginde ve embriyo pigmentasyonu görülmeyen yeni yumurtlamaya ait yumurtalar

İkinci evre: Soluk yeşil renkli, hafif göz pigmentasyonu görülen yumurtalar

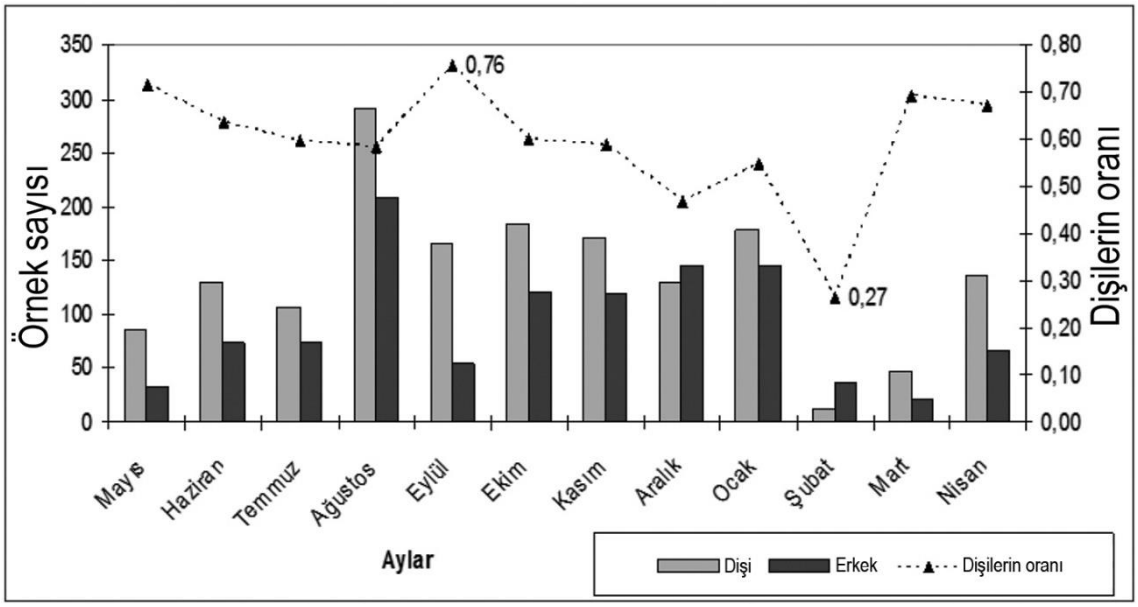
Üçüncü evre: Embriyo göz pigmentasyonu açıkça görülen ve embriyonun olgunlaştığı renksiz yumurtalar.

BULGULAR

Yapılan çalışmada, Sığacık Körfezi'nden 1488 yumurtalı dişi, 149 yumurtasız dişi ve 1112 erkek olmak üzere toplam 2749 *P. heterocarpus* bireyinin bazı morfometrik özellikleri incelenmiştir.

Yıllık cinsiyet oranı dikkate alındığında, dişilerin erkeklere oranla daha fazla sayıda bireyle temsil edildikleri dikkati çekmekte olup, sadece Aralık ve Şubat aylarında erkek bireylerin sayısının dişi bireylerden daha fazla olduğu görülmüştür (Şekil 3).

Dişi ve erkek bireylerde mevsimsel olarak yapılan boy-ağırlık ilişkileri analizlerinde elde edilen değerler sırasıyla aşağıdaki gibidir (Tablo 1).



Şekil 3. İncelenen bireylerin aylara göre birey sayıları ve dişi bireylerin populasyondaki oranları
Figure 3. Number of specimens according to the sampling dates and ratios of females in the population

Tablo 1. Erkek ve dişilerde mevsimlere göre karapaks boyu, ağırlık, birey sayısı ve boy ağırlık ilişkisi değerleri
Table 1. Carapace length, weight, number of specimens and parameters of the length-weight relations of males and females according to seasons

		Karapaks boyu (mm)		Ağırlık (gr)		*n*	*a*	*b*	r^2
		Min.	Maks.	Min.	Maks.				
İlkbahar	Erkek	9,76	14,66	0,93	3,01	123	0,0045	2,3493	0,8084
	Dişi	10,65	17,24	1,13	3,66	269	0,0013	2,8946	0,7972
Yaz	Erkek	9,58	13,65	0,91	2,76	257	0,0092	2,0941	0,6077
	Dişi	9,76	14,52	1,19	3,33	628	0,0165	1,9196	0,6518
Sonbahar	Erkek	9,31	15,28	0,98	2,65	303	0,0218	1,7597	0,7115
	Dişi	8,76	16,00	0,93	4,32	521	0,0090	2,1561	0,6148
Kış	Erkek	9,06	15,62	0,84	3,47	328	0,0095	2,0708	0,6518
	Dişi	9,72	17,65	0,77	3,98	320	0,0077	2,2070	0,7154

.

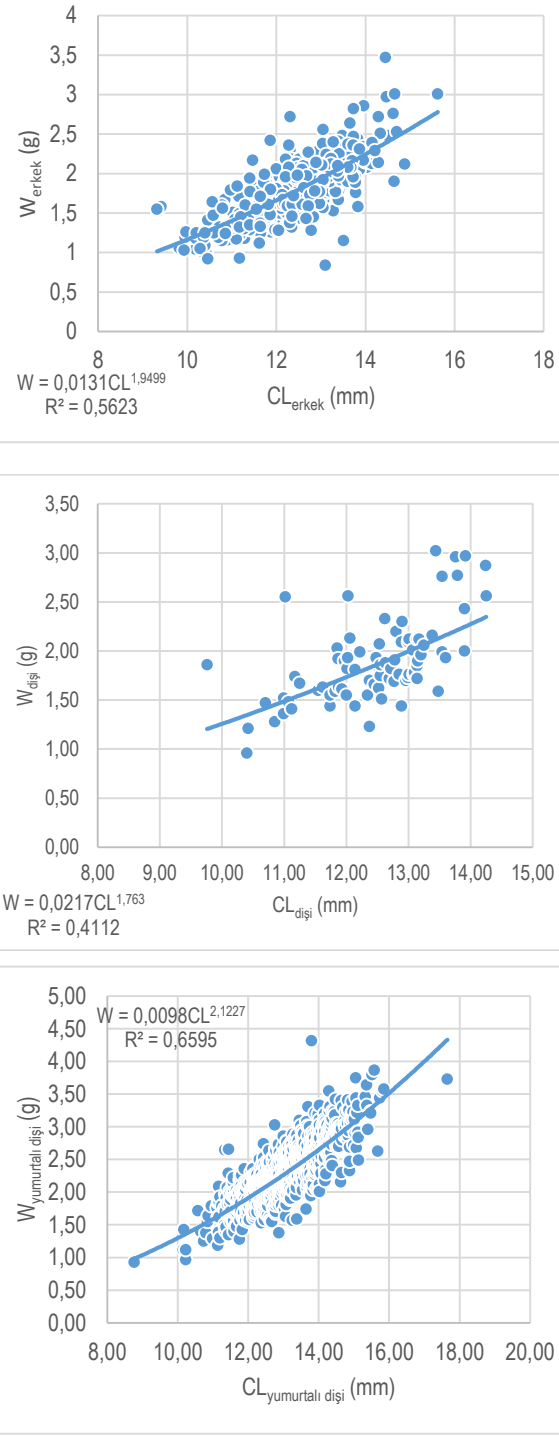
Örneklenen bireylerde erkek, dişi ve yumurtalı dişi olmak üzere boy-ağırlık ilişkilerinde elde edilen sonuçlar Şekil 4'te verilmiştir.

İncelenen tüm gruplarda ve tüm mevsimlerde allometrik katsayısı (b) 3'ten az bulunmuş olup, negatif allometri görülmektedir. Sadece İlkbahar döneminde dişi bireylerde allometrik katsayısı 2,8945 değerine ulaşarak 3'e yaklaşmıştır.

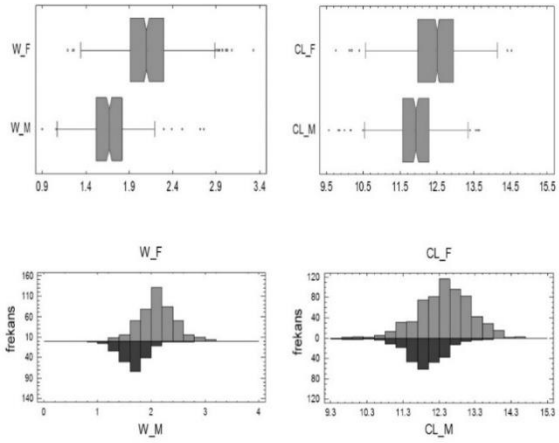
Von Bertalanffy büyüme parametreleri dişilerde L_∞: 26,25 mm, k: 0,38 $yıl^{-1}$, erkeklerde L_∞: 23,63 mm, k:0,49 $yıl^{-1}$ olarak hesaplanmıştır.

Hazırlanan kutu grafiğinde dişi (W_F) ve erkeklerin (W_M) ağırlıklarının karşılaştırılması yapılmıştır. Dişilerin ortalama ağırlıkları 2,30 ± 0,49 g, erkeklerin ortalama ağırlıkları ise 1,78 ± 0,34 g olarak tespit edilmiştir. Benzer şekilde, dişi (CL_F) ve

erkeklerin (CL_M) karapaks boylarının karşılaştırılması da yapılmıştır. Dişilerin ortalama karapaks boyları 13,06 ± 1,06 mm erkeklerin ortalama karapaks boyları ise 12,32 ± 0,96 mm olarak tespit edilmiştir (Şekil 5).



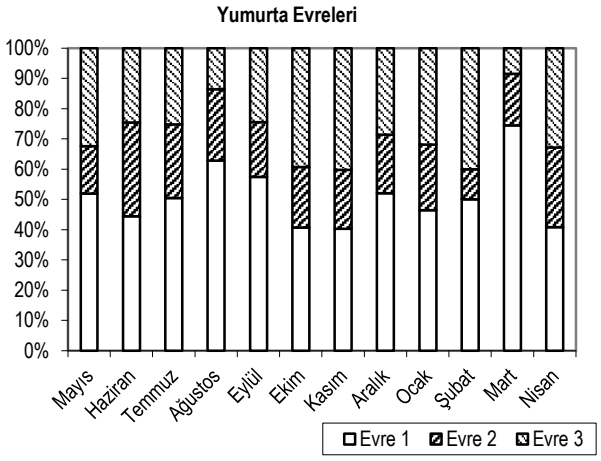
Şekil 4. Erkek, dişi ve yumurtalı dişi bireylerde yıllık boy-ağırlık ilişkileri
Figure 4. Annual length-weight relations of male, female and ovigerous female specimens



Şekil 5. Dişi ve erkek bireylerde ağırlık ve karapas boylarının kutu ve frekans grafikleri.
Figure 5. Box-whisker and frequency graphs of weights and carapace lengths of male and female specimens.

Dişi (W_F) ve erkek (W_M) bireylerin ağırlıkları bir frekans grafiğine dökülerek erkek ve dişi bireyler arasındaki ağırlık farkı gösterilmiştir (Şekil 4). Bu durumda dişi bireylerin büyük bir kısmı 2,0 ile 2,2 g arasında ağırlığa sahip iken erkek bireyler 1,6-1,8 g arasında ağırlığa sahiptirler. Benzer şekilde dişi (CL_F) ve erkek (CL_M) bireylerin karapaks boyları bir frekans grafiğine dökülerek erkek ve dişi bireyler arasındaki boy farkı ortaya konulmuştur. Bu durumda dişi bireylerin büyük bir kısmı 11,50-13,00 mm arasında karapaks boyuna sahip iken erkek bireyler 11,30-12,30 mm arasında karapaks boyuna sahiptirler.

Yumurtaların gelişim evreleri incelendiğinde, üç evreye dahil olan yumurtalar tüm yıl boyunca gözlemlenmiştir. Birinci evredeki yumurtaların Mart'ta, ikinci evredeki yumurtaların Haziran'da ve üçüncü evredeki yumurtaların Ekim ve Kasım aylarında yoğun oldukları tespit edilmiştir (Şekil 6).



Şekil 6. Yumurta evrelerinin aylara göre oransal dağılımı
Figure 6. Proportional distributions of the stages of eggs according to months

Yumurtalı dişilerin, yıl boyunca değişen oranlarda populasyonda temsil edilmeleri sebebiyle, türün kesin yumurtlama periyodunun tespiti zorlaşmaktadır. Yaptığımız çalışmada iki temel yumurtlama sezonu olabileceği düşünülmektedir. Bu sezonlardan biri Ağutos, diğeri ise Mart ayları olabilir (Şekil 6).

TARTIŞMA VE SONUÇ

P. heterocarpus ve *P. martia* Doğu Akdeniz'de en bol bulunan pandalid krustase türleri arasında yer almakta olup, 350-550 m aralığındaki derinliklerde yapılan ticari trol avcılığının en önemli hedef dışı (by-catch) av veren türlerini oluşturmaktadır (Chilari vd., 2005).

P. heterocarpus'un Akdeniz'deki vertikal dağılımı hakkında önceki çalışmalar incelendiğinde, türün genellikle 46-699 m derinlikler arasında, sıklıkla da 250 m civarı derinliklerde dağılım gösterdiği rapor edilmektedir (Company ve Sarda, 1997). Fanelli vd. (2004) Akdeniz'in orta kısmında yaptıkları çalışmada *P. heterocarpus* bireylerinin 100-600 m derinliklerde dağılım gösterdiğini bildirmektedir. Özcan ve Katağan (2009), Sığacık Körfezi'nde 200-600 m derinlikleri arasında yaptıkları çalışmada, *P. heterocarpus* bireylerine 300-400 m konturunda daha sıklıkla rastlamış olup, az sayıda bireyin 400-600 m derinlikten örneklendiğini belirtmektedir. Bizim çalışmamızda örneklemeler 128-550 m derinlikler arasında 36 trol çekimi ile yapılmış olup, her derinlikte *P. heterocarpus* bireylerine rastlanmıştır. Çalışmanın yapıldığı en derin yerler olan 550 m civarı derinliklerde 300-400 m konturuna göre daha az sayıda bireye rastlanmıştır ve bu haliyle Özcan ve Katağan (2009)'daki verilerle paralellik arz etmektedir.

Birçok decapod türünde olduğu gibi *P. heterocarpus*'ta da dişi bireylerin karapaks boyu ve ağırlık bakımından erkek bireylerden daha büyük oldukları tespit edilmiştir (Tablo 1, Şekil 5). Türkiye'nin Kuzeydoğu Akdeniz derin sularında yapılmış bir çalışmada (Can vd., 2006), *P. martia* bireylerinde de benzer sonuçlar elde edilmiş, dişi bireyler ile erkek bireyler arasındaki farkın dişiler lehine olduğu ve istatistiki açıdan önemli bulunduğu ($p<0,05$) belirtilmektedir. Pandalid decapod'lardan *P. edwardsii* ve *P. martia* üzerinde yapılmış diğer çalışmalarda da benzer boyut farklılıklarından bahsedilmektedir (Campisi vd., 1998; Chilari vd., 2005; Koçak vd., 2012).

Boy-ağırlık ilişkileri incelendiğinde, yıl boyunca "b" değerinin 3'ün altında olduğu görülmüştür. Bu durum allometrik büyümeye işarettir. Sığacık Körfezi'nde daha önceden yapılmış bir çalışmada (Özcan and Katağan, 2011), *P. heterocarpus*'un erkek ve dişi bireylerinde negatif allometrik büyümenin mevcudiyetinden bahsetmektedir. Söz konusu çalışmada incelenen 74 bireyde "b" değeri 0,568 olarak verilmiştir. Bizim çalışmamızda mevsimsel (Tablo 1) ve yıllık (Şekil 4) boy-ağırlık ilişkisi ölçümlerinde "b" değeri 1,7596 ile 2,8946 arasında değişim göstermiştir. *P. martia* üzerinde yapılan benzer bir çalışmada da "b" değerleri 3'ün altında tespit edilmiştir (Koçak vd., 2012).

Bu ve önceki çalışmalar dikkate alındığında, *P. heterocarpus* türünün Sığacık Körfezi'nde 100-600 m derinlikler arasında ve çoğunlukla da 200-300 m derinlikler arasında bolca bulunduğu görülmektedir. Bu haliyle Sığacık Körfezi'nin ekolojik şartlarının türün sağlıklı populasyonlar oluşturabilmesi için uygun olduğu söylenebilir. *P. heterocarpus* türünün derin deniz balıkçılığı yapılan bölgelerdeki en önemli yan türlerden olması ve ekonomik öneme sahip olması sebebiyle, diğer ekonımik türler ile birlikte bilimsel tabanlı sürdürülebilir bir balıkçılık yönetimi ile ele alınması gerekmektedir. Ülkemiz ve Doğu Akdeniz havzasında yapılacak benzeri çalışmalar sayesinde türün biyolojik özellikleri ve yaşam döngüsü hakkında önemli bilgiler edinilecektir.

TEŞEKKÜR

Arazi çalışmalarını birlikte gerçekleştirdiğimiz Hapulo trol teknesi kaptanı ve tayfalarına teşekkürü bir borç biliriz. Bu çalışma TÜBİTAK 108Y102 nolu proje tarafından desteklenmiştir.

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Determination of nutritional composition of *Enteromorpha intestinalis* and investigation of its usage as food

Enteromorpha intestinalis'in besinsel kompozisyonunun belirlenmesi ve gıda amaçlı kullanımının tespiti

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Öz: Bu çalışmada Muğla Akyaka Kadın Azmağı'ından toplanan yeşil makroalg *Enteromorpha intestinalis*'in besinsel kompozisyonunun mevsimsel olarak belirlenmesi ve gıda amaçlı kullanımının tespiti amaçlanmıştır. Ortam koşulları ve ardından etüvde kurutma işleminden sonra, *E. intestinalis* çay, çorba ve baharat şeklinde hazırlanmış ardından duyusal değerlendirmeye alınmıştır. Besinsel kompozisyon analiz sonuçlarına göre; ancak *E. intestinalis*'in içerdiği daha yüksek miktarda protein, ilkbaharda kül ve C vitamini, sonbaharda çoklu doymamış yağ asitleri nedeniyle, kullanım alanına bağlı olarak 12 ay boyunca değerlendirilebileceği düşünülmektedir. Duyusal analiz bulgularına göre ise; elde edilen ürünler Türk damak tadına çok yakın olmasa da, ürünlerin farklı içeriklerle çeşitlendirilmesinin kabul edilebilirliklerini arttırdığı sonucuna varılmıştır.

Anahtar kelimeler: *Enteromorpha intestinalis, makroalg, besinsel kompozisyon, duyusal analizler*

Abstract: The aim of this study was to determine the nutritional composition of green macroalgae *Enteromorpha intestinalis*, collected from Muğla Akyaka Kadın Azmağı seasonally and investigate for consumption as food. After drying process in ambient conditions and then oven, *E. intestinalis* was prepared as tea, soup and spice and offered to the panelist team for sensorial test. Based on the nutritional composition analysis results, *E. intestinalis* can be utilized in a variety of ways depending on its intended field of usage, due to its higher content of crude protein in summer, ash and vitamin C in spring and polyunsaturated fatty acids in autumn. According to sensory analysis; processed products are not very close to the Turkish palate, although flavoring of these products with different additives increased the acceptability.

Keywords: *Enteromorpha intestinalis, macroalgae, nutritional composition, sensory analysis*

INTRODUCTION

Macroalgae is an important coastal source for human consumption and environment in many countries (Ratana-arporn and Chirapart, 2006). Because of its health benefits it had been used in many fields such as food, medicine, cosmetics, agriculture since ancient times. The importance of algae in human nutrition is due to the fact that it has the necessary ingredients at desired levels for healthy nutrition. Especially high protein, vitamins and minerals in its structure and the low amount of lipid puts the consumption of algae after fish for healthy nutrition as an attractive food. Green algae (Chlorophyta) are mostly used in the food industry due to their high content of protein, vitamins and minerals (Ova Kaykaç et al., 2008).

Seasonal changes in the life cycle of algae also change their chemical structure (Çetingül, 2001). Macroalgae, which are beneficial for human health has oppurtunities to be used in many fields. Due to its nutritional content, it is utilized in many countries but although our country is surrounded by sea and has several inland waters and rich flora, macroalgae is not preferred as food.

In this study, our purpose was to determine nutritional composition of Enteromorpha intestinalis which is found in Muğla Akyaka Kadın Azmağı for each season in order to increase the interest and the awareness about the algae which has beneficial components for human health. After determining nutritional composition, alternative products like tea, soup and spice were prepared from this macroalgae to increase acceptability and were invastigated whether they are appealing to the Turkish palate with sensory analysis.

MATERIALS AND METHODS

Collection of material and drying procedure

E.intestinalis was used as material. Sampling was carried out in Akyaka Kadın Azmağı (Muğla). For nutritional composition and other analysis, samples were collected manually from the coordinates of 37˚3' 11.83" N-28˚19' 47.32" E and 0.5-1m depth, between August 2013-April 2014, over four seasons; in August, November, January and April. Necessary permissions were taken from Republic of Turkey Ministry of Food, Agriculture and Livestock, General Directorate of Fisheries and Aquaculture. Collected samples were placed in opaque plastic bags and were brought to Muğla Sıtkı Koçman University, Faculty of Fisheries Quality Control Laboratory by placing in styrofoam boxes within half an hour. Subsequently the samples which were purified from debris (stone and sand) by washing with pure water and were kept in -18°C about one month for each sampling period until analysis were carried out.

Before starting analysis, algae samples were thawed at 25±2˚C ambient temperature. After thawing process, kept at 25±2˚C ambient temperature for the following 24 hours, according to Turan (2007) the samples were dried at 40°C in drying oven for 24 hours and milled by commercial blender (Waring commercial blender, Torington, USA).

Nutritional composition analysis

Seasonal crude protein (AOAC, 2002), crude lipid (AOAC, 2006), moisture (AOAC, 1995), ash (AOAC, 1990), carbohydrate (Varlık et al., 2007), chlorophyll-a (Rohani-Ghadikolaei et al., 2012), fatty acid (AOAC, 2001), vitamin (AOAC, 2000; Gökmen et al., 2000; Reyes and Subryan, 1989) and mineral (Hussain et al., 2011) analysis were carried out for dried *E. intestinalis*. All analysis were carried out with dry material since the products were going to be prepared as dried material.

Product preparation and sensory analysis

Tea, soup and spice were produced for evaluation at sensory panels. After literature review and pre-trials, appropriate concentration ratios were determined as 1%, 3%, 5% and at these concentrations seaweed tea was prepared using 100% natural tea bags. All concentration groups were brewed at 100±2°C. Brewing lasted 3, 5 and 10 minutes. Sensory analysis were carried out for prepared seaweed teas for two panel days. At the first panel each concentration group that were brewed in three different brewing time were prepared as 9 different groups and offered to sensory evaluation (Table 1). The most admirable group in terms of concentration and brewing time was defined as control group for second panel. In the second panel, mint-lemon or apple-cinnamon mix were added to the control group with different concentrations to give different flavours (Table 2).

Table 1. Seaweed teas prepared at different brewing time and concentrations

1% concentration (A)	3% concentration (B)	5% concentration (C)
•3 minutes (A-3) •5 minutes (A-5) •10 minutes brewing (A-10)	•3 minutes (B-3) •5 minutes (B-5) •10 minutes brewing (B-10)	•3 minutes (C-3) •5 minutes (C-5) •10 minutes brewing (C-10)

Table 2. Seaweed teas prepared at different content and ratios

Control group (A)	Mint-lemon seaweed tea ratio(B)	Apple-cinnamon seaweed tea ratio(C)
•1% concentration, 5 minutes brewing	•2:1 (B-2) •4:1 (B-4) •8:1 (B-8)	•2:1 (C-2) •4:1 (C-4) •8:1 (C-8)

The most appropriate ingredient for seaweed soup was determined after pre-trials. Accordingly soups were prepared with wheat flour, corn flour, potato starch, corn starch for thickening, onion powder, salt, sugar, pepper, sunflower oil and noodle for flavouring. Dried and milled seaweed powders were added to this mix at different concentrations; 10% (B), 15% (C), 20% (D) and were presented to sensory analysis with seaweed-free group (A) by adding 150 ml drinking water (Table 3). Furthermore, milk cream was added to each group while cooking.

Table 3. Seaweed soup content for one panelist

	A (%)	B (%)	C (%)	D (%)
Seaweed	-	10.00	15.00	20.00
Wheat flour	15.00	15.00	13.00	11.00
Salt	6.50	6.50	6.50	6.50
Onion powder	4.00	4.00	4.00	4.00
Potato starch	10.00	7.15	6.50	6.00
Sugar	1.50	1.50	1.50	1.50
Black pepper	0.01	0.01	0.01	0.01
Corn flour	13.50	10.00	8.50	7.50
Corn starch	11.00	7.50	6.50	5.00
Noodle	20.00	20.00	2.00	20.00
Sunflower oil	3.50	3.50	3.50	3.50
Milk cream	15.00	15.00	15.00	15.00

Seaweed spices were prepared with dried and milled seaweeds. Different groups containing spices were prepared with 2:1 seaweed and spice mix ratio (2 parts of seaweed, 1 part of spice mix) (Table 4). During sensory panel, spice mixtures were mixed with sunflower oil and served on toast breads.

Table 4. Spice mix contents

	A (g)	B (g)	C (g)	D (g)
Seaweed	30	30	30	30
Thyme	*	7.5	5	3.75
Red pepper flakes	*	7.5	5	3.75
Onion powder	*	*	5	3.75
Cumin	*	*	*	3.75

Panels for tea, soup and spice products derived from *E. intestinalis* were carried out with 30 panelists in Sensory Panel Room between 10.00-11.30 am and 14.00-15.00 pm. Sensory criterions for products were detected according to characteristics of products and scoring test evaluated between 1-9 points (1 point; Extreme poor, 2 points; Too bad, 3 points; Poor, 4 points; Better than bad, 5 points; Average, 6 points; Better than middle, 7 points; Good, 8 points; Very good, 9 points; Excellent) (Anonymous, 2010). Drinking water was presented to panelists for rinsing their mouths between sample tasting, each sample was encoded with 3 digit letters or numbers. In each panel, opinions of panelists were recorded.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows, SPSS Inc., Chicago, IL, USA). Experiments were performed in triplicate (N=3) for three independent samples and a completely randomized design (CRD) was used. Data were presented as mean values standard deviations and a probability value of P>0.05 was considered significant. Analysis of variance (ANOVA) was performed and the mean comparisons were done by Duncan's multiple range tests.

RESULTS

Nutritional composition analysis results

As a result of nutritional composition analysis for dry material; protein content of dried material in summer, autumn, winter and spring was determined as 13.42±1.31%, 4.67±0.81%, 6.29±0.99% and 12.34±2.92%, respectively. The highest protein content was detected in summer with 13.42±1.31%, the lowest content was in autumn with 4.67±0.81% (P<0.05). Crude lipid content was determined between 0.02±0.01%-1.31±0.57% values seasonally, the highest content obtained in summer (P<0.05). Moisture values investigated seasonally were determined between 10.74±0.11-12.15±0.18%. Big differences were not observed seasonally (P>0.05). Highest ash content was obtained in spring (17.35±1.47%)(P<0.05). Carbohyrate and chlorophyll-a content changed between 58.03±2.31-70.64±0.76% and 4.07-5.89%, respectively (Table 5).

Table 5. Nutritional composition values of *E. intestinalis* obtained seasonally

	Protein(%)	Lipid(%)	Moisture(%)	Ash(%)	Chlorophyll-a(%)	Carbohydrate(%)
Summer	13.42±1.31a	1.31±0.57a	12.14±1.11a	14.81±0.23b	4.07*	58.03±2.31b
Autumn	4.67±0.81b	0.22±0.10b	12.15±0.18a	11.75±0.55c	4.90*	70.64±0.76a
Winter	6.29±0.99b	0.22±0.06b	11.23±0.10b	12.45±0.70c	5.04*	69.01±1.03a
Spring	12.34±2.92a	0.02±0.01b	10.74±0.11b	17.35±1.47a	5.89*	59.79±1.33b

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important (P<0.05) differences between values indicated by different letters in the same column. *Values were not evaluated statistically because they contain single data.

For fatty acids it stands out; high contents of linoleic acid (C18:2) (%11.11) in winter, linolenic acid (C18:3) (%14.93) and Cis-11,14-eicosadienoic acid (C20:2) (%17.76) in autumn, among polyunsaturated fatty acids. High contents of palmitic (C16:0) and palmitoleic (C16:1) acid among saturated and monounsaturated fatty acids were detected (Table 6).

Table 6. Results of fatty acid composition obtained seasonally

	Summer	Autumn	Winter	Spring
Caproic acid (C6:0)	1.82	-	-	-
Lauric acid (C12:0)	0.73	0.43	-	-
Tridecanoic acid (C13:0)	0.24	-	-	-
Myristic acid (C14:0)	5.06	2.38	1.82	1.81
Pentadecanoic acid (C15:0)	1.99	-	-	-
Palmitic acid (C16:0)	20.00	28.54	43.29	25.10
Palmitoleic acid (C16:1)	2.83	15.00	2.38	3.59
Heptadecanoic acid (C17:0)	0.82	-	-	-
Stearic acid (C18:0)	6.80	1.94	25.06	15.15
Oleic acid (C18:1)	21.71	3.52	10.85	20.11

	Summer	Autumn	Winter	Spring
Linoleic acid (C18:2)	3.77	7.51	11.11	19.42
Trans-linolenic acid (C18:3n6)	6.69	1.53	-	-
Linolenic acid (C18:3)	1.71	14.93	2.36	6.90
Cis-11,14-eicosadienoic acid (C20:2)	-	17.76	-	5.52
Cis-8,11-14-eicosatrienoic acid (C20:3)	-	0.37	-	-
Cis-5,8,11,14,17 eikosapentaenoik asit(C20:5n3)	-	3.32	1.89	2.40
Behenic acid (C22:0)	-	0.67	-	-
Cis-13,16-Dokosadienoik acid (C22:2)	3.89	-	-	-
Tricosanoic acid (C23:0)	19.93	-	-	-

According to mineral contents investigated in the study, calcium was observed in each season with the maximum contents compared to other minerals. The maximum calcium content (15977 mg/kg) was obtained in autumn. Micro minerals were obtained in this order; Fe> Mn> Cu> Zn (Table 7).

Table 7. Results of studied mineral analysis seasonally (mg/kg)

	Summer	Autumn	Winter	Spring
Fe	305.30	338.70	218.50	250.40
Cu	15.10	14.60	21.90	18.60
Zn	12.10	11.90	5.90	8.70
Mn	80.30	80.70	90.20	86.70
Ca	14780	15977	14879	14962
K	972.20	1052.70	1022.50	938.60

Mineral analysis results were not evaluated statistically because of containing single value.

The maximum vitamin A (0.156±2.83mg/100g) and vitamin E (7.91±0.11mg/100g) amounts were detected in winter, the difference between other seasons statistically significant (P<0.05). While there was no difference statistically (P>0.05) between seasons in terms of vitamin B_2, the highest B_1 and B_3 value were observed in spring and were statistically significant from other seasons (P<0.05) (Table 8).

Table 8. Results of vitamin analysis obtained seasonally (mg/100g)

	Summer	Autumn	Winter	Spring
Vitamin A (Retinol)	0.145 ± 0.71^{b}	0.033 ± 0.50^{d}	0.156 ± 2.83^{a}	0.081 ± 1.54^{c}
Vitamin B1 (Thiamine)	0.12 ± 0.00^{b}	0.12 ± 0.00^{b}	0.11 ± 0.00^{b}	0.17 ± 0.02^{a}
Vitamin B2 (Riboflavin)	0.97 ± 0.01^{a}	0.95 ± 0.01^{a}	0.95 ± 0.06^{a}	0.89 ± 0.02^{a}
Vitamin B3 (Niacin)	0.73 ± 0.02^{b}	0.81 ± 0.03^{b}	0.81 ± 0.05^{b}	2.42 ± 0.09^{a}
Vitamin B6 (Pyridoxine)	0.23 ± 0.02^{a}	0.18 ± 0.01^{ab}	0.20 ± 0.02^{ab}	0.15 ± 0.01^{b}
Vitamin C (Ascorbic acid)	2.78 ± 0.08^{b}	3.41 ± 0.00^{b}	2.56 ± 0.02^{b}	147 ± 2.00^{a}
Vitamin E (Tocopherol)	2.75 ± 0.29^{c}	1.23 ± 0.01^{d}	7.91 ± 0.11^{a}	5.13 ± 1.03^{b}

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important (P<0.05) differences between values indicated by different letters in the same line

Sensory Analysis Results

According to the first panel of seaweed tea sensory analysis results, considering overall acceptability values the most appreciated group was A-5 with 6.52±1.44 points (good), the least appreciated group was C-10 with 5.29±1.75 points (middle) and the difference between two groups was statistically significant (P<0.05) (Table 9).

Table 9. Sensory anaylsis results of seaweed teas prepared at different concentrations and brewing times

	A-3	A-5	A-10	B-3	B-5	B-10	C-3	C-5	C-10
Colour	5.94±1.67^{abc}	6.29±1.42^{a}	6.09±1.33^{ab}	6.00±1.65^{abc}	5.55±2.08^{abc}	5.52±2.06^{abc}	5.22±1.80^{bc}	5.00±1.95^{c}	5.32±1.87^{abc}
Clarity	6.29±1.42^{ab}	6.71±1.19^{a}	6.42±1.26^{ab}	6.00±1.24^{abc}	5.74±1.63^{bc}	5.77±1.69^{bc}	5.19±1.92^{c}	5.23±1.71^{c}	5.29±1.79^{c}
Flavour	5.74±1.61^{a}	6.10±1.83^{a}	5.94±1.86^{a}	6.39±1.67^{a}	6.42±1.95^{a}	6.35±1.68^{a}	5.90±1.82^{a}	6.42±1.78^{a}	6.06±1.95^{a}
Odour	7.35±1.23^{a}	7.32±1.33^{a}	7.13±1.57^{ab}	6.35±1.84^{bc}	6.16±1.86^{c}	5.74±1.83^{cd}	4.58±1.61^{e}	5.16±1.81^{de}	4.71±1.64^{e}
Fish/ seaweed aroma	5.21±1.95^{a}	5.10±1.99^{a}	5.55±1.96^{a}	5.10±2.14^{a}	5.14±2.01^{a}	5.34±2.41^{a}	5.62±2.03^{a}	4.93±2.43^{a}	5.48±1.96^{a}
After-taste liking	5.84±1.42^{abc}	6.35±1.23^{a}	6.10±1.68^{ab}	5.81±1.51^{abc}	5.55±1.77^{abc}	5.58±1.75^{abc}	5.32±2.14^{bc}	5.03±2.27^{c}	5.13±2.05^{bc}
Overall acceptability	6.05±1.40^{ab}	6.52±1.44^{a}	6.23±1.59^{ab}	5.90±1.49^{ab}	5.65±1.87^{ab}	5.73±1.70^{ab}	5.39±1.84^{b}	5.39±1.78^{b}	5.29±1.75^{b}

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important (P<0.05) differences between values indicated by different letters in the same line.

For overall acceptability criterion of seaweed teas constituted for second panel, it was detected that the most admirable group was B-2 with 6.53±1.50 points (good), the least admirable group was A with 5.00±1.76 points (middle). The difference between two groups was statistically significant (P<0.05). Each criterions dealed individually and in terms of overall acceptability it is observed group B-2 reached maximum point (Table 10).

Table 10. Sensory analysis results of seaweed prepared at different contents

	A	B-2	B-4	B-8	C-2	C-4	C-8
Colour	6.63±1.54^{a}	6.53±1.50^{a}	6.44±1.29^{a}	6.53±1.59^{a}	6.06±1.63^{a}	6.19±1.71^{a}	6.50±1.63^{a}
Clarity	7.28±1.37^{a}	6.59±1.58^{a}	6.72±1.22^{ab}	7.06±1.41^{ab}	5.91±1.53^{b}	5.94±1.72^{b}	5.94±1.50^{b}
Odour	4.53±2.11^{c}	6.75±1.72^{bc}	6.06±1.63^{ab}	5.29±1.99^{a}	6.16±1.92^{ab}	6.40±1.60^{a}	6.19±1.96^{ab}
Flavour	5.13±1.38^{c}	6.70±1.53^{bc}	6.12±1.91^{ab}	5.43±1.79^{a}	6.17±1.66^{ab}	6.20±1.67^{ab}	5.93±1.95^{abc}
Fish/seaweed aroma	5.08±2.19^{b}	6.71±1.38^{a}	5.55±1.50^{ab}	5.48±2.09^{b}	5.70±1.78^{ab}	5.95±1.64^{ab}	5.57±1.47^{ab}
Overall acceptability	5.00±1.76^{b}	6.53±1.50^{a}	6.25±1.30^{a}	5.72±1.73^{ab}	6.16±1.63^{a}	6.47±1.81^{a}	6.06±1.61^{a}

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important (P<0.05) differences between values indicated by different letters in the same line.

Seaweed soup that was investigated in terms of overall acceptability, the most appreciated group was observed as group B with 6.43±1.87 points, its difference from group C and D was statistically significant (P<0.05) (Table 11).

Table 11. Sensory analysis results of seaweed soup prepared at different concentrations

	A	B	C	D
Appearance	6.50±2.06^{a}	6.13±2.05^{a}	5.73±2.02^{b}	5.43±1.83^{b}
Colour	6.70±2.14^{a}	6.20±2.04^{a}	5.73±2.10^{b}	5.70±1.95^{b}
Odour	6.35±1.68^{a}	6.45±1.86^{a}	6.26±1.83^{a}	5.52±1.90^{b}
Fish/seaweed aroma	-	6.40±1.90^{a}	5.90±1.90^{b}	5.62±1.97^{b}
Flavour	6.43±1.72^{a}	6.53±1.81^{a}	5.80±1.77^{b}	5.97±1.75^{b}
Consistency	6.53±1.66^{a}	6.63±1.54^{a}	6.57±1.68^{a}	6.13±1.85^{a}
Dissolution rate	6.30±2.45^{a}	6.20±2.07^{a}	6.00±1.84^{ab}	5.70±1.76^{b}
After-taste liking	6.07±1.48^{a}	6.17±1.88^{a}	5.67±1.81^{b}	5.67±1.66^{b}
Overall acceptability	6.33±2.07^{a}	6.43±1.87^{a}	5.83±1.66^{b}	5.73±1.68^{b}

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important (P<0.05) differences between values indicated by different letters in the same line.

Table 12. Sensory analysis results of seaweed spice prepared with different concentrations

	A	B	C	D
Appearance	5.97±1.83^{b}	7.00±1.13^{a}	6.65±1.36^{ab}	7.19±1.01^{a}
Colour	6.37±1.77^{b}	7.10±1.24^{ab}	7.00±1.34^{ab}	7.30±1.24^{a}
Odour	5.50±1.89^{b}	6.93±1.66^{a}	7.10±1.56^{a}	6.60±1.30^{a}
Fish/seaweed aroma	5.36±1.91^{b}	6.36±1.66^{a}	6.56±1.79^{a}	6.21±1.56^{ab}
Flavour	4.72±1.96^{b}	6.34±1.56^{a}	6.41±1.62^{a}	5.90±1.18^{a}
After-taste liking	4.63±2.11^{b}	6.17±1.93^{a}	6.40±1.79^{a}	5.67±1.65^{a}
Overall acceptability	4.93±2.03^{b}	6.33±1.63^{a}	6.60±1.71^{a}	6.00±1.39^{a}

Values were given as average and ± standard deviation of 3 paralleled analysis. There are statistically important ($P<0.05$) differences between values indicated by different letters in the same line.

When seaweed spices invastigated in terms of overall acceptability, group C was the most appreciated with 6.60±1.71 points. Group A was the least appreciated group with 4.93±2.03 points. The difference between group A and C was statistically significant ($P<0.05$) (Table 12).

DISCUSSION

Macroalgae has rich a nutritional composition in terms of protein, fatty acids, vitamins and minerals and they constitute quite valuable for nutrition. In this study, high protein contents were determined and specimens had quite high amounts in summer and spring compared to other seasons. Çetingül (2001) specified that the maximum protein content of algae is observed mostly in rapid growing period of the species and, the minimum content, when thallus structure deteriorates. Ova Kaykaç et al. (2008) indicated fluctuations among seasons arise due to the changing of the factors such as temperature, salinity, nitrogen and nutrients of aquatic environment in which the species live. Akköz et al. (2011) determined the protein content for *E. intestinalis* as 15.02±1.02% which was obtained from Konya Acıgöl. McDermid and Stuercke (2003) determined protein content of *E. intestinalis* collected from Hawaii as 11.40±0.80% on dry material, Manivannan et al. (2008) also determined protein content of *E. intestinalis* collected from Mandapam (India) coastal region as 16.38±0.50%. These results have similarities with the protein content in summer season in our study. The differences between protein values might arise due to differences of geographic region, species, the season of sampling, laboratory conditions, analysis variables and etc.

It was thought that the maximum lipid value obtained in summer depends on the maximum growth of the algae. Siddique et al. (2013) reported that consumable algaes are not good lipid sources and contain crude lipid below 4%. Lipid content of green algaes show difference between 0.60% and 4.30% (Parekh et al., 1977). Mamatha et al. (2007) determined lipid content of *Enteromorpha compressa* that was used for snacks, 0.30%, Akköz et al. (2011) determined 1.63±0.09% for *E. intestinalis* obtained from Konya Acıgöl. The values obtained in our study shows similarities with the values obtained in other studies.

Pillai (1956) indicated moisture changes depend on growth stages of algaes and they have higher moisture content at young stages. Aguilera-Morales et al. (2005) determined moisture content in dry material of *Enteromorpha spp.* as 9.00±0.74 g/100g.

In the study the highest ash content (17.35±1.47%) was observed in spring ($P<0.05$) with the increase of sunlight and photosynthesis. Aguilera-Morales et al. (2005) determined ash content of *Enteromorpha spp.* as 36.38±0.42 g/100g. Changes of ash content show differences according to algae species, geographic origin and mineralization method (Nisizawa et al., 1987; Sanchez-Machado et al., 2004; Siddique et al., 2013). High levels of ash content is an indicator of high mineral content (Yaich et al., 2011; Siddique et al., 2013).

Fırat et al. (2007) indicated carbohydrate content of *Chlorophyceae* is 1-47%. Mamatha et al. (2007) determined carbohydrate content of *E. compressa* that was used for snacks as 48,20%. Rohani-Ghadikolaei et al. (2012) also determined carbohydrate of *U. lactuca* and *E. intestinalis* as 59.1% and 35.5%, respectively. Also they determined chlorophyll-a value of *E. intestinalis* as 5.6% similar to our study.

Despite containing low levels of lipid, algaes have higher ratio than other land plants (Darcy-Vrillon, 1993). While land plants generally produce ω-6 fatty acids, some certain sea and fresh water plants produce ω-3 fatty acids. Yaich et al. (2011) determined linoleic and linolenic acid of *Ulva lactuca* as 2.43 and 3.20% respectively. Rohani-Ghadikolaei et al. (2012) determined EPA for *E. intestinalis* obtained from Persian Gulf of Iran as 0.3% and DHA is non-defined. Norziah and Ching (2000) determined fatty acids of *Gracilaria changgi* which was collected from Malaysia and found EPA as 33.10±6.30%, palmitic acid as 22.00±2.70% and oleic acid as 21.90±3.40%. This result was similar with palmitic and oleic acid amounts that were found to be dominant in our study.

Garcia-Sartal et al. (2013) reported macroalgaes bioaccumulate essential elements like Ca, Fe at high levels and more than land plants. It is known that karst sources occur from $CaCO_3$ and the amount of calcium occurs discharge of karst sources collecting to Kadin Azmagi (Cesur et al., 2014). Important differences which occur seasonally may be associated with the increase in temperature, nutrient content

and other dissolved material in water by accession of materials to food chain with rain water. Aguilera-Morales et al. (2005) determined potassium (1.10±0.56 g/100g), calcium (2.10±0.79 g/100g) amounts for *Enteromorpha spp.* and these results were similar with our results. Akköz et al. (2011) determined zinc content of *E. intestinalis* as 20.76±1.32% obtained from Konya Acıgöl.

Burtin (2003) reported that vitamin C content of green and brown algae may change between 50–300 mg/100g in dry material. Sarojini and Sarma (1999) concluded vitamin C content of 24 species of green algae annually ranged from 8.96 to 99.52 mg/100g. This result was similar with the vitamin C content that reached 147±2.00 mg/100g in our study. Vitamin C content of macroalgae may change seasonally in significant amounts. It was observed in the studies that vitamin C content of most of macroalgae reach the maximum amount twice a year including vegetative part of early growing phase of thallus and other proliferation phase. It is thought that differences that occur in vitamin contents may arise due to genetic differences among green, red and brown algae, region and seasonal differences.

According to the first seaweed tea panel; it is thought that A-5 was the most appreciated group because of its lowest algae concentration, the lightest colour and was the most pleasing to eye as well as, sensing less peculiar to seaweed odour with short brewing time, lightest seaweed aroma. For second seaweed tea panel it was commented that due to mint-lemon content, group B-2 repress fish/seaweed aroma that is unfamiliar to Turkish palate, gained more appreciation. When compared to first panel it is observed that points increased in second panel, this increase is thought to be because of the addition of mint-lemon and apple-cinnamon flavors which are familiar tastes for our palate and they repress seaweed aroma. Lee et al. (2008) prepared green tea at different brewing time and temperature; as a result of sensory analysis green teas that brewed at 60°C 3 minutes and 80°C 1 minute were appreciated the most.

Intensive seaweed particles in groups C and D for seaweed soups did not leave a good feel in the mouth and, due to intensive seaweed aroma these groups were appreciated less. In their study Kılınç et al. (2013) prepared soups with *Ulva rigida* and *Gracilaria verrucosa* with the addition of flour, salt, yoghurt, egg, lemon, onion, garlic, red pepper, mint, and water and applied cooking for 30 minutes. They evaluated that in terms of sensory analysis and as flavour both soups respectively got 7.54±0.71 and 7.84±0.58 points over 9, and both soups were determined as quite nice in terms of overall acceptability.

For seaweed spice sensory panel; it was detected that the most appreciated group in terms of odour was group C, onion powder in mix content was appreciated by panelists due to its similarities with spicy chips in stores. Group B was found bitter tasting compared to other groups because of its red pepper flake content. Comments show that other mixtures can be used in fish soup, breakfast sauce, cracker, flavour fish or red meat while cooking with barbecue and grill. Senthil et al. (2011) evaluated spice mixtures prepared at different concentrations for *Eucheuma* with descriptive quantitative analysis, according to seven-point hedonic scale for colour, aroma, after-taste liking, overall acceptability. In terms of aroma, after-taste liking, overall acceptability the highest concentration (25%) seaweed spice got the highest score.

Algae are rich sources in terms of protein, unsaturated fatty acids, vitamin and mineral. Nutrient content of *E.intestinalis* is not at extremely high levels but due to the changes in nutrient content seasonally, (highest protein content in summer; ash and vitamin C contents in spring; polyunsaturated fatty acids in autumn) *E.intestinalis* may be used in different seasons depending on the intended use. Tea, soup, spice products with additions recieved appreciation by consumers. The study revealed seaweed can also be used as an organic ingredient in some food products in the food industry. It is thought that, seasoning of these products will be a good alternative for fish consumers, healthy nutrition enthusiasts and people looking for new flavours. This will provide openings for new business areas with positive contributions to the economy. When emphasized benefits of these products on health are made public, people will gain new consumption habits and an alternative food source to land vegetables will be constituted.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Antifouling bakır pritiyonun midye (*Mytilus galloprovincialis*)'de toplam hemosit sayıları üzerine etkilerinin belirlenmesi

Determinations of the effects antifouling copper pyrithione on total hemocyte counts of mussel (*Mytilus galloprovincialis*)

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Öz: Bu çalışmada, 24 ve 96 saat süre ile 10 ve 30 µg/L subletal bakır pritiyona (CuPT) maruz kalan denizel kirliliğin indikatör canlılarından kara midyelerin (Mytilus galloprovincialis) total hemosit sayıları üzerindeki etkisi incelenmiştir. Toplam hemosit sayısı (THS) sağlık göstergesi ve stres indikatörü olarak kullanılan bir parametredir. Yapılan mikroskobik sayımlar sonunda Bakır pritiyona maruz kalan midyelerde toplam hemosit sayıları kontrol grubuna göre azaldığı belirlenmiştir.

Anahtar kelimeler: *Mytilus galloprovincialis, Hemosit, Bakır pritiyon*

Abstract: In the present study, total hemocyte counts of Mytilus galloprovincialis (Black mussel), indicator species for marine pollution, was investigated after exposed to 10 and 30 µg/L sublethal CuPT for 24 and 96 hours. The total hemocyte counts were significantly decreased at group exposed to CuPT for control group. Total hemocyte counts are good biomarker for determining the effects of antifouling agents and other contaminants to the marine ecosystems.

Keywords: *Mytilus galloprovincialis, Hemocyte, Copper Pyrithion*

GİRİŞ

Teknolojik değişikliklerin getirdiği çevre kirliliğine bağlı olarak, deniz canlıları birçok toksik maddeye maruz kalmaktadır. Son yıllarda antropojenik aktivitenin artmasının ve endüstriyel kirlenmenin sonucunda deniz çevresinde pek çok toksikant birikmektedir. Fouling organizmaların yerleşiminden kaçınmak için en yaygın metot antifouling boyalarla denizel yapıları kaplamaktır. Antifouling ürünlerin aktif maddesi olarak kullanılan tributiltin (TBT)'in zararlarının fark edilmesi ve yasaklanmasının ardından bu alanda kullanmaya müsait olan başka aktif maddeler önem kazanmıştır. Zehirli boyalarda (TBT) Tribütilinin' in yaygın kullanımınının ciddi çevre sorunları yaratması sebebiyle diuron, bakır pritiyon (CuPT) ve çinko pritiyon (ZnPT) gemilerin korunması için dünya çapında alternatif bir bileşik olarak tanıtılması gerçekleştirilmiştir (Gatidou vd., 2007) İlk defa 1990'larda piyasaya arz edilen ve antifouling ürünlerde en çok kullanılan aktif maddelerden biri de booster grubu bir biyosit olan bakır pritiyondur (Yebra vd., 2004). Çinko pritiyon ve bakır pritiyon, deniz suyunda direkt güneş ışığı altında hızlı bir fotodegradasyona uğradığı için toksisitesi düşüktür ve deniz suyunda kalıcılığı yoktur nötr haldedir. ZnPT, CuPT gibi metal pritiyonların ışığın sınırlı olduğu marina ve limanlarda, gemilerin gölgesinde kalan sularda ve sedimentlerde veya yüksek türbiditeli su kolonlarında kalıcı olduğu bildirilmiştir (Turley vd., 2000; Turley vd., 2005).

Çinko pritiyon sedimentte bakır varlığında bakır pritiyon ve mangan pritiyon formlarına dönüşmektedir. Sucul çevrede oluşturabileceği olumsuz toksik etkiler, deniz trafiğinin çok yoğun olduğu denizel ekosistemlerde toksisitesinin belirlenmesi açısından büyük önem taşımaktadır (Bao vd., 2014). Sucul organizmalar arasında önemli bir yer tutan midyeler biyodeneyler ve toksikolojik çalışmalar için biyoindikatör olarak en uygun organizma gruplarından birini

oluştururlar. Bu canlılar sedenter yaşam sürdürmeleri çok miktardaki suyu solungaçlarıyla filtre ederek beslenmeleri ve ekonomik öneme sahip deniz ürünü olarak tüketilmelerinden dolayı toksikolojik ve ekotoksikolojik çalışmalarda sıklıkla tercih edilen indikatör türlerdir.

Midyelerde toplam hemosit sayısı (THS) sağlık göstergesi ve stres indikatörü olan bir parametredir. Toksik maddeye maruz kalan bivalve türlerinde hemosit sayılarında değişikler meydana gelerek immun sistem gücünün zayıflamasına neden olur (Auffet vd., 2006). Toplam hemosit sayısı, deniz organizmalarının hastalığa karşı direncini ve hayatta kalma kapasitesini etkilemektedir (Pipe ve Coles 1995; Dyrynda vd., 2000). CuPT' nin (bakır pritiyon) midyeler üzerindeki immüno toksik etkisi hakkındaki çalışmalar oldukça azdır. Bu çalışmada, 24 ve 96 saat süre ile subletal bakır pritiyona (CuPT) maruz kalan denizel kirliliğin indikatör canlılarından Mytilus galloprovincialis türünün total hemosit sayıları üzerindeki etkisi incelenmiştir.

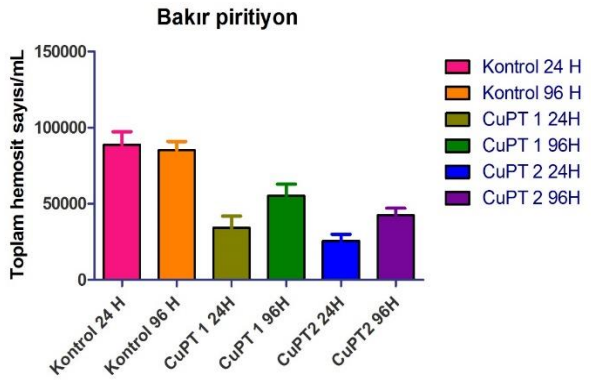
MATERYAL VE METOT

İzmir İli, Foça (N38°40.037' E26°44.748') bölgesinden toplanan (Şekil 1). *Mytilus galloprovincialis* uygun şartlarda laboratuvara getirilerek bir hafta süre ile akvaryumlarda adaptasyona (pH: 7.88, Sıcaklık: 17.5 ± 1°C) tabi tutulmuşlardır. Yapay deniz suyu olarak Coral Pro Salt (Red Sea Europe, France) ‰35 tuzlulukta hazırlanmıştır. 15 L'lik akvaryumlarda 15'er midye (ort. boy 4.21 cm, n = 60) stoklanmış, 96 saatlik süre ile 10 ve 30 µg/L bakır pritiyona maruz bırakılmıştır.24 ve 96 saat sonunda hemolenf örnekleri insulin enjektörü yardımıyla adüktör kası uyarılarak alınmıştır.

Hemolenf örnekleri 1:1 oranında hemolenf ve %4 lük formalin olacak şekilde 2.5 luk enjektörlerle çekilmiştir. Daha sonra ışık mikroskobu altında toplam hemosit sayısı Thoma lamı kullanılarak sayılmıştır. İstatistik değerlendirmede Kruskall Wallis testi uygulanmıştır.

BULGULAR

96 saatlik süre ile ön deneylerle belirlenen 10 ve 30 µg/L bakır pritiyona maruz bırakılan midyelerde 24 ve 96 saat sonunda hemositometre ile yapılan sayım sonucunda bakır pritiyona maruz kalan midyelerde toplam hemosit sayılarının kontrol grubu midyelerine göre azaldığı saptanmıştır (Şekil 1). Yapılan mikroskobik incelemede toplam hemosit sayısındaki azalmanın 24 saat maruziyette daha fazla olduğu belirlenmiştir.



Şekil 1. Bakır pritiyona maruz kalan midyelerin toplam hemosit sayılarındaki (THS) değişim
Figure 1. Changes in total hemocyte counts (THS) of mussels exposed to copper pyrithione

TARTIŞMA VE SONUÇ

Çevresel kirleticilerden olan toksik metaller diferansiyel hemosit sayılarında değişikliğe neden olmaktadır. Hücresel seviyede (Cd) kadmiyumun, Chora vd. (2009) iskelet yapısını, hücre adezyonu ve hücre şeklini bozduğunu, Brousseau vd. (2000), hemosit canlılığı ve hemosit populasyonlarında değişikliklere neden olduğunu belirtmişlerdir (Olabarrieta vd., 2001). Bivalve türlerde hemositler morfolojik olarak granüllü ve granülsüz olmak üzere 2 sınıfa ayrılırlar, granüllü hücreler basofilik ve eosinofilik olmak üzere iki tiptedir (Chandurvelan vd., 2013).

Granüllü hücrelerin fagositozda önemli rol oynadığı düşünülmektedir. Bu iki hücre tiplerinin fonksiyonel farkları bu çalışmada ve diğer çalışmalarda tam olarak anlaşılmamıştır ancak bivalve hemositlerinin hyalünositleri hakkında az da olsa bilgi vardır. Bununla beraber Hyalünositlerin rolü tam olarak bilinmemektedir. Hyalünositlerin ekstrasellüler matriks üretimi ve homeostatik fonksiyonda rol oynadığı daha önceki çalışmalarda gösterilmiştir. (Wang vd., 2012). Hyalünositler, granülositlere göre daha küçük ve granülsüzdür merkezde büyük nukleusa sahiptir. Bununla beraber her iki hücre tipinin sitotoksik immün cevapla ilişkili olduğuna inanilmaktadır (Wang vd., 2012). Aynı zamanda epitel regenerasyonun erken evresinde önemli rol oynadığı düşünülmektedir (Wang vd., 2012). Ayrıca diferansiyel hemosit sayımları, metal maruziyeti sonucu değişiklik göstermekle beraber Eosinofilde azalma buna karşın bazofilde artış gözlenmiştir (Cima., 1999). Çift kabuklu yumuşakçalarda sistemin hücresel ve humoral komponentleri, çevresel kirletici ile karşılaştıklarında immun cevabı baskılayabildiği yada harekete geçirdiği belirlenmiştir (Cima., 1999; Pipe vd., 1999).

Bu çalışmada, bakır pritiyona maruz kalan midyelerde toplam hemosit sayıları kontrol grubuna göre azalmıştır (Tablo1). Toplam hemosit sayısındaki düşüşü hasat sonrası elden geçirme sırasında stresin artışı ve sağlık durumunun kötüleşmesinin bir göstergesi olarak kullanılabileceği belirtilmiştir (Le Moullac ve Haffner., 2000). Çevresel stres, hemopoetik dokuların mitotik aktivitesini değiştirebilir, bu durum hemosit dönüşümünde düşüşle sonuçlanmaktadır (Le Moullac ve Haffner., 2000). Bu bulgulara benzer olarak çalışmamızda bakır pritiyonun yarattığı strese bağlı olarak toplam hemosit sayılarının düştüğü söylenebilir.

Sonuç olarak, total hemosit sayısının biyosidal ürün kullanımının denizel ekosisteme etkisini göstermede basit , hızlı ve iyi bir biyobelirteç olduğu ve hedef olmayan organizmalara etkilerinin incelenmesinde kullanılabileceği belirlenmiştir.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Batı Karadeniz dip trol balıkçılığının genel özellikleri ve çekim süresi ile toplam avın ıskarta üzerine etkisi

General characteristics of bottom trawl fishery and effect of haul duration and total catch on discard in the Western Black Sea

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Öz: Bu çalışmada, Batı Karadeniz dip trol balıkçılığının genel karakteri ile çekim süresi, hedef, ıskarta ve toplam av miktarı gibi bazı parametreler arası ilişkiler regresyon ve korelasyon analizi ile incelenmiştir. Çalışma verileri İğneada ve Rumeli Feneri bölgelerinde 2012-2014 yılları arasında 66 geçerli dip trol çekiminden elde edilmiştir. Sonuç olarak 2010-2014 yılları arasında dip trol balıkçılarının denize çıktıkları gün sayısı 99 ile 167 arasında değiştiği tespit edilmiştir. Çekim süresi arttıkça toplam av artarken ıskarta av miktarı da artmaktadır. Karadeniz demersal kaynaklarının sürdürülebilir kullanımının sağlanması için yalnızca karaya çıkan av üzerinden düzenlemeler yapmak yerine balıkçılık girdi kontrollerinin de (denize çıkılan gün sayısı ve çekim süresi gibi) balıkçılık yöneticileri tarafından planlanması gerekmektedir.

Anahtar kelimeler: *Denize çıkılan gün, çekim süresi, korelasyon, girdi kontrolü*

Abstract: In this study, general characteristics of bottom trawl fishery and relationships of inter parameter such as haul duration, total and discard catch were defined by regression and correlation analysis. Data of study was obtained by 66 valid bottom trawl hauls in İğneada and Rumeli Feneri regions between the years 2012-2014. Accordingly, days at sea of bottom trawlers varied between 99 and 167 days for between years of 2010 and 2014. The total amount of catch increases as haul duration increases. In the meantime, however, discard amount increases as well. To be able to provide the sustainable exploitation of Black Sea demersal resources, controls of fishery inputs (days at sea and haul duration etc.) should be planned by fishery authorities instead of regulations based on only landings.

Keywords: *Days at sea, haul duration, correlation, input control*

GİRİŞ

Avcılık, oldukça dinamik bir yapıya sahip olan su ürünleri üretiminin temel kaynağıdır (Yücel, 2006). Türkiye'nin 2016 yılında 554 859 bin ton olan su ürünleri üretiminin yaklaşık % 54,3'si avcılık yoluyla elde edilmekte, bu üretimin % 63,8'i Karadeniz'den sağlanmaktadır (TÜİK, 2017). Bu durum Karadeniz'i Türkiye balıkçılık kaynakları içerisinde avcılık yolu ile üretimde lider konuma getirmektedir. Demersal balık türleri, dünya genelinde olduğu gibi ülkemizde de pelajik stoklardan daha az avlanmasına karşın ekonomik getirisi oldukça yüksek olan türlerdir (Genç, 2000). Öztürk ve Karakulak'a (2003) göre ise Karadeniz'de demersal balıkçılık kıyısal popülasyona ve deniz ekosistemine çok önemli ektiye sahip önemli bir balıkçılık sektörüdür. Bu bölgede barbun (*Mullus barbatus*), mezgit (*Merlangius merlangus*) ve kalkan (*Scopthalmus maximus*) gibi çok değerli demersal balık türleri avlanılmaktadır. 2016 yılında Karadeniz'de toplam üretim içinde bulunan demersal balık türlerinin yıllık av miktarı mezgit için 10.977,5 ton, barbun için 2708,8 ton ve kalkan için 199,7 ton olarak gerçekleşmiştir (TÜİK, 2017).

20. yüzyılın ilk yılları ile önceki yıllar karşılaştırıldığında, balıkçılık teknolojisi konusunda gelişmiş ülkelerin devamlı olarak balık üretimlerini arttırdıkları görülmüştür (Thurow, 1982). Balıkçılık faaliyetlerinin yoğunlaştığı ülkeler, balıkçılık kaynaklarını en fazla kullanan ülkelerdir. Bu durum stokların aşırı bir şekilde kullanılmasına neden olmuştur (Thurow, 1982). Dünya Gıda Tarım Örgütü (FAO) tarafından izlenen 600 deniz balığı stokunun %3'ü sömürülmemiş, %20'si kısmen sömürülmüş, %52'sinin tamamen sömürülmüş, %17'sinin aşırı sömürülmüş, %7'sinin tükenmiş, %1'inin yenilenmekte olduğu bildirilmiştir (FAO, 2011). Bu sömürülme miktarları dikkate alındığında balıkçılığın etkileri açıkça görülmektedir.

Deniz ekosistemi balıkçılık aktivitelerinden değişik şekillerde etkilenebilir (ICES, 2000 ve 2003) ;

1. Hedef balık ve kabuklu popülasyonları üzerinde mortalite etkisi,
2. Deniz tabanı, dip balıkları ve omurgasızlarla ilişkili olarak habitatlarda meydana gelen değişim,
3. Ekosistemin yapı, fonksiyon ve bütünlüğünde görülen değişim.
4. Ticari balık ve kabuklu popülasyonların küçük bireyleri, ticari olmayan balık, bentik omurgasız, deniz kuşu ve deniz memelilerini içeren hedef dışı popülasyonların bolluk ve kompozisyonda hedef dışı ve ıskartayla olan ilişkisi.

Iskarta, bir av operasyonunda avlanan ve ekonomik, yasal ya da kişisel nedenlerle denize dökülen kısmı ifade eder (Kınacıgil vd., 1999). Iskarta, minimum karaya çıkarma boyundan küçük bireylerin avlanması, pazar değeri düşük veya ticari değeri olmayan türlerin avlanması, avın zarar görmesi ve kotanın dolması gibi çok çeşitli nedenlerden dolayı ortaya çıkar (Feekings vd., 2012). Dip trolü, demersal türlerin avcılığında kullanılan en önemli balıkçılık tekniği olup Dünya'da karaya çıkan avın yaklaşık %22'si, ıskartanın ise %50'si dip trol avcılığından kaynaklanmaktadır (Kelleher, 2005). Ayrıca, en karmaşık ıskarta problemleri, türlerin karışık bulunduğu dip trol balıkçılığında görülür (Johnsen ve Eliasen, 2011; Catchpole vd., 2005b). Ancak Türkiye'de sınırlı sayıda çalışma trol balıkçılığında ıskarta konusuna odaklanmaktadır (Metin vd. 2000; Kınacıgil vd., 2001; Özbilgin vd. 2006; Aksu, 2012; Ceylan vd. 2014)

Iskarta miktarının belirlenmesi, ekosistem yaklaşımlı bir balıkçılık yönetimi hedefi olarak yakın zamanda önemli hale gelmiştir (Borges vd., 2005). Eğer balıkçılık yönetimi için önleyici araçlar önerilecekse neyin ne kadar ıskarta edileceğini belirleyen faktörlerin anlaşılması esastır (Rochet ve Trenkel, 2005). Iskartanın azaltılması için kullanılan yöntemler incelendiğinde ise iki kontrol mekanizması görülmektedir (Hall, 1996); birim çabadaki ıskarta av miktarının (DPUE) ya da balıkçılık eforunun düşürülmesi (Hall vd., 2000). Fakat ıskarta miktarının azaltılması için yapılan birçok araştırma DPUE üzerine odaklanmaktadır. Batı Karadeniz, dip trol balıkçılığı için çok önemli bir balıkçılık sahasıdır ve İğneada'dan Sinop'a kadar bu balıkçılık sahasının kullanan 322 dip trol balıkçısı bulunmaktadır (Kaykaç vd., 2014). Batı Karadeniz dip trol balıkçılığında ıskarta miktarının belirlenmesi ve ıskarta oranının derinliğe göre değişimine yönelik bir çalışma bulunmaktadır (Yıldız ve Karakulak, 2017). Bu çalışmada ise, Batı Karadeniz dip trol balıkçılığının genel özellikleri, denize çıkılan gün sayısı gibi bazı balıkçılık girdilerinin tespiti ile çekim süresi, toplam ve hedef av miktarının ıskarta miktarı üzerine etkisi incelenmiştir.

MATERYAL VE METOT

Çalışma Sahası

Karadeniz, Akdeniz Genel Balıkçılık Komisyonu (GFCM)'nun alt alanlarının en büyüğü ve bölgenin en karmaşık ekosistemlerinden birisidir (GFCM, 2012). Karadeniz'in Türkiye sularında trol avcılığına en elverişli olan sahalar, batıda İğneada-Kefken arası, doğuda ise Sinop, Samsun ile Ordu illeri arasında kalan sahalardır. Bu sahaların dışında kalan litoral saha oldukça kırıklı ve trol çekimi için müsait olmayan sahalardır (Kara, 1980). Orta ve Batı Karadeniz kıyıları bu bakımdan ülkemizin önemli trol av sahalarıdır. Karadeniz'de 1947 yılında 1 trol teknesi, 1952 yılında 2 trol teknesi mevcut iken 1953 yılında trol balıkçılığından tamamen vazgeçilmiştir. Ancak, 1955 yılında Samsun ilinde soğuk hava deposuna sahip 1 dip trol teknesi, bu tip balıkçılığın devam etmesinde öncü olmuştur (Öker, 1956). 1964 yılında İstanbul'a kayıtlı 20 trol teknesi mevcut iken (Arısoy, 1964) bugün bu sayı oldukça artarak günümüzde 155'e yükselmiştir.

Balıkçılık verileri

Bu çalışmada, İstanbul Boğazı-Şile ve İğneada-Kıyıköy bölgelerinde, 2012-2013 ve 2013-2014 balıkçılık sezonu boyunca aylık periyotlar halinde ticari av tekneleri ile trol balıkçılığına iştirak edilmiştir. Rumeli Feneri ve İğneada balıkçı barınakları, Batı Karadeniz'de trol balıkçılığının yoğun olduğu balıkçı yerleşimleridir. Toplamda 66 geçerli dip trolü avcılığında veriler kaydedilmiştir. Trol çekimleri süresince çekim koordinatları, operasyon süreleri (saat), toplam ve ıskarta av miktarları (kg) tekne üzerinde kaydedilmiştir. Çalışma boyunca av güverteye döküldüğünde hangi kısmın alıkonulup hangi kısmın ıskarta edileceğine balıkçı karar vermiştir.

Çalışmada, avcılık operasyonlarına iştirak edilen iki ticari trol teknesinin toplam boyları ve motor güçleri sırasıyla 19 m ve 700 HP ile 21 m ve 822 HP. Araştırmada kullanılan Akdeniz tipi alçak ağız açan klasik dip trol ağlarının toplam boy, ağız genişliği ve yüksekliği sırasıyla 32 m, 12 m ve 0,8 m ile 35 m, 15 m ve 1,2 m'dir. Trol ağlarının kollarında 55 mm tam göz boyunda ağlar kullanılırken, torba tam gözü açıklığı 40 mm, muhafaza tam göz açıklığı 80 mm olarak ölçülmüştür. Teknelerde kullanılan geleneksel trol kapıları dikdörtgen şeklinde genellikle 1,60X80 cm boyutlarında ve ağırlıkları yaklaşık 130-150 kg arasındadır. Balıkçılardan alınan bilgiye göre teorik olarak dip trol ağlarının yaklaşık yatay ağız açıklığı 5 m, dikey ağız açıklığı 2 m, kapılar arası mesafe 150 m, palamar halat 80-90 m'dir.

Çekimler sırasında tekne hızı ve başlangıç-bitiş koordinatları teknede bulunan Küresel Konumlama Sistemi (GPS) yardımıyla tespit edilmiştir. Çekimlerin yapıldığı derinlikler ise teknede bulunan Echo-sounder yardımıyla kaydedilmiştir. Dip trol tekneleri ile ilgili bilgiler 2010-2014 yılları için Su Ürünleri Bilgi Sisteminden (SÜBİS) Gıda, Tarım ve Hayvancılık Bakanlığı İstanbul İl Müdürlüğü yardımıyla süzülerek hesaplanıştır.

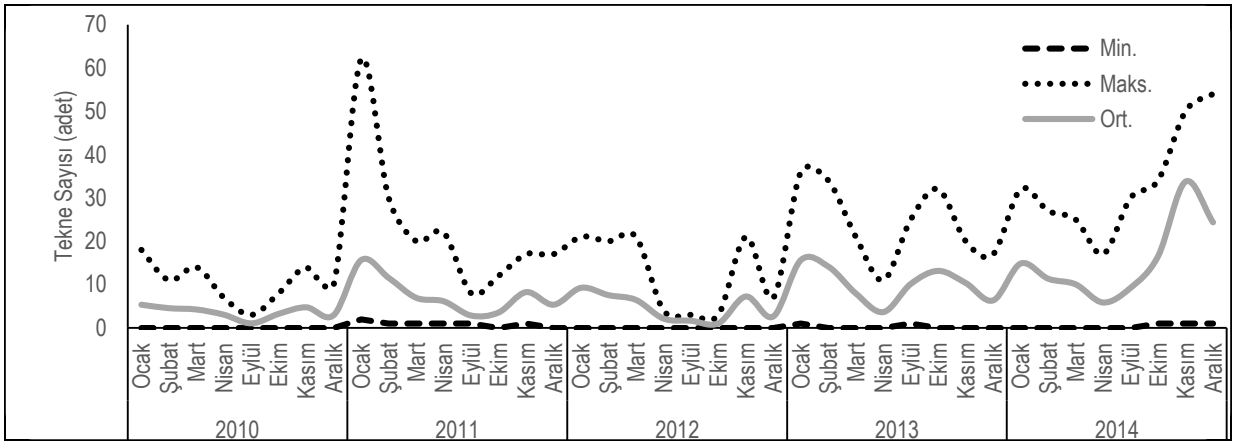
Veri Değerlendirme

Verilerin değerlendirilmesinde Microsoft Office Professional Plus 2013 Excel ve SPSS 21.0 programları kullanılmıştır. Korelasyon analizi için Sperman Korelasyon testi uygulanmıştır. Korelasyon testi sonuçlarının yorumlanmasında korelasyon katsayısı; 0,90-1,00 ise çok yüksek, 0.70-0.89 ise güçlü, 0,50-0,69 ise orta, 0,26-0,49 ise zayıf ve 0,00-0,25 ise çok zayıf olarak kabul edilmiştir (Balcı ve Ahi, 2016). Regresyon analizinde ise en küçük kareler metodu kullanılmıştır.

BULGULAR

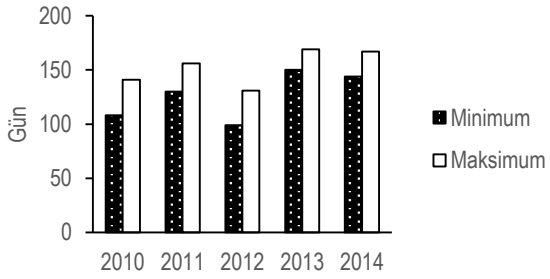
Gıda, Tarım ve Hayvancılık Bakanlığı'nın yayınladığı 4/1 Numaralı Ticari Amaçlı Su Ürünleri Avcılığının Düzenlenmesi Hakkında Tebliğ (No: 2016/35)'e göre trol av sezonu Eylül ayının 15'i ile Nisan ayının 15'i arasında gerçekleşmektedir (Anon, 2016). Ancak bölgedeki trol balıkçıları Eylül aylarında palamut (Sarda sarda) göçünü izleyerek trol balıkçılığı yerine uzatma ağlarıyla palamut balığı avcılığı yaptığı gözlenmiştir. Bölgede ki balıkçı tekneleri hava şartları ve çıkan ürün miktarına göre günde 4-6 (4,5 ± 0,13)arası çekim yapmaktadır. Sabah güneş doğmadan 05:00-05:30 gibi balıkçı limanından ayrılan tekneler akşam 18:00-20:00 gibi limana geri dönmektedir. Analiz edilen 66 çekim boyunca çekim süresinin 1 ile 2,5 (2,0 ± 0,04) saat arasında değiştiği kaydedilmiştir.

Hedef türler olan barbun ve mezgit balıklarını avlamak için sezon başlangıcı olan Eylül ayında denize çıkan tekne sayısı kış aylarına göre oldukça düşüktür (Şekil 1). Ayrıca, sonbaharda sık esen rüzgarlar nedeniyle tekne sayıları Ekim ayında da diğer aylara göre düşük düzeyde kalmaktadır. Denize çıkan trol tekne sayılarının 2014 yılı dışında, genellikle Ocak ve Şubat aylarında yükseldiği, Mart ayından sonra düşüşe geçtiği, Nisan ayında ise en düşük seviyeye indiği görülmektedir.



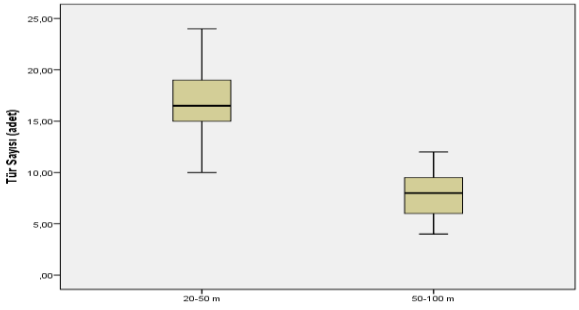
Şekil 1. Batı Karadeniz'de yıllar ve aylara göre denize çıkan dip trol teknelerinin sayısı.
Figure 1. Number of bottom trawl vessels go for fishing by years and months in the western Black Sea

Trol balıkçıları bir yılda toplam yedi aylık bir avcılık dönemine sahiptir. Trol teknelerinin dip trolü balıkçılığı için denize çıktıkları gün sayısı 99 ile 167 gün (139,5 ± 7,32) arasında değişmektedir (Şekil 2).



Şekil 2. Batı Karadeniz'deki dip trolü teknelerinin yıllara göre denize çıktıları gün sayıları
Figure 2. Number of days at sea of bottom trawl vessels by years in the western Black Sea

Analiz edilen 66 çekim boyunca elde edilen tür sayısı 4 ile 24 arasında değişmiş ortalama tür sayısı 13 ± 0,63 olarak hesaplanmıştır (Tablo 1). En yüksek tür sayısı 24 tür ile 2012 yılı Kasım ayında 20-50 m derinlik konturunda, en az tür sayısı 4 tür ile 2013 yılı Mart ayında 50-100 m derinlik konturunda elde edilmiştir. Derinliğe bağlı incelemelerde, trol çekimleri sonucunda ortalama tür sayısı (S) 20 – 50 m derinlik konturunda 16, 50-100 m derinlik konturunda ise ortalama 8 tür olarak belirlenmiştir (Şekil 3). Daima ıskarta edilen tür sayısı 20-50 m derinlik konturunda 24, 50-100 m derinlik konturunda ise 18 olarak hesaplanmıştır.



Şekil 3. Derinlik konturlarına göre dip trol ağları ile Batı Karadeniz'de avlanan tür sayılarının minimum, maksimum, standart sapma ve ortalama değerleri
Figure 3. Minimum, maximum and average number of species caught by bottom trawl nets in the western Black Sea in comparison with depth contours

Tablo 1. Batı Karadeniz'de derinlik konturlarına göre dip trol ağları ile avlanan türlerin listesi ve değerlendirilme durumu
Table 1. The list of species caught and valuation by bottom trawl bottom trawl nets in the western Black Sea in comparison with depth contours

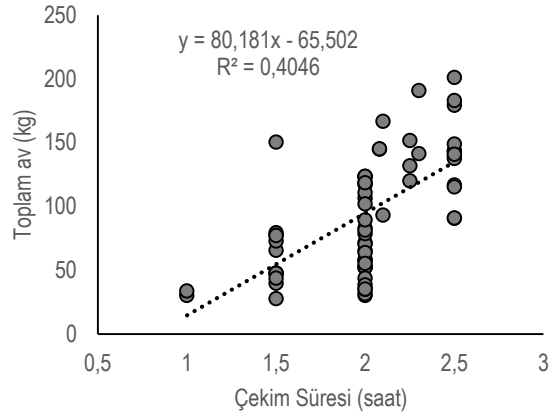
Türler	20-50 m	50-100 m	Değer
Osteichthyes			
Merlangius merlangus euxinus	+	+	Avın büyük kısmı alıkonulan
Mullus barbatus	+	-	Avın büyük kısmı alıkonulan
Pomatomus saltatrix	+	-	Tamamen alıkonulan
Alosa immaculata	+	+	Avın büyük kısmı alıkonulan
Trachurus mediterraneus	+	+	Avın büyük kısmı alıkonulan
Trachinus draco	+	+	Tamamen ıskarta
Scopthalmus maximus	+	+	Tamamen alıkonulan
Neogobius melanostomus	+	+	Tamamen ıskarta
Uranuscopus scaber	+		Tamamen ıskarta
Mesogobius batrachocephalus	+	+	Tamamen ıskarta
Scorpaena porcus	+	+	Tamamen ıskarta
Sprattus sprattus	-	+	Tamamen ıskarta
Pegusa nasuta	+	+	Tamamen ıskarta
Gobius niger	+	+	Tamamen ıskarta
Gaidropsarus mediterraneus	+	+	Tamamen ıskarta
Spicara smaris	+	-	Tamamen ıskarta
Platichthys flesus	+	+	Tamamen ıskarta
Syngnathus acus	+	-	Tamamen ıskarta
Arnoglossus kessleri	+	-	Tamamen ıskarta
Chelidonichthys lucerna	+	+	Tamamen ıskarta
Hippocampus guttulatus	+	+	Tamamen ıskarta
Parablennius tentacularis	+	-	Tamamen ıskarta
Engraulis encrasicolus	+	-	Tamamen ıskarta
Chondricthtyes			
Raja clavata	+	+	Yalnızca büyük bireyleri alıkonulan
Dasyatis pastinaca	+	+	Tamamen ıskarta
Squalus acanthias	+	+	Yalnızca büyük bireyleri alıkonulan
Mollusca			
Rapana venosa	+	+	Tamamen ıskarta
Mytilus galloprovincialis	+	+	Tamamen ıskarta
Crustacea			
Liocarcinus depurator	+	+	Tamamen ıskarta
Eriphia verrucosa	+	-	Tamamen ıskarta
Crangon crangon	+	-	Tamamen ıskarta
Echinodermata			
Marthasterias glacialis	+	+	Tamamen ıskarta
Asterias rubens	+	+	Tamamen ıskarta

Çekim süresi ile toplam av ve ıskarta av miktarı arasında yapılan korelasyon analizine göre çekim süresi ile bu iki av miktarı arasındaki ilişkinin anlamlı olduğu ortaya çıkmıştır (P<0,05). Ancak bu anlamlı ilişkilerin kuvveti orta derecelidir (Toplam av-çekim süresi R=0,689; Iskarta-çekim süresi R=0,489; Tablo 2). Toplam av ile hedef av ve ıskarta av miktarı arasında yapılan korelasyon analizine göre toplam av ile bu iki değer arasındaki ilişkinin anlamlı olduğu ortaya çıkmıştır (P<0,05). Bu anlamlı ilişkilerin kuvveti ise güçlüdür (Toplam av - ıskarta av R=0,762; Toplam av - hedef av R=0,874; Tablo 2).

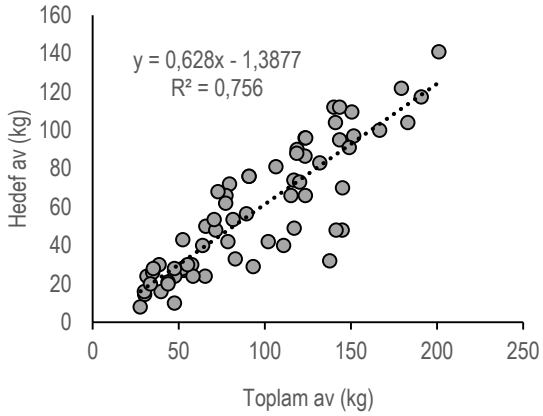
Çekim süresi ile toplam av ve ıskarta av miktarı arasında yapılan regresyon analizine göre çekim süresi ve bu iki değer arasında pozitif bir ilişki vardır (Şekil 4 ve 5). Çekim süresi arttıkça toplam av ve ıskarta av miktarı artmaktadır. Toplam av ile hedef av ve ıskarta av miktarı arasında yapılan regresyon analizine göre toplam av ile bu iki çıktı arasında pozitif bir ilişki vardır (Şekil 6 ve 7). Toplam av arttıkça hedef av ve ıskarta av artmaktadır (Şekil 8 ve 9). Ancak, çekim süresi ile toplam av ve ıskarta av miktarı arasındaki regresyon modellerinde, tanımlayıcılık katsayıları (R^2)'nın düşüklüğü regresyon modelinin açıklayıcılık gücünün düşük olduğunu göstermektedir.

Table 2. Correlation relationships related to trawl hauls
Tablo 2. Trol çekimlerine ait korelasyon ilişkileri

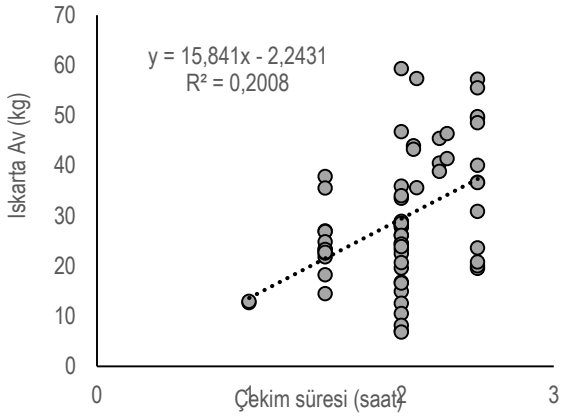
İlişki türü	*P*	*R*	Kuvvet
Toplam av-Çekim süresi	P<0,05	0,689	Orta
Iskarta av-Çekim süresi	P<0,05	0,489	Orta
Toplam av-Iskarta av	P<0,05	0,762	Güçlü
Toplam av-Hedef av	P<0,05	0,874	Güçlü



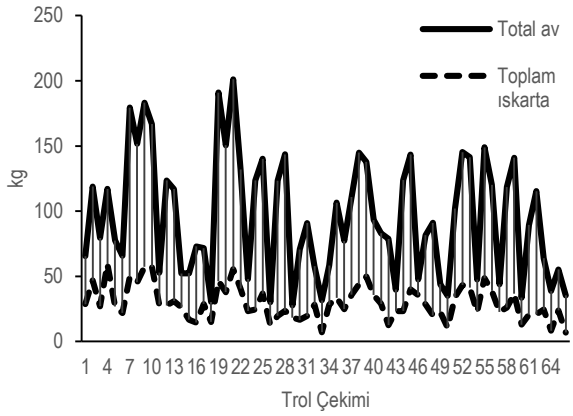
Şekil 4. Çekim süresi ve toplam av miktarı arasındaki regresyon ilişkisi
Figure 4. Regression relationship between haul duration and total catch



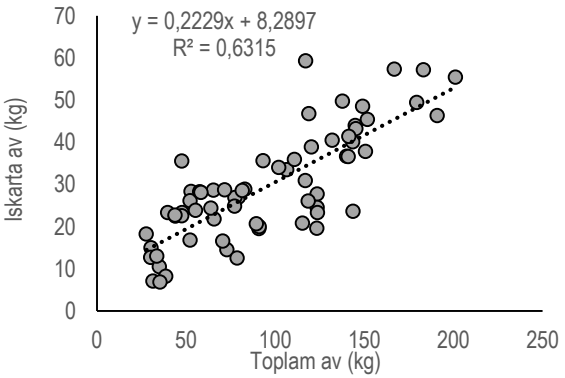
Şekil 7. Hedef av ve toplam av miktarı arasındaki regresyon ilişkisi
Figure 7. Regression relationship between total catch and target catch



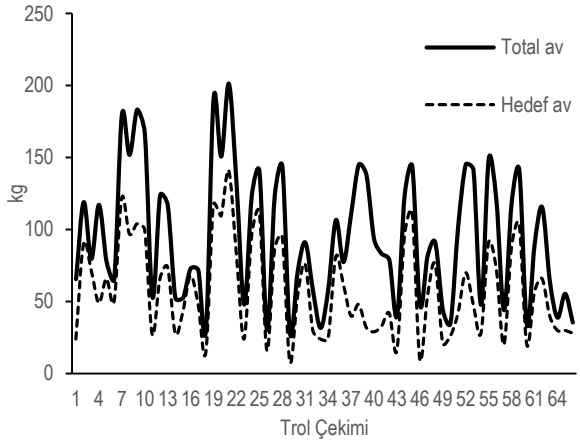
Şekil 5. Çekim süresi ve ıskarta av miktarı arasındaki regresyon ilişkisi
Figure 5. Regression relationship between haul duration and discard catch



Şekil 8. Toplam av ve ıskarta avın örnekleme periyodu boyunca değişimi
Figure 8. Fluctuation in total catch and discard catch during study period



Şekil 6. Iskarta av ve toplam av miktarı arasındaki regresyon ilişkisi
Figure 6. Regression relationship between total catch and discard catch



Şekil 9. Toplam av ve hedef avın örnekleme periyodu boyunca değişimi
Figure 9. Fluctuation in total catch and target catch during study period

TARTIŞMA VE SONUÇ

Karadeniz, kıyısı olan ülkelerin ekonomisini etkileyen önemli bir balıkçılık alanı olarak görünmektedir (Eremeev ve Zuyev, 2007). Balıkçılık ise Karadeniz ekosisteminin değişimlerinden en çok etkilenen sektördür. Aynı zamanda, balıkçılık aktiviteleri ekolojik durumun kötüleşmesine ve balık stoklarının azalmasına etki eden en önemli faktördür. Karadeniz'in ihtiyofauna kompozisyonunda meydana gelen değişimler, birincil olarak bazı popülasyonların birey sayılarındaki değişimleri içerir (Radu vd., 2013). Birçok balık türünün av miktarları, ticari balıkçılık için önemlerini yitirecek kadar düşmüştür. Karadeniz'den elde edilen avın dinamikleri (değişkenliği), balıkçılık çabası ve sömürülen stokların üretim kapasitesi arasındaki farklılıklar gerçeği tam olarak yansıtmaktadır (Radu vd., 2013).

Batı Karadeniz'de dip trol balıkçılarının denize çıktıkları gün sayısına etki eden faktörler; fırtınalı gün sayısı, yeterli tayfaya sahip olup olmama durumu ve ticari pelajik balık yoğunluğudur. Dip trol tekneleri sezon başında palamut ve lüfer avcılığına yöneldiği için bu balıkların av durumuna göre deniz çıkıp çıkmamaya karar vermektedir. Bu durum neredeyse Kasım ayının 15'ine kadar devam edebilmektedir. Zengin vd. (2017) Karadeniz'in diğer önemli dip trol sahalarını içeren Samsun bölgesinde yaptıkları çalışmada, bir ticari trol teknesinin günde yaklaşık 12 ile 14 saat arasında denizde kaldığını ve bu sürede her bir operasyon yaklaşık 1,5 saat sürecek şekilde yaklaşık 5-6 operasyon gerçekleştirdiğini bildirmiştir. Bu çalışmada da benzer sonuçlar Batı Karadeniz dip trol balıkçılığı için tespit edilmiştir. Ancak, bazı uygun balıkçılık sahalarında çekim sürelerinin 2,5 saate kadar çıktığı gözlemlenmiştir.

Iskartanın azaltılmasına yönelik yönetim tedbirleri, girdi ve çıktı kontrolleri olan teknik önlemleri içerir (Condie, 2013). Girdi kontrolleri, balıkçılık için harcanabilecek zamanın, kullanılabilecek av aracı miktarının ve tekne sayı ve büyüklüklerinin sınırlandırılması yoluyla toplam avcılık miktarının kontörlünü amaçlayan önlemleri içerir (Pope, 2002). Iskartayı ele alan birçok yaklaşım ya av aracı seçiciliğinin geliştirilmesi ya da zaman ve bölge yasağı üzerinde durmaktadır (Davis, 2002; Cook, 2003; Broadhurst vd., 2006).

Çekim süresinin ıskartaya etki ettiği tespit edilmiştir; fakat açık bir eğilim bulunmamaktadır (Feekings ve Madsen, 2012). Bazı çalışmalar da ise uzun çekimlerin düşük ıskarta oranıyla sonuçlandığı belirtilmiştir (Murawski, 1996; Machias vd., 2001). Buna karşın, Rochet ve Trenkel (2005) ıskartanın doğrusal olamayan bir şekilde arttığını ve uzun çekimlerde balığın zarar görmesinden dolayı veya ağ gözleri tıkanarak kaçışa engel olunduğu için ıskartanın artıyor olabileceğini ifade etmiştir. Bu çalışmada benzer şekilde toplam av miktarı arttıkça doğrusal olmasa da ıskarta miktarının arttığı belirlenmiştir. Bu artışa sebep olan nedenin tam olarak belirlenmesi için Stepputtis vd (2016) çalışmasında olduğu gibi operasyonlar sırasında trol torbasının yüksek çözünürlüklü kameralar yardımıyla izleneceği çalışmalara ihtiyaç doğmaktadır.

Başka çalışmalarda ise çekim hızının da ıskarta miktarına etki ettiği belirlenmiştir (Hall vd., 2000; Broadhurst vd., 2006). Bir balığın yüzme hızı ve dayanıklılığı balık boyuna bağlı olduğu için (Beamish, 1978), çekim hızı alıkonulan balık miktarına ve büyüklüğüne etki eder (Broadhurst vd., 2006). Sürüklenen av araçlarına yönelik zamansal ve mekânsal kısıtlamalar dışında, çekim süresi ve çekim hızının düzenlenmesi tür ve boy seçiciliğinin artmasını ve ıskartanın düşmesini sağlayabilecek en basit operasyonel değişimlerdir (Broadhurst vd., 2006). Böylelikle, kısa çekim sürelerinin uygulanması daha az tür çeşitliliğine ve daha yoğun hedef türlere sahip avlarla sonuçlanabilir (Murawski, 1996). Batı Karadeniz'de ıskarta olarak etkilenen tür sayısı 18 ile 24 arasında olduğu görülmektedir. Karadeniz'de ıskarta olarak etkilenen tür sayısının yüksek olmayışı tür çeşitliliğinin düşük olmasından kaynaklanmaktadır.

Karaya çıkarılan av düzenlemesini temel alan balıkçılık yönetim sistemleri, her ne kadar arzu edilmese de, sıklıkla yüksek ıskarta ile sonuçlanabilir (Crean ve Symes, 1994). Alternatif olarak filodaki balıkçı tekne sayısı ve tekne boyunun ve/veya denize çıkılan gün sayısının sınırlandırılması yoluyla balıkçılık düzenlemesi yapılabilir. Bu düzenleme ıskartayı ve ayrıca balıkçılık gelirini düşürebilir çünkü karaya çıkan av sınırlanacaktır. Filo etkinliği düzenlenmedikçe, yapılan düzenlemeler ekonomik kaybın azaltılmasını arttırabilir ve sonuç olarak ıskartadaki düşüş ortadan kalkacaktır (Frandsen, 2011).

Catchpole vd., (2006) bildirdiğine göre denize çıkılan gün sayısı Kuzey Denizi ile Baltık Denizi arasındaki Kattegat ve Skagerrak bölgelerinde sınırlandırılmıştır ve bu uygulama balıkçılık çabasına nazaran ıskarta miktarının düşmesini sağlamıştır fakat balıkçılar için oldukça maliyetli olmuştur. Bu sınırlama balıkçıları av araçlarının avcılık etkinliğini arttırmaya yönelik olarak teşvik etmiştir. Ayrıca, Frandsen (2011) Kattegat bölgesinde denize çıkılan gün sayısının "İsveç Izgarası" kullanılıyorsa sınırlandırılamayacağını bildirmiştir. Balıkçılık zamanındaki sınırlandırma balıkçıların seçici av araçlarının kullanımına adaptasyonu için teşvik edici bir uygulamadır. Bu uygulamadan da anlaşılacağı üzere balıkçılık zamanı kısıtlamaları kullanılan av aracına yönelik kurallarla kombine edilerek kullanılmalıdır.

Ekonomik değeri olan balık türlerinin çoğunluğu Karadeniz'e kıyısı olan ülkelerin münhasır ekonomik bölgelerinde paylaşılmaktadır (STCEF, 2011 ve 2012; Nicolaev ve Radu, 2008). Karadeniz'de bir bölgesel balıkçılık yönetim organizasyonu olmadığı için, ortak paylaşılan ve göç eden türlerin avcılığında ortak bir balıkçılık yönetimi uygulanmamakta, her bir kıyısal ülke ayrı bir balıkçık yönetimi düzenlemektedir (Radu vd., 2013). Dip trol balıkçılığı Karadeniz'e kıyısı olan ülkelerde Türkiye dışında yaygın bir avcılık metodu değildir. Bu sebeple trol balıkçılığının düzenlenmesi ile ilgili bölgesel mekanizmalar değil ulusal yönetim otoritesi kararlar almak zorundadır. Ancak, Türkiye'de uygulanan balıkçılık yönetiminde henüz ıskarta konusunda her

hangi bir yönetmelik ya da uygulama bulunmamaktadır. Son yıllarda ticari demersal balık stoklarının av miktarlarında yaşanan düşüşlerde değerlendirildiğinde dip trol ağlarının çevreye olası etkilerinin azaltılması ve ekosistemin korunması açısından öncelikle ticari dip trol avcılığı operasyonlarında ıskarta avın kaydedilmesi ve bununla birlikte ıskartanın azaltılması için teknik ve operasyonel önlemlerin alınması gerekir.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Yüzer ağ kafeslerde kullanılan polietilen dikmelerin rotasyon ve enjeksiyon yöntemleri ile üretimlerinin karşılaştırılması

A comparison of rotation and injection production methods for polyethylene brackets of floating net cages

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Öz: Deniz ve iç sulardaki baraj göllerindeki balık yetiştiriciliği çalışmalarında kullanılan yüzer ağ kafes sistemlerinin en önemli bileşenlerinden bir tanesini dikmeler oluşturmaktadır. Dikme üretiminde geçmişten günümüze kullanılan en yaygın yöntem rotasyon sistem iken son yıllarda plastik işleme teknolojilerinin gelişmeye başlaması ile birlikte, pek çok alanda olduğu gibi dikme üretiminde de enjeksiyon yönteminin kullanılması gündeme gelmiştir. Bu çalışmada ticari bir kafes üretim tesisinde iki üretim metodunun iş gücü, kullanılan hammadde özelikleri ve birim zamandaki üretim kapasitesi ile enerji tüketimi ve üretim maliyetleri açısından karşılaştırılması yapılmıştır. Elde edilen sonuçlarda, enjeksiyon yöntem ile üretimin seçilmesi durumunda iş gücünün yarı yarıya azaltılabileceği, rotasyon sistemde kullanılan toz yapıdaki düşük yoğunluklu polietilen (LDPE) malzeme yerine granül formdaki hammaddenin de seçilebileceği, bir saatlik zaman diliminde enjeksiyon yöntemle %50 oranında daha fazla sayıda dikme üretilebileceği görülmüştür. Bununla birlikte her iki yöntemin kullanımı sırasında harcanan enerji miktarı göz önünde bulundurulduğunda enjeksiyon sistem ile üretimin %80 oranında enerji tasarrufu sağlayabileceği görülmüş, üretim maliyetlerinin de %9.2 oranında azaltılabileceği hesaplanmıştır.

Anahtar kelimeler: *Ağ kafes, dikme, rotasyon, enjeksiyon*

Abstract: One of the important components of net cages that have been used for aquaculture activities in marine and freshwater environment, are brackets. Rotation system have been used to produce brackets for a long time; but as plastic process technology has just well developed, using of injection method has become more popular. This study presents a comparasion between both production methods on ingredient utilization, production capacity per hour, energy consumption and production costs in commercial production conditions. According to the results, obtained injection metdod can reduce the number of employee up to fifty percent, instead of using powder LDPE material as an ingredient in the rotation method, injection method can use granüle form of LDPE, the number of brackets were produced in a hour can be increased up to 50%. In terms of energy consumption, the injection method can provide up to 80% profit and finally producing brackets with injection method reduce the production costs 9.2%

Keywords: *Net cage, bracket, rotation, injection*

GİRİŞ

Yüzer ağ kafesler, yetiştiriciliği yapılan sucul canlılar için belki de doğadaki yaşam ortamlarına en yakın özellikleri sunabilen yetiştiricilik ortamlarından bir tanesidir. Tatlı su balıklarının yetiştiriciliğinde baraj gölü ve göletlerde, deniz balıklarının yetiştiriciliğinde kıyı ve kıyı ötesi alanlarda kullanılan ağ kafeslerin geçmişi yüzyıllar öncesine kadar uzanmaktadır (Coche, 1978; Beveridge, 1987; Huguenin, 1997). Dünyanın su ürünleri yetiştiriciliği uygulamalarında önde gelen ülkelerinin özellikle deniz balıklarının yavru aşamadan itibaren yetiştiriciliğine ait faaliyetler incelendiğinde, kıyı sularında gözlenen hızlı kirlilik, turizm yatırımları gibi öncü nedenlere bağlı olarak, bu çalışmaların açık deniz ortamlarına yerleştirilen ağ kafeslerde sürdürüldüğü görülmektedir. Açık deniz yetiştiriciliği kıyısal alanlardaki yetiştiricilik modelleri ile kıyaslandığında, açık denizde sürdürülen yetiştiricilik çalışmalarının daha kuvvetli akıntı, dalga boyu ve rüzgar şiddetine maruz kaldığı görülmektedir. Bu zorlu fiziksel koşullar nedeniyle kullanılan ağ kafes materyalinin de aynı oranda sağlam ve dayanıklı olmasını gerekmektedir (Loland, 1991; DeCew vd., 2005; Suhey vd., 2005).

Ağ kafes yapısının dayanıklılığı üzerinde önemli rolü olan en önemli parça dikmedir. Günümüzde ağ kafes dikmelerinin imalatında rotasyon ve enjeksiyon olmak üzere iki yöntem

kullanılmaktadır. Rotasyon sistem ağ kafes endüstrisinde yıllardan beri kullanılan bir yöntem olmasına rağmen enjeksiyon sistem daha yeni bir dikme üretim modeli olarak karşımıza çıkmaktadır. Bu çalışmada, rotasyon ve enjeksiyon sistemle imal edilen ağ kafes dikmelerinin işçilik, hammadde tüketimi, kullanılan sistemlerin enerji tüketimi ve birim üretim maliyetlerine ilişkin bilgiler ticari bir üretim ortamında yapılan kıyaslamalar ışığında sunulmaktadır.

MATERYAL VE METOT

Denemelerde kullanılan rotasyon sistemi ve üretim metodu

Bu çalışma İzmir ili Torbalı ilçesinde ağ kafes üretimi yapan özel bir fabrikada sürdürülmüştür. Rotasyon sistemle üretim yapmak için bir dikme kalıbı ile rotasyon fırını kullanılmıştır (Şekil 1a ve 1b).

Şekil 1a. Rotasyon sistem dikme kalıpları (orijinal)
Figure 1a. Rotation system stitch patterns (original)

Şekil 1b. Rotasyon sistemde kullanılan fırın (orijinal)
Figure 1b. Furnace used in rotation system (original)

Rotasyon sistem ile üretim yapmak için özel bir plastik firmasından Rotomoulding marka düşük yoğunluklu ve siyah granül yapıdaki polietilen hammadde (LDPE) temin edilmiştir. Hammadde öğütülerek toz hale getirilmiş, şekil 1a'da gösterilen kalıplara dökülmüş ve kalıp kapakları kapatılmıştır. Dörtlü kalıp ile farklı yönlere dönerek çalışan sistem, 450 °C sıcaklığa ayarlanmış fırına konulmuş ve 90 dakika süre ile bu sıcaklığa ve rotasyon hareketine maruz bırakılmıştır. Tamamen kalıbın şeklini alan ürün fırından çıkarılmış ve oda sıcaklığında 30 dakika süre ile soğumaya bırakılmıştır. Belirtilen bu yöntemle dört işçi kullanılarak toplam 100 adet kafes dikmesi üretilmiştir.

Denemelerde kullanılan enjeksiyon sistemi ve üretim metodu

Enjeksiyon sistemle üretim yapabilmek için ilgili fabrikanın araştırma ve geliştirme biriminde üretilen enjeksiyon makinesinden yararlanılmıştır (Şekil 2a ve 2b). Bu makine ekstruder, kelepçe, piston, hidrolik ünite, soğutucu ve kumanda panelinden meydana gelmektedir.

Şekil 2a. Enjeksiyon sistemde kullanılan ekstruder (orijinal)
Figure 2a. Extruder used in injection system (original)

Şekil 2b. Enjeksiyon sistemin hidrolik ünitesi
Figure 2b. Hydraulic unit of the injection system

Enjeksiyon sistemle üretim yapabilmek için, rotasyon sistemde belirtildiği gibi, Rotomoulding marka siyah granül LDPE temin edilmiştir. Rotasyon sistemden farklı olarak enjeksiyon sistemde granül hammadde herhangi bir öğütme işlemine gerek kalmaksızın sistemin ekstruder birimine konulmuş, hidrolik ünite yardımı ile kalıp içerisine hammadde

basılmıştır. Enjeksiyon yöntemde iki işçiden yararlanılarak 100 adet kafes dikmesi imal edilmiştir.

BULGULAR

Rotasyon ve enjeksiyon yöntemle imal edilen kafes dikmelerine ilişkin kıyaslama Tablo 1'de ve Şekil 3'te sunulmaktadır.

Tablo 1. Rotasyon ve enjeksiyon yöntemle üretilen dikmelerin kıyaslanması
Table 1. Comparison of rotations and syringes produced by injection method

Kıyaslama Kriteri	Rotasyon Yöntem	Enjeksiyon Yöntem
Üretimde çalışan personel sayısı	4	2
Hammadde yapısı	LDPE, toz	LDPE, granül
Harcanan hammadde (kg/dikme)	17 kg	17 kg
Bir saatte üretilen dikme sayısı	2	4
Enerji tüketimi (kw/saat)	400	80
Üretim maliyeti (Avro/dikme)	76	70

Şekil 3. Rotasyon sistemle (solda) ve enjeksiyon sistemle (sağda) üretilen kafes dikmeleri
Figure 3. Cage trims produced by rotation system (left) and injection system (right)

Elde edilen sonuçlar rotasyon sistemle yapılan üretimin daha fazla işçilik gerektirdiğini, enjeksiyon sistemin ise işçilik giderlerini yarı yarıya düşürebileceğini göstermiştir. Rotasyon sistemde satın alınan hammaddenin işlenebilmesi için bir öğütücü yardımı ile toz formuna getirilmesi gerekmektedir. Bu çalışma kapsamında imalatı yapılan ve geliştirilen enjeksiyon sistem ise hammaddeyi doğrudan granül formunda kullanarak hammaddenin toz haline getirilmesine gerek kalmadan üretim yapabilmektedir. Bu sistem aynı zamanda orijinal hammadde ile benzer özelliklere sahip granül yapıdaki geri dönüşüm artığı ürünleri de kullanabilmektedir.

Her iki üretim sisteminde kullanılan hammadde miktarının aynı oranda ve bir dikme üretimi için 17 kg olduğu görülmüştür. Buna karşılık birim zamanda enjeksiyon yöntemle üretilen dikme sayısı rotasyon sistemle üretilenin iki katına ulaşmıştır. Enerji tüketimi değerleri incelendiğinde ise enjeksiyon sistem ile üretim yapılması durumunda %80 oranında tasarruf sağlanabileceği görülmüştür. Üretim maliyetleri hesaplandığında ise enjeksiyon yöntemle üretilen kafes dikmelerinin rotasyon sistemle üretilenlere oranla %9.2 daha düşük maliyet ortaya koyduğu sonucuna varılmıştır.

TARTIŞMA VE SONUÇ

Bu çalışmada günümüzde ağ kafes dikmelerinin üretiminde kullanılan iki yöntem olan rotasyon ve enjeksiyon sisteme dair kıyaslamalar yapılmıştır. Rotasyon sistem dünyada yaygın olarak bilinen bir sistem olmakla birlikte, enjeksiyon sistem genel anlamda sağlayabildiği daha fazla teknolojik gelişme sayesinde son yıllarda daha fazla kullanım alanı bulmaya başlamıştır (Lader ve Enerhaug, 2005).

Fredrikson vd. (2003), enjeksiyon sistemle üretilen kafes dikmelerinin rotasyon sistemle kıyaslandığında dayanımının daha yüksek olduğunu belirtmektedir. Bunun en önemli nedeni olarak da rotasyon sistemde kalıp boşluklarının tamamen hammadde ile doldurulamaması, buna karşılık enjeksiyon sistemde hammaddenin hidrolik sistem kullanılarak basılması nedeniyle kalıp içerisinde hiçbir boşluğun kalmaması gösterilmektedir. Bir ağ kafes sisteminde olası fiziksel darbelerde ilk kırılan parçanın kafes dikmeleri olduğu düşünülürse enjeksiyon sistemin başarısı ortaya çıkmış olacaktır.

Tsukrow vd. (2003), kafes dikmelerinin üretiminde enjeksiyon yöntemin tercih edilmesi durumunda ve bu sistemin sağladığı yüksek basınç sayesinde atık LDPE ürünlerin de bir hammadde olarak kullanılabileceğini, bu sayede bir geri dönüşüm imkanı sağlanabileceğini bildirmektedir. Gerçekten de enjeksiyon yöntem hem kullanılacak hammaddenin öğütülmesine gerek duymaması hem de doğada en uzun sürede yok olabilen polietilen bazlı ürünlerin yeniden kullanımına izin vermesi nedeniyle daha çevreci bir üretim metodu olarak da adlandırılabilir. Elde edilen sonuçlardan da görüleceği üzere enjeksiyon yöntemde kullanılan üretim modeli daha az enerji gerektirmektedir. Akdeniz coğrafyası ve özellikle de Türkiye'deki enerji maliyetlerinin ne derece yüksek olduğu göz önünde bulundurulursa bu sistemin verimliliği bir kez daha vurgulanmış olacaktır. Son olarak da denizlerde ağ kafeste üretilen çipura ve levrekler için bir fizibilite vermek yararlı olabilir. Yılda 1000 tonluk çipura-levrek üretimi için bir yatırımcının 30 metre çapında 20 adet ağ kafese sahip olması gerekmektedir. Bu çaptaki bir kafes için 44 adet dikme kullanılması gerekmektedir. Bu durumda kurulacak ağ kafes sistemindeki dikme sayısı 880 adet olacak, bu dikmelerin enjeksiyon sistemle imal edilmesi durumunda dikme üreticisine toplam 61.600 Avro, rotasyon sistemle üretilmesi durumunda ise toplam 66.880 Avro ödenmesi gerekecektir. Bu hesaplama

ışığında bir yatırımcının sadece kafes dikmelerine ödeyeceği ücret enjeksiyon yöntemde yaklaşık %10 daha ucuz olacaktır.

Sonuç olarak; enjeksiyon yöntem kullanılarak imal edilen dikmelerin ağ kafes sistemlerinde daha yaygın olarak kullanılmaya başlanması, işçilik ve enerji tüketim maliyetlerini azaltacak, birim zamanda üretilen parça sayısını arttıracak bir üretim modeli olarak gösterilebilir. Bununla birlikte, enjeksiyon sistemle üretim, rotasyon sistemle kıyaslandığında artık ve granül yapıdaki plastik maddeleri de hammadde olarak kullanabildiğinden çevreye saygılı bir üretim modeli olarak da adlandırılabilir. Bu çalışmada ağ kafes dikmelerinin imalat aşamasındaki kıyaslamalarına yer verilmiştir; gelecekte sürdürülecek olan çalışmalarda ise her iki yöntemle üretilen dikmelerin ticari üretim ortamlarındaki dayanıklılığının ve su ortamındaki kırılma indekslerinin belirlenmesinin, son kullanıcılara daha net ve daha kesin bilgiler sunacağı düşünülmektedir.

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

The effect of clove oil on frozen storage stability and quality of rainbow trout (*Oncorhynchus mykiss*)

Gökkuşağı Alabalığı (*Oncorhynchus mykiss*)'nın kalitesi ve dondurulmuş depolama stabilitesi üzerine karanfil yağının etkisi

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Öz: Bu çalışmada, 6 ay boyunca dondurulmuş alabalık filetolarının kalitesi üzerine doğal bir koruyucu olarak karanfil yağının (0.5% ve 1%v/w) etkisi değerlendirildi. Vakum paketlenmiş örnekler -18ºC'de depolandı. Depolama süresince mikrobiyolojik (Toplam anaerob bakteri, psikrofilik bakteri, laktik asit bakterileri ve maya-küf) ve duyusal (koku, renk, tekstür) parametreler incelendi. Mikrobiyal gelişme kontrol grubunda depolama süresince en yüksekti. Karanfil yağı vakum paket ile birlikte kullanıldığı kombinasyonlarda dondurulmuş alabalık filetolarının duyusal kalitesi üzerine olumlu etki gösterdi. Sonuçlarımıza göre karanfil yağı, etkili antibakteriyel ve doğal bir koruyucu olarak dondurulmuş gökkuşağı alabalığı kalitesini artırmak için vakum paket ile birlikte kullanılabilir.

Anahtar kelimeler: *Esansiyel yağlar, karanfil yağı, dondurulmuş depolama, Gökkuşağı alabalığı, mikrobiyolojik kalite, duyusal kalite*

Abstract: The present study evaluated clove oil (0.5% and 1%v/w) use as a natural preservative on the quality of frozen rainbow trout fillets during of six months. Vacuum packed samples were stored at -18 ˚C. Microbiological parameters (total anaerobe, psychrophilic bacteria, lactic acid bacteria, mold-yeast) and sensory quality (odour, color and texture) were determined during the storage period. Microbial growth was high over a period of frozen storage for control samples. The existence of clove oil demonstrated to develop the sensory quality of frozen rainbow trout fillets when used in combination with vacuum pack. According to our results, clove oil as natural protective and influential antibacterial can be used in conjunction with vacuum pack to augment frozen stored rainbow trout quality.

Keywords: *Essential oil, clove oil, rainbow trout, frozen storage, microbiological quality, sensory quality*

INTRODUCTION

Frozen and chilled storage are widely used protection methods for fish and fish product, owing to the microbiological growth and some biochemical processes can be minimized with these methods. But, the quality of fish muscle will also deteriorate throughout frozen storage as the fishes have high protein and unsaturated fatty acid contents (Simeonidou et al. 1997; Tironi et al. 2010; Dusukcan et al. 2014). That's why, some measures must be taken to extend the shelf life of fish in cold storage.

Clove oil is a plant widely cultivated in the world. Its antimicrobial potential was established when its essential oil extracts killed many Gram positive and Gram negative organisms including some fungi. The antimicrobial activity of clove is attributable to eugenol, oleic acids and lipids found in its essential oils (Nzeako et al. 2006). Clove oil has been listed as a ''Generally Regarded As Safe'' substance by the United States Food and Drug Administration when administered at levels not exceeding 1500 ppm in all food categories. Nontraditional preservation techniques are being developed to satisfy consumer demand with regard to nutritional and sensory aspects of foods. This increasing demand has opened new dimensions for the use of natural preservatives derived from plants and animals. In biopreservation, storage life is extended, and/or safety of food products is enhanced by using natural compounds (Nzeako et al. 2006; Yıldız Oguzhan, 2015). Besides, plant and spices extracts possessing an antioxidant activity preserve the cells from the harm caused by the free radicals and they have an major role in the antioxidant defense (Tuna Keleştemur, 2011; Tuna Keleştemur and Özdemir, 2013).

The impact of essential oils on the shelf-life of fish and fish products has been studied (Harpaz et al.,2003; Mahmoud et al., 2006; Goulas and Kontominas, 2007), but there are very limited study (Solanki et al., 2016) on fish, treated with clove oil.

Therefore, the objective of the present study was to determine the effect of vacuum pack and in combination with the addition of clove oil, as a natural preservative, on the shelf-life extension of rainbow trout (*Oncorhynchus mykiss*) fillets by evaluating microbiological and sensory quality.

MATERIALS AND METHODS

Preparation of fish samples and storage conditions

Clove oil was acquired from Kalsec® (Kalsec®, Inc, Kalamazoo). Fresh rainbow trout (*O. mykiss*) samples (varying from 250 to 280 g weight and total rainbow trout 150) were obtained Keban Alabalık Co. aquaculture farm located in Keban Dam Lake. Fish samples were placed in ice box and transferred within 1 h to the fish-processing laboratory of the Faculty of Fisheries of Firat University. Fishes were immediately weighed, gutted, headed and filleted. Then fillets were washed with water and were divided to three lots.

First group: Control (Control group, no clove oil)
Second group: 0.5 Co (0.5 % v/w Clove oil added)
Third group: 1 Co (1% v/w Clove oil added)

Clove oil was added onto the surface (two sides) of each fillet using a micropipette followed by mild uniform distribution (directly with gloved fingers) of the oil for each sample. The clove oil ratio was determined by preliminary studies. All samples were vacuum-packaged and stored in -18 °C and analysed once a month during 6 month to determine the microbiological and sensory attributes.

Microbiological analysis

Rainbow trout (10 g) obtained from each fillet were transferred aseptically to a Stomacher bag containing 90 ml of sterile 0.1% peptone water (Buffer Peptone Water, LAB M) and homogenised for 1 min using a laboratory blender (Stomacher 400, Lab. Blender, London, UK) at high speed. Tenfold successive dilutions were made with 0.1% peptone water from these homogenates as required. Petri dishes for determination of the total anaerobe on brewer anaerobe agar and then incubated at 30 °C for 3 days. Psychrophile was determined on Plate Count Agar (PCA, Merck 1.05463) after incubation at 7°C for 10 days. Lactic acid bacteria were enumerated on de Man Rogosa Sharpe agar (MRS, Oxoid, CM361) incubated at 30°C for 5 days. Yeast and mold bacteria were enumerated on Potato Dextrose Agar (PDA, Merck 1.10130) incubated at 22 °C for 5 days enumerated. Microbiological counts were expressed as log colony-forming units (cfu) per gram of sample (Harrigan 1998; ICMSF, 1986).

Sensory analysis

Ten experienced panelists, staff members of the department of fish processing and technology, who had experience on fish and fish products were chosen to evaluate the quality of fillets. Panelists were asked to evaluate appearance, odor and texture of raw samples. Appearance, odor and texture were scored on a 10-point hedonic scale. A score of zero was used as a rejection attribute point (Simeonidou et al., 1997).

Statistical analysis

The study has been composed of three independent repetitions. By using the SAS program, the data was processed. According to General Linear Model (GLM) procedures, averages of the least squares were designated through Fisher's Least Significant Difference (LSD) test and the statistical significance level was taken as 0.05 hereby (SAS 1999).

RESULTS AND DISCUSSION

Microbiological changes during frozen storage

Deterioration of fish mainly occurs as a result of bacteriological activity leading to loss of quality and subsequent spoilage. Changes in the microbial flora (total anaerobe, psychrophilic bacteria, lactic acid bacteria, mold-yeast) of rainbow trout fillets during frozen storage are illustrated in Fig.1

Initial (1th month) total anaerobe counts was 0.95 log cfu/g in all groups (Fig. 1). After storage of two months, significant differences ($p<0.05$) were found between control group and clove oil treated groups. Bacteria populations increased in all groups during storage. However, the lowest bacteria counts were obtained from Group 1Co. At the end of the storage period of 6 months 4.55, 3.14 and 2.06 log10 cfu/g were measured for Control, 0.5 Co and 1 Co group, respectively. These results show that the addition of clove oil had effect on the total anaerobe bacteria of frozen trout. Similar studies show the effectiveness of essential oils such as clove applied to mean samples to prolong their shelf life, inhibiting microorganism growth and measuring the antioxidant activity and therefore increasing the product's shelf life (Burt, 2004)

The psychrophilic bacteria counts of control and other groups were recorded during frozen storage. Initial populations of psychrotrophic bacteria of Control, 0.5 Co and 1 Co samples were 2.14, 1.88 and 1.16 log10 cfu/g, respectively. Psychrophilic bacteria counts of Control, 0.5Co and 1Co groups were 8.11, 7.12 and 7.20 log10 cfu/g at the end of the storage period, respectively. Based on the statistical analysis, clove oil treated groups had significantly lower ($p<0.05$) counts when compared to control samples during storage. Control and 0.5Co, 1Co samples exceeded the value of 6 log cfu/g for psychrotrophic bacteria count, considered as the upper acceptability limit for fish and fish products, after 4 months and 6 of storage, respectively. Therefore, compared with the control samples, a shelf life extension of 2 months was achieved for clove oil treated samples, as determined by psychrotrophic bacteria counts. Our results for psychrophilic bacteria are in agreement with findings of fresh fish species stored with other essential oils (Erkan, 2007; Ozyilmaz 2007; Attouchi and Sadok; 2011; Emir Çoban and Patır 2013).

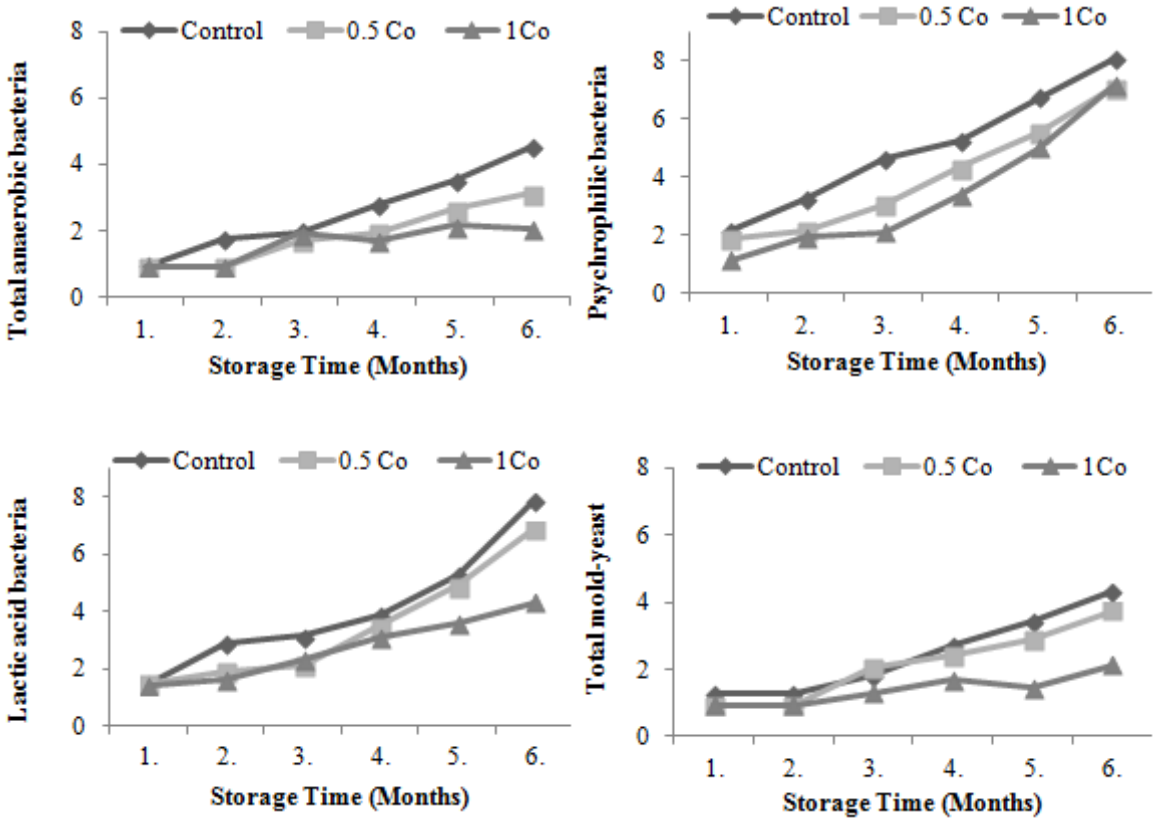

Figure 1. Changes in the microbial flora of rainbow trout fillets during frozen storage**. Control:** without clove oil vacuum packaged **0.5 Co:** added clove oil 0.5 % v/wt, vacuum packaged **1 Co:** added clove oil 1 % v/wt, vacuum packaged

Vacuum-packed food is stored in the absence of oxygen and some microorganisms have restricted growth. Instead, the bacterial population occurs mainly of lactic acid bacteria. In vacuum-packed seafood, lactic acid bacteria are problematic as they produce typically sour odors and flavours. Lactic acid bacteria counts of Control, 0.5Co and 1Co groups (LAB) were determined as 1.50, 1.51 and 1.40 log10 cfu/g, respectively at the beginning of storage. LAB counts in all groups increased during storage (Fig 1). Increases in treated groups were less than the control group. These results may explain the inhibitory effects of essential oils on LAB (Burt, 2004; Emir Çoban and Patır 2013). Kostaki et al (2009), reported that the treatment of fresh fish fillets (sea bass) with a mixture of thyme oil reduced the final LAB counts by approximately 1 log, compared with control group. Likewise, Kykkidou et al. (2009) reported that thyme–oregano oil treatment was effective in eliminatingthe growth of TVC and LAB in modified atmosphere packaged fish under refrigerated storage. They are also in agreement with those reported by other researcher (Erkan 2007; Chouliara et al.2007; Kykkidou et al. 2009; Atrea et al. 2009; Emir Çoban and Patır 2013).

In the present study, the number of yeast–mold of control and clove oil treated samples were determined as 1.26 and 0.95 log10 cfu/g, respectively at the beginning of storage. Yeast–mold amount increased in all groups during storage (Fig 1). Yeast–mold populations were highest in the control samples, as expected, compared to the added clove oil samples. Clove oil causes a decrease in the number of bacterial cells, demonstrating they can be used to protect a food matrix such as fish, prolonging the bacteria lag period and that's why prolonging its shelf life. Similar findings have been found by Suhr and Nielsen (2003) and Emir Çoban and Patır (2013).

Sensorial changes during frozen storage

The acceptability of fish products during frozen storage depends on the changes in their sensory attributes. Fish products were considered to be acceptable for human consumption until the sensory score reached 4 (Amerine et al.1965; El-Hanafy et al. 2011). The sensory scores of frozen trout fillet with clove oil are presented in Fig 2.

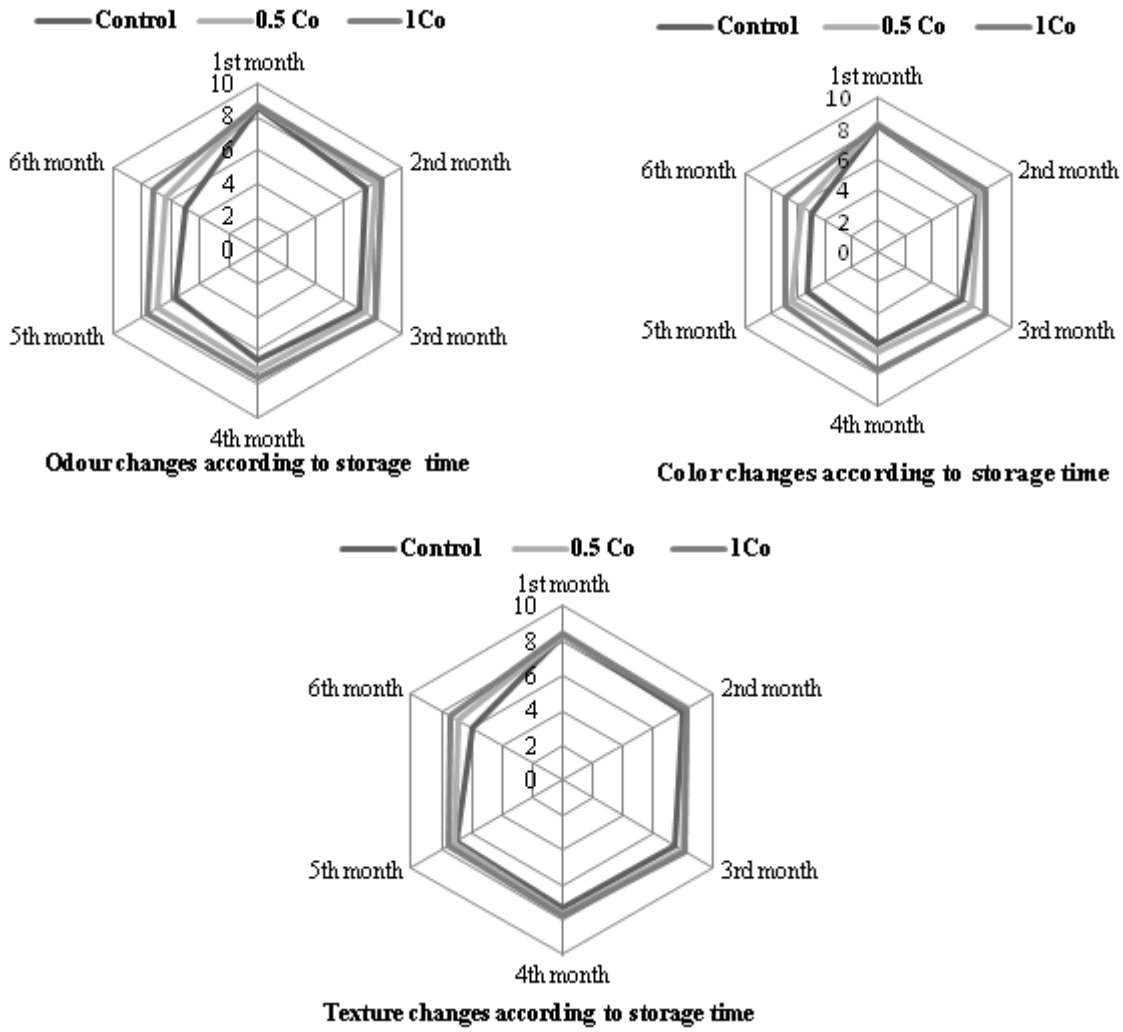

Figure 2. The results of the sensory evaluation of rainbow trout fillets during frozen storage **Control:** without clove oil vacuum packaged **0.5 Co:** added clove oil 0.5 % v/wt, vacuum packaged **1 Co:** added clove oil 1 % v/wt, vacuum packaged.

All the samples at 1th months had high odour scores ranged from 8.5 to 8.7, which means that all samples at initially were in excellent quality. During the storage period, there was a significant loss in the fish quality for all samples. Odour score of control, 0.5Co and 1 Co groups were determined as 5, 6.4, 7.2, respectively at 6th months. Similar findings were reported by other researcher (Özyilmaz 2007; Chouliara et al. 2007; Emir Çoban and Patır 2013). Plant extract applied groups were more preferred than control groups like in our study.

Initially the best odour score were found in control samples, however the score significantly decreased at the end of the storage period. The samples treated with 0.5% clove oil were the most preferred fillets followed by the samples with 1% clove oil. (Fig 2).

Chemical and physical changes of proteins occurring during frozen storage may result in texture deterioration. This is an important problem because it negatively affects sensory quality. Texture modification is mainly a result of damage caused to the protein structure. In Fish, most of these changes are caused by the production of formaldehyde in the muscle (Sotelo et al. 1995). The formaldehyde liberated reacts with proteins to form crosslinks. These changes also causes loss of taste and odor. The rainbow trout fillets treated with clove oil were the most preferred samples in terms of sensory characteristics, whereas control samples had low sensory scores.

CONCLUSION

Consumer demands for foods with a prolonged shelf life are of major importance. Ensuring food safety and at the same time meeting demands for retention of nutrition and quality attributes has resulted in increased interest in alternative preservation techniques for inactivating microorganisms.

This study has clearly shown that preservation of frozen fish applying clove oil have longer shelf life than normal. Moreover, as fish has good sensory quality, a proper preservation technique suggested in this paper is highly relevant.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

İstanbul İli Anadolu Yakası doğal kaynak sularının bakteriyolojik kalite parametrelerinin değerlendirilmesi

The evaluation of bacteriological quality parameters of natural spring water in Anatolian side of Istanbul Province

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Öz: Bu çalışmada, İstanbul ili Anadolu yakasının farklı bölgelerinde halkın kullanımına açık olan doğal kaynak suyu çeşmelerinin bir yıllık periyot içinde (2014 yılı/12 ay) bakteriyolojik kalite parametrelerinin incelenmesi ve insan sağlığı açısından değerlendirilmesi amaçlandı. Bu amaçla belirlediğimiz 10 adet doğal kaynak suyu istasyonundan bir yıl süreyle (2014 yılı/12 ay) her ay bakteriyolojik analizler için numuneler alındı. Bakteriyolojik analizler; membran filtrasyon yöntemi kullanılarak Koliform bakteri, *Escherichia coli,* Fekal koliform ve Enterokok sayımı ile tespit edildi. Bir yıl süreyle toplanan 95 örneğin, yapılan bakteriyolojik analizleri neticesinde 46'sının ulusal ve uluslararası standartlara göre içilebilir nitelikte, 49'unun ise içilemeyecek nitelikte olduğu görüldü. Örneklerimizin % 47,4'ünde Koliform Bakteri; % 27,4'ünde Enterokok; % 17,9'unda *Escherichia coli* ; % 14,7'sinde Fekal koliform tespit edilerek standartlara uygun olmadığı belirlendi. Örneklerimizin % 48,4'ünün ise standartlarda belirtilen değerlere uygun olduğu tespit edildi.

Anahtar kelimeler: *Escherichia coli, Doğal kaynak suları, Bakteriyolojik analizler*

Abstract: The main purpose of this study was to investigate the bacteriological quality parameters of drinking fountains found in the Anatolian side of Istanbul on an annual basis (2014 year/ 12 month) and their evaluation in terms of human health. Samples were taken monthly from 10 different public drinking fountains for bacteriological analysis for a year in 2014. Bacteriological analysis were carried on using the membrane filtration technique; Coliform bacteria, *Escherichia coli*, Fecal coliform and Enterococcus counting. 95 samples were collected in total and bacteriological analysis performed on these showed that 46 % of the samples were drinkable and 49 % of them were not drinkable according to the national and international standards for drinking water quality. Additionally, 47,4 % of the samples had Coliform bacteria, 27,4 % had Enterococcus, 17,9 % had *Escherichia coli* and 14,7 % had Fecal coliform which showed that they were out of the standards. On the other hand, 48,4 % of the samples were compatible with the values indicated in the standards.

Keywords: *Escherichia coli, Natural spring waters, Bacteriological analysis*

GİRİŞ

Su, yaşamının tüm formlarını destekleyen ve dolayısıyla yaşam için vazgeçilmez olan en temel bileşiktir. Kentsel, endüstriyel ve iklimsel gelişmede öngörülen değişiklikler içme suyunun bütünlüğünü ve sürdürülebilirliğini tehdit etmektedir. Düzensiz kentleşme, aşırı nüfus artışı, bozulan çevre şartlarıyla sera gazlarındaki artış ve aşırı sanayileşme ile artan endüstriyel atıklar gibi nedenlerle içilebilir su kaynakları giderek azalmakta, kimyasal ve bakteriyolojik kirliliğin boyutları her geçen gün artmaktadır (Muluk vd., 2013). Sularda patojenik bakteri, mantar, alg, patojenik protozoa gibi organizmaların bulunması ile oluşan kirlilik biyolojik kaynaklı su kirliliğini oluşturur. İçme suyu ve kaynaklarda fekal kirlenme kontrolü birincil öneme sahiptir. *Escherichia coli* (*E.coli)* gibi fekal indikatör bakteriler dışkı kirlenmesinin en önemli göstergesidir (Murcia vd.,2017; WHO, 2011). İnsan ve hayvan dışkılarıyla kirlenmiş sularla tifo, dizanteri, kolera ve birçok bağırsak enfeksiyonu ve asalaklar yayılabilir (Güler ve Çobanoğlu, 1994).

Dünya Sağlık Örgütü (WHO) kaynaklarına göre Amerika Birleşik Devletleri'nde bile her yıl sudan kaynaklanan yaklaşık 70.000 hastalık vakası bildirilmektedir. Bu hastalıkların en büyük kaynağı foseptik ve kanalizasyondur (Sönmez ve Çizmecioğlu, 2007). Suda bulunan bakteriler, *Spirillum, Vibrio, Pseudomonas, Achromobacter, Chromobacterium* cinsi bakterilerden oluşan suyun doğal mikroflorası olan bakteriler; *Bacillus, Streptomyces, Enterobacteriaceae*'nin saprofit türlerinden oluşan topraktan suya karışan mikroorganizmalar; Fekal koliformlar, *Enterococcus faecalis, Clostridium*

perfringens ve diğer bağırsak patojenlerinden oluşan insan ve hayvan dışkısı ile kirlenme sonucu suda bulunabilen bakterilerdir. *Salmonella* tipleri, *Shigella dysenteriae, Vibrio cholerae, Bacillus anthracis, Francisella tularensis, Pasteurella* tipleri, *Leptospirae* tipleri, *Chlamydiae psittaci* gibi türler su kirliliğine neden olan bakterilerdir (Guzman-Fernandez vd., 2016; Can, 2011).

Koliform Bakteriler, fakültatif anaerobik, Gram-negatif, sporsuz, çubuk şeklinde, 48 saatte 35°C'de laktozu fermente ederek gaz oluşturan bakterilerdir (APHA,2012). Koliform grubu bakteriler; Enterobacteriacaea familyası içinde yer alırlar. Su mikrobiyolojisi açısından önemli olan *E.coli*, *Citrobacter, Klebsiella, Enterobacter, Hafnia, Serratia, Edwardsiella, Proteus, Providencia, Arizona* ve *Erwinia* cinsleri koliform grubu bakterilerdir. Koliformlar, insan ve sıcakkanlı hayvanların bağırsak sistemlerinde bulunurlar. Bu açıdan fekal kontaminasyonun en iyi indikatörleri olarak değerlendirilirler. *E.coli* içme suyunda kesinlikle bulunmamalıdır ve dışkı kaynaklı kirlenmesinin kesin kanıtıdır (Hyland vd., 2003; Shafi vd., 2017). Enterobacteriaceae familyasının bir üyesi olan *E.coli*, beta-galaktosidaz ve beta-glukorinidaz enzimlerinin bulunmasıyla karakterizedir. Boyu 2-6 µm ve eni 1-1.5 µm olan basil şeklinde, Gram negatif, bazen hareketli, fakültatif anaerop, 1-2 mm çapında S tipi koloniler oluşturan bakterilerdir. Glikoz, laktoz, maltoz, mannitol ve ksiloz'u fermente ederek asit ve gaz oluştururken, sükroz, salisin, rafinozu fermente etme etkisi değişkendir. Adonitol ve inozitol'ü ise genellikle fermente etmezler (Rıfaat vd., 2014). Bu çalışmanın amacı İstanbul ili Anadolu yakasının farklı bölgelerinde halkın kullanımına açık olan doğal kaynak suyu çeşmelerinin bir yıllık dönem içinde (2014 yılı/12 ay) bakteriyolojik kalite parametrelerinin incelenmesi ve insan sağlığı açısından değerlendirilmesidir.

MATERYAL VE METOT

Doğal kaynak suyu çeşmelerinin özellikleri

İstanbul ili Anadolu yakası'nda bulunan değişik yerleşim alanlarından farklı bölgeleri temsil edebilecek şekilde 10 adet kaynak suyu çeşmesi belirlenerek (N1-N10), Ocak 2014-Aralık 2014 arasında 12 ay süreyle her ay bakteriyolojik analizler için numuneler alındı. Numune alma işlemleri; TS EN ISO 5667-1 (2008), TS EN ISO 5667-3 (2013) ve TS ISO 5667-5 (2008) standartlarına göre yapıldı. Bakteriyolojik analizler için numune alma, muslukların temizlenmesi, dezenfeksiyonu ve suyun boşa akıtılmasıyla ilgili işlemler TS EN ISO 19458 2006 standardına göre uygulandı. Numune alma kapları olarak, Pasteur fırınında (kuru sıcak hava ile) 160ºC'de en az 2 saat bekletilmek suretiyle sterilizasyonu sağlanmış olan 700 ml'lik koyu renkli cam şişeler kullanıldı. Bakteriyolojik analizler için sterilize edilmiş, temiz, kuru, hasarsız, 700 ml hacimli, kapakla sıkıca kapatılabilen, numune bileşimini koruyacak uygun malzemeden yapılmış koyu renkli cam şişeler numune kabı olarak kullanıldı. Toplanan numuneler portatif buzluklarda buz kalıpları ile taşınarak örneklerin ısınması engellendi. Numuneler laboratuvarda açılıncaya kadar sızdırmaz bir şekilde muhafaza edildi.

Membran filtrasyon yöntemi

Membran filtrasyon yöntemi, büyük partikül içermeyen sıvıların analizlerinde kullanılır. Bunun başında da su analizleri gelmektedir. Amaç sıvı örnek içerisindeki partiküllerin fiziksel olarak tutulmasını sağlamaktır. Bunu gerçekleştirmek için uygun por çapına sahip filtreler kullanıldı. Bu çalışmada koliform bakteri ve *E.coli* sayısı, enterokok bakteri sayısı, fekal koliform bakteri sayısı tayin yöntemlerinde membran filtrasyon yöntemi kullanıldı. Membran filtrasyon sisteminde analiz yapılırken ilk önce çalışma alanı dezenfekte edildi. Besiyerleri 3,5 ml steril distile su ile ıslatıldı. Paslanmaz çelik hunilerin iç yüzeyi, kapağı ve filtre tutucu ateşten geçirildi. Pens ateşten geçirildi ve kısa bir süreliğine soğuması sağlandı. Membran çıkarılarak membran filtre tutucu üzerine yerleştirildi. Musluk açılıp, vakum pompası çalıştırılarak numune filtre edildi. Hava kabarcıkları oluşturmadan filtre besiyeri üzerine yerleştirildi. Besiyerlerinin uygun sıcaklık ve sürelerde inkübasyonunun sonunda üreyen koloniler değerlendirildi (TSE, 2006).

Koliform bakteri ve *E.coli* sayısı tayin yöntemi

Koliform Bakteri ve *E.coli* sayımında; TS EN ISO 9308-1, *E.coli* ve koliform bakterilerin tespiti ve sayımında membranla süzme yöntemi kullanıldı. Membran filtrasyon sistemi çalışmadan önce steril edildi. Türe özgü Tergitol besiyeri üretici firmanın verdiği talimatlara göre 3,5 ml steril saf su ile ıslatıldı. 0.45 µm por çapına sahip steril membran filtre, steril pens kullanılarak membran filtrasyon sisteminin porlu tablası üzerine yerleştirildi. Tabla üzerine dikkatlice huni sistemi yerleştirildi ve kilitlendi. Çalışılacak numunenin 250 ml'si bakterileri tutan membran filtre üzerinden, steril edilmiş membran filtrasyon sisteminden süzüldü. Numune vakum ile filtrelendi. Huninin kilidi açılarak membran filtre steril pens ile havadan oluşabilecek kontaminasyonları önlemek için hemen Tergitol besiyeri üzerine, membran filtre ile besiyeri arasında hava kalmayacak şekilde yerleştirilerek (36±2)°C'de (21±3°C) saat inkübasyona bırakıldı. Membran filtre üzerinde sarı ve turuncu-sarı renkli koloniler ve membran filtre altında ise sarı nokta oluşturan laktoz pozitif bakteriler sayıldı.

Tergitol besiyerinde koliform bakteri kırmızı koloniler, *E.coli* ve *Enterobacter aerogenes* ise turuncu-sarı koloniler oluştururlar. Besiyerinde üreyen bu laktoz pozitif kolonilerden 5 tipik ve 5 atipik (parlak olmayan) koloni alınarak TSA besiyerine her koloniden ayrı ayrı ekim yapıldı ve (36±2)^{0}C'de (21±3^{0}C) saat inkübe edildi. İnkübasyon sonrasında oluşan kolonilerden doğrulama deneyi olarak oksidaz ve indol deneyleri yapıldı. Oksidaz testi için N,N-Dimethyl-1,4- phenylene diammonium chloride (0,1 µmol) ve α-naphthol (1,0 µmol) içeren oksidaz stripler kullanıldı. Steril plastik öze yardımıyla kolonin bir kısmı oksidaz strip üzerine sürüldü. 30 saniye içinde koyu mavi-mor rengin ortaya çıktığının görülmesi pozitif reaksiyon olarak kabul edildi. İndol testinde TSA besiyerinde üreyen kolonilerden triptofan sıvı besiyeri bulunan cam tüpe birer öze dolusu inoküle edildi ve (44±0.5)°C'de (21±3°C) saat inkübasyona bırakıldı. İçerisine 0.2 ml–0.3 ml kovacs reaktifi ilave edilmek suretiyle indol üretimi incelendi. Sıvı besiyeri yüzeyinde kiraz kırmızısı

bir rengin oluşması indol üretimini doğrular ve testin pozitif olduğunu gösterir. Oksidaz negatif reaksiyon veren bütün koloniler kolifom bakteri, oksidaz negatif ve indol pozitif reaksiyon veren bütün koloniler ise *E.coli* olarak sayıldı. Membran filtre üzerinde sayılan karakteristik koloniler ve yapılan doğrulama testlerinin sonuçlarının da dikkate alınmasından sonra ISO-8199'a uygun olarak numunenin 250 ml'sinde mevcut koliform bakteri ve *E.coli* sayıları hesaplandı. Analiz sırasında pozitif kontrol olarak *E.coli* (ATCC 25922), negatif kontrol olarak da *Staphylococcus aureus* (ATCC 25923) kullanıldı (TSE, 2011).

Enterokok bakteri sayısı tayin yöntemi

Enterokok bakteri sayımı tayininde, TS EN ISO 7899-2 membran filtrasyon yöntemi kullanıldı. Membran filtrasyon sistemi çalışmadan önce steril edildi. Türe özgü Azid besiyeri üretici firmanın verdiği talimatlara göre 3,5 ml steril saf su ile ıslatıldı. 0.45 µm por çapına sahip steril membran filtre, steril pens kullanılarak membran filtrasyon sisteminin porlu tablası üzerine yerleştirildi. Tabla üzerine dikkatlice huni sistemi yerleştirildi ve kilitlendi. Çalışılacak numunenin 250 ml'si bakterileri tutan membran filtre üzerinden steril edilmiş membran filtrasyon sisteminden süzüldü. Numuneler, vakum ile filtrelendi. Huninin kilidi açılarak membran filtre steril pens ile havadan oluşabilecek kontaminasyonları önlemek için hemen Azid besiyeri üzerine, membran filtre ile besiyeri arasında hava kalmayacak şekilde yerleştirilerek (36±2)°C'de (44±4°C) saat inkübasyona bırakıldı. İnkübasyondan sonra tipik olarak kolonin ortasında veya etrafında, kırmızı, mor veya pembe renk oluşumu ile ortaya çıkan tüm koloniler dikkate alındı. Tipik kolonileri içeren membran ve koloniler steril pens ile, ters yüz etmeden önceden 44°C'de ısıtılmış Bile Aesculin Agarlı (BAA) petri kabına aktarıldı. (44±0.5)°C'de 2 saat inkübe edildi. İki saatin sonunda plaklar hemen okundu. Çevresindeki besiyerinde ten renginden siyah renge kadar değişebilen renkler oluşturan tüm tipik koloniler pozitif reaksiyon vermiş olarak kabul edilerek bağırsak enterokoku olarak sayıldı (TSE, 2002).

Fekal koliform bakteri sayısı tayin yöntemi

Fekal koliform bakteri sayımı tayininde American Public Health Association (APHA, 2012) yöntemi kullanıldı (APHA, 2012).

İstatistiksel analizler

Bu çalışmada elde edilen verilerin istatistiksel yönden değerlendirilmesinde Statistica©ver.9.1 software (StatSoft, Inc., Tulsa, USA, 2009) kullanılmıştır. $p \leq 0.05$ değeri anlamlı kabul edilmiştir. Anadolu yakasına içme suyu sağlayan en önemli kaynak suyu çeşmeleri ve bulundukları bölgeler Tablo 1.'de verilmiştir.

Tablo 1. Anadolu yakası doğal kaynak suyu çeşmeleri ve bölgeleri
Table 1. The spring water fountains and their areas on Anatolian side

İstasyon/Numune	Kaynak suyu çeşmeleri	Bulundukları bölgeler
N1	Başıbüyük	Başıbüyük Mahallesi (Maltepe)
N2	Ferah	Büyük Çamlıca Mahallesi (Çamlıca)
N3	Göztepe	Göztepe Mahallesi (Kadıköy)
N4	Haminnine	Küçük Çamlıca Mahallesi (Çamlıca)
N5	İçerenköy	İçerenköy Mahallesi (Ataşehir)
N6	Kayışdağ	Kayışdağ Mahallesi (Ataşehir)
N7	Kozyatağı	Kozyatağı Mahallesi (Kadıköy)
N8	Sahrayıcedit	Sahrayıcedit Mahallesi (Kadıköy)
N9	Tatlısu 1	Esenkent Mahallesi (Maltepe)
N10	Tatlısu 2	Esenkent Mahallesi (Maltepe)

BULGULAR VE TARTIŞMA

Bu çalışmada İstanbul ili Anadolu Yakası'nda değişik yerleşim alanlarından farklı bölgeleri temsil niteliği taşıyabilecek 10 adet kaynak suyu çeşmesinden bir yıllık sürede (2014 yılı /12 ay) temin edilen 95 örnekte yapılan bakteriyolojik analizlerde 46 örneğin ulusal ve uluslararası standartlara göre bakteriyolojik bakımdan içilebilir nitelikte, 49 örneğin ise içilemeyecek nitelikte bakteriyolojik kirliliğe sahip olduğu görüldü. Numunelerimizin % 47,4'ünde Koliform bakteri; % 27,4'ünde Enterokok; % 17,9'unda *E. coli* ; % 14,7'sinde fekal koliform tespit edilerek standartlara uygun olmadığı görüldü.

Örneklerin % 48,4'ü ise standartlarda belirtilen değerlere uygun olduğu tespit edildi. Bakteriyolojik analizlerimizin sonucunda fekal koliform bakterilerin ve özellikle *E.coli*'nin tespiti kaynak suyu çeşmelerine fekal bulaşma olduğunu göstermesi bakımından oldukça önemlidir. Bakteriyolojik yoğunluk özellikle sıcaklıkların yükseldiği ilkbahar-yaz aylarında daha yoğun olarak tespit edildi. Koliform bakteri konsantrasyonu en yoğun olarak eylül ayında N5 (İçerenköy Mahallesi, Ataşehir) kaynak suyu çeşmesinde 17000 kob/250ml olarak; en yoğun *E.coli* konsantrasyonu mayıs ayında N8 (Sahrayı Cedid Mahallesi, Kadıköy) kaynak suyu çeşmesinde 180 kob/250ml olarak; en yoğun Enterokok konsantrasyonu haziran ayında N2 (Büyük Çamlıca Mahallesi, Çamlıca) kaynak suyu çeşmesinde 70 kob/250ml olarak; en yoğun fekal koliform konsantrasyonu ise mayıs ayında N8 (Sahrayı Cedid Mahallesi, Kadıköy) kaynak suyu çeşmesinde 180 kob/250ml olarak belirlendi. İstasyonlara göre Ocak-Aralık 2014 ayları arasındaki bakteriyolojik analiz sonuçları Tablo 2.'de gösterilmiştir.

Tablo 2. Ocak-Aralık 2014 arası doğal kaynak sularındaki bakteriyolojik analizler
Table 2. The bacteriological analysis of natural spring water between January-December 2014

İstasyonlar		Aylar											
N1	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	500	520	1100	130	-	-	130	-	-	-	-	150
E.coli	kob/250 ml	0	0	0	0	-	-	58	-	-	-	-	0
Enterokok	kob/250 ml	10	10	25	30	-	-	13	-	-	-	-	35
Fekal koliform	kob/250 ml	0	0	5	6	-	-	60	-	-	-	-	0
N2	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	0	3	13	0	480	3	50	80	0
E.coli	kob/250 ml	0	0	0	0	3	0	0	0	3	0	5	0
Enterokok	kob/250 ml	0	0	0	0	68	70	43	0	5	0	40	0
Fekal koliform	kob/250 ml	0	0	0	0	3	0	0	0	3	0	80	0
N3	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	-	-	-	-	-	-	-	-	-
E.coli	kob/250 ml	0	0	0	-	-	-	-	-	-	-	-	-
Enterokok	kob/250 ml	0	0	0	-	-	-	-	-	-	-	-	-
Fekal koliform	kob/250 ml	0	0	0	-	-	-	-	-	-	-	-	-
N4	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	0	18	0	-0	320	0	0	0	0
E.coli	kob/250 ml	0	0	0	0	0	0	0	0	0	0	0	0
Enterokok	kob/250 ml	0	0	0	0	0	0	0	0	0	0	0	0
Fekal koliform	kob/250 ml	0	0	0	0	0	0	0	0	0	0	0	0
N5	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	120	250	120	4800	300	140	17000	0	20	0
E.coli	kob/250 ml	0	0	50	90	0	0	0	20	5	0	20	0
Enterokok	kob/250 ml	0	0	0	0	0	0	30	8	10	0	0	0
Fekal koliform	kob/250 ml	0	0	50	90	0	0	0	25	5	0	20	0
N6	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	0	0	1000	160	200	0	0	0	0
E.coli	kob/250 ml	0	0	0	0	0	10	20	25	0	0	0	0
Enterokok	kob/250 ml	0	0	0	0	0	0	18	25	0	0	0	0
Fekal koliform	kob/250 ml	0	0	0	0	0	15	20	25	0	0	0	0
N7	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	30	230	3700	210	-	-	5	80	0
E.coli	kob/250 ml	0	0	0	0	0	25	0	-	-	0	0	0
Enterokok	kob/250 ml	0	0	0	0	0	0	30	-	-	0	0	0
Fekal koliform	kob/250 ml	0	0	0	0	0	25	0	-	-	0	0	0
N8	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	0	0	0	3000	-	-	-	-	-	-	160
E.coli	kob/250 ml	0	0	0	0	180	-	-	-	-	-	-	100
Enterokok	kob/250 ml	0	0	0	5	8	-	-	-	-	-	-	5
Fekal koliform	kob/250 ml	0	0	0	0	180	-	-	-	-	-	-	100
N9	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	0	10	0	0	2200	70	0	30	1200	220	190	0
E.coli	kob/250 ml	0	0	0	0	0	0	0	0	0	0	3	0
Enterokok	kob/250 ml	0	0	0	0	0	0	0	0	30	5	0	0
Fekal koliform	kob/250 ml	0	0	0	0	0	0	0	0	3	5	3	0
N10	**Birim**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Koliform bakteri	kob/250 ml	75	85	0	0	90	2000	0	-	-	0	40	0
E.coli	kob/250 ml	0	0	0	0	0	3	0	-	-	0	0	0
Enterokok	kob/250 ml	25	30	0	0	0	0	15	-	-	3	0	0
Fekal koliform	kob/250 ml	10	15	0	0	0	3	5	-	-	0	0	0

Dünya Sağlık Örgütü (WHO, 2011), ABD Çevre Koruma Ajansı (EPA, 2008), Avrupa Birliği (EC, 1998), Türk Standartları Enstitüsü İçme Suyu Standardı (TSE, 2005), ve Sağlık Bakanlığı İnsani Tüketim Amaçlı Sular Hakkındaki Yönetmelikte belirtilen bakteriyolojik parametreler ile ilgili sınır değerler (2013) Tablo 3.'de verilmiştir.

Tablo 3. İçme sularında olması gereken bakteriyolojik kalite parametreleri
Table 3. The bacteriological quality parameters that should be in drinking waters

	Dünya Sağlık Teşkilatı (WHO, 2011)	ABD Çevre Koruma Ajansı (EPA, 2008)	Avrupa Birliği (EC, 1998)	TSE İçme suyu standartı 266 (2005)	İnsani tüketim amaçlı sular hakkındaki yönetmelik
KoliformBakteri (kob/250ml)	0	0	0	0	0
***E. coli* (kob/250ml)**	0	0	0	0	0
Enterokok (kob/250ml)	0	-	0	0	0
Fekal kolifrom kob/250ml)	-	-	-	-	0

Bu çalışmada, İstanbul ili Anadolu yakasında bulunan, halkın kullanımına sunulmuş doğal kaynak suyu çeşmelerinin bir yıllık süreçte (2014 yılı/12 ay) bakteriyolojik kalite parametrelerinin incelenmesi ve elde edilen verilerin insan sağlığı açısından değerlendirilmesi amaçlanmıştır. Halkın yararına sunulan kaynak suyu çeşmelerinin içme ve kullanma amaçlarına yönelik olarak kullanılabilmeleri için insan sağlığını tehdit edici unsurları barındırmamaları ve insan sağlığına uygun su kalitesine sahip olmaları gerekmektedir. Bu bağlamda, kaynak suyu çeşmelerimizin su kalitesi parametreleri açısından WHO, EPA, EC ve Türk Standartları Enstitüsü TS 266 içme suyu standardı ve Sağlık Bakanlığı insani tüketim amaçlı sular hakkındaki yönetmelikte ifade edilen özelliklere uygunlukları değerlendirildi.

İçme suyu kaynaklı en önemli tehdit edici faktör patojen mikroorganizmaların varlığıdır (Dunn, 2014). Suların mikrobiyal kalitesinin tespiti fekal indikatör mikroorganizmaların analizine dayanmaktadır. Bunlar *E.coli* veya alternatif termotolerant koliformlar olarak seçilen organizmalardır. Yani fekal koliformlar ve *E.coli* yaygın olarak sularda fekal kontaminasyon göstergesi olarak kullanılmaktadır ve bu şekilde kesin olarak bu suların patojenik enterik bakteri varlığı ile ilişkili olduğu gösterilmiştir (Ochoo vd., 2017). *E.coli* içme suyunda bulunmamalıdır ve dışkı kirlenmesinin kesin kanıtıdır. Enterokoklar insan ve hayvanların gastrointestinal sisteminde kommensal yaşayan, fırsatçı patojenlerdir ve idrar yolu enfeksiyonu, endokardit ve sepsise neden olan bakterilerdir (Poulsen vd., 2012; Shafi vd., 2017). Gümüş ve arkadaşlarının 2012 yılında yaptığı bir çalışmada Karaman il merkezindeki 72 tatlı su çeşmesinden 28'inde (%38,8) bakteriyolojik kirlilik saptanmıştır. Örneklerden %31,94'ünde koliform Bakteri, %18'inde *Escherichia coli*, %12.5'inde hem koliform hem *E.coli* bulunmuştur (Gümüş, 2012). Yelekçi vd. 2012 yılında yaptığı diğer bir çalışmada Kilis ili şebeke sularından alınan 90 örnekten, beş tanesinin mikrobiyolojik kirlilikten yani koliform bakteri ve *E.coli* bakımından içmeye uygun olmadığı tespit edilmiştir. Şekerci vd. 2012 yılında yaptığı çalışmada ise Erzurum il merkezinde rastgele seçilen 45 çeşmeye ait mikrobiyolojik analizler sonucunda 10 örnekte (%22.7) hem toplam hem de fekal koliform bakteriye rastlanmıştır. Ağaoğlu vd. 2007 yılında yaptıkları benzer bir araştırmada Van ili merkezindeki kaynak/çeşme sularından alınan örneklerin %56'sı; ilçelerdeki kaynak/çeşme sularının ise %76'sı koliform grubu mikroorganizmalar yönünden standartlara uygun bulunmamıştır. Yiğit 2002'de yaptığı çalışmada İstanbul İli Arnavutköy Beldesi civarındaki 14 farklı kaynak /köy çeşmelerinden sadece 3 tanesinde akan suların mikrobiyolojik olarak uygun olduğu, diğer kaynak suları ve köy çeşmelerinden akan suların ise içme suyu olarak kullanılamayacağı bildirilmiştir. Günşen vd. 2000 yılında Bursa, Uludağ'daki kaynak sularının su kalitesinin incelenmesi amacıyla yaptıkları araştırmada kaynaklardan alınan 280 adet numunenin %7.69'unda koliform bakteri tespit edilerek mikrobiyolojik açıdan standartlara aykırı oldukları rapor edilmiştir. İçme sularının mikrobiyal kalitesinin tespiti fekal indikatör mikroorganizmaların analizine dayandığından halkın kullanımına sunulan kaynak suyu çeşmelerinin fekal koliform, *E.coli* ve Enterokok gibi fekal indikatör mikroorganizmaları barındırmaması gereklidir.

Bakteriyolojik analizlerimizin sonucunda fekal koliform bakterilerin ve *E.coli*'nin tespit edilmesi kaynak suyu çeşmelerine fekal kontaminasyon olduğunu göstermesi yönünden çok önemlidir. Sonuç olarak, halkın kullanımına açık olan kaynak suyu çeşmelerinin su kalitesi açısından sağlığı tehdit edici nitelikte olması önemli sağlık sorunlara neden olması muhtemeldir. İçme ve kullanma sularında patojen mikroorganizmaların neden olacağı bakteriyolojik kirlenmenin tespiti ve muhtemel salgın hastalıkları önlemek için bakteriyolojik kontrollerinin sürekli olarak yapılması gerekmektedir. Bu nedenle kaynak suyu çeşmeleri düzenli aralıklarla denetlenmeli ve sağlığı tehdit edici özellikler gösterdiği takdirde bu durum giderilene kadar halkın kullanımına sunulmamalıdır.

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Shelf life of rainbow trout fillets hot smoking with different sauces

Farklı soslarla sıcak tütsülenmiş gökkuşağı alabalıklarının raf ömrü

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Abstract: In this study, products of smoked fish were prepared from rainbow trout (*Oncorhynchus mykiss*, Walbaum 1792). Smoked fish with different sauce were prepared by targeting an increase in the consumption of trout which has a considerable production potential and is a delicious fish. 4 groups (A, B, C and D) applied with different sauces were prepared in the study. Samples were stored in a refrigerator (4 ºC) during storage. The aim of the study is to determine the chemical, microbiological and sensorial changes, the shelf life of products during the storage period of products. Study had 2 replicates and analyses had 3 parallels.
As a result, the qualities of chemical, microbiological and sensorial of the smoked samples prepared in our study were examined. The evaluation of data showed the shelf life as 14 days for A, 28 days for B, 21 days for C and 35 days for D with sauces. When the data obtained were evaluated, the shelf life was determined as 14 days for A, 28 days for B, 21 days for C and 35 days for D with sauces.

Keywords: *Rainbow trout, smoked, different sauce, shelf life*

Öz: Çalışmada, gökkuşağı alabalıklarından (*Oncorhynchus mykiss*, Walbaum 1792) füme ürünler hazırlanmıştır. Farklı soslar ilave edilen füme balıklar, önemli miktarda üretim potansiyeli ve lezzetli bir balık olan alabalık tüketiminde bir artışı hedefleyerek hazırlanmıştır. Çalışmada farklı soslar uygulanarak 4 grup (A, B, C ve D) elde edilmiştir. Örnekler, muhafaza süresince buzdolabı koşullarında (+4 ºC) muhafazaya alınmıştır. Bu araştırmada, ürünlerin muhafaza kalitesini ve raf ömrünü etkileyen kimyasal değişikliklerin belirlenmesi amaçlanmıştır. Çalışma 2 tekerrürlü ve analizler 3 paralelli olarak yapılmıştır.
Sonuç olarak, çalışmamızda hazırlanan tütsülenmiş örneklerin, kimyasal, mikrobiyolojik ve duyusal özellikleri belirlenmiştir. Elde edilen veriler değerlendirildiğinde örneklerin raf ömrü, A grubu için 14 gün, B grubu için 28 gün, C grubu için 21 gün ve D grubu için 35 gün olarak belirlenmiştir.

Anahtar kelimeler: *Gökkuşağı alabalığı, tütsüleme, farklı sos, raf ömrü*

INTRODUCTION

Smoking of food products for storage is one of the oldest known food storage methods. It is applied to all kinds of meat and meat products, cheese and seafood including the crustaceans (Stolyhwo and Sikorski, 2005). Previously performed solely for protecting the product, smoking now also aims at offering the product to the consumers in different forms by changing the taste of the product (Varlet et al., 2007). The smoking process preserves fish by means of the synergistic action of different factors, such as salt incorporation. The principle of storage through smoking is to remove a certain part of the water that the fish contains and to prevent the development of microorganisms by ensuring the passage of bactericides in the smoke into the fish. These changes delay the microbiological and oxidative changes that lead to spoilage, extending the shelf-life of the processed fish (Cornu et al., 2006; Rizo et al., 2015). One of the processing technologies applied on the fish is smoking. Smoking technology and consumption of smoked products developed and became widespread in Japan and other Far Eastern countries, Canada, European Union (EU) countries and Scandinavian countries. In our country, consumption of smoked products is rather uncommon when compared to other countries and some enterprises perform smoking by using this technology and sell these products to foreign countries (Bilgin et al., 2007).

Rainbow trout (*Oncorhynchus mykiss,* Walbaum 1792), which is the most commonly farmed species in our country, is a delicious fish. Thus, this highly favored species is subjected to freezing or smoking processes in addition to fresh consumption.

In this study, differently sauced smoked fish were prepared by targeting an increase in the consumption of trout which has a considerable production potential and is a delicious fish. The impacts of the sauces used on the shelf life were studied by examining the chemical, microbiological and sensorial changes of these products.

MATERIALS AND METHODS

Fish material and treatments

The experimental material consisted of farmed rainbow trout *(Oncorhynchus mykiss)* weighing 1.0 kg. After slaughter (gill cut and bleeding) fishes were eviscerated, cleaned and placed on ice (ice/fish, 1/3) into the strafor boxes and transported (4 °C) to the laboratory in one hour period. Study had 2 replicates and analyses had 3 parallels.

Preparation of smoked fish and storage conditions

Fish were processed as smoked. all fish were filleted and by hand to remove skin, bones, fins and visible adipose tissue In this study, flow diagram of the production of smoked fish is shown in Figure 1.

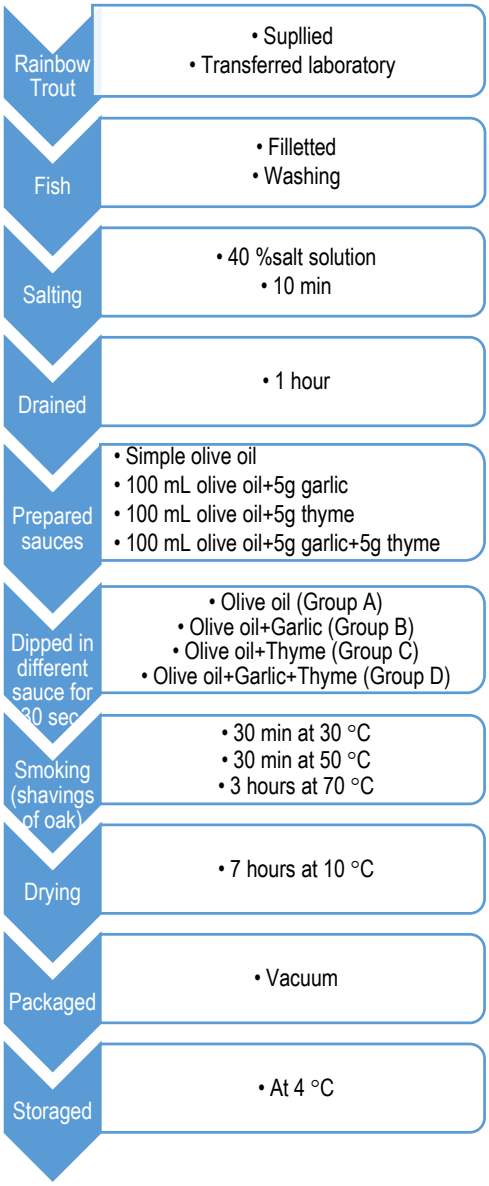


Figure 1. The flow diagram of smoked trout filets with different sauces

Chemical analyses

pH value of the samples was measured with a digital electronic pH meter (Thermo Scientific Orion 3-Star Benchtop, Cambridge, UK) (AOAC, 2002). TVB-N amounts in the products produced for the study were determined by the method reported by Varlik et al. (1993). TBA value was determined as described by Tarladgis et al. (1960). 10 g homogenized samples were washed into the distillation flask and 2 g magnesium oxide and a drop or two of antifoam solution were added. The contents were boiled and distilled into 10 ml of 3 percent boric acid solution with added indicator in a 500 ml conical flask. After distillation, contents of the conical flask were titrated with 0.1N HCl (Schormüller, 1968).

Microbiological analyses

Each sample was first treated as follows: a sample (10 g) was taken from each fish fillet, placed aseptically into a stomacher bag (Seward Medical, Worthing, UK) containing 90 mL of 0.1% buffer peptone water, and the mixture was homogenized for 60 s using a Stomacher (Lab Blender 400, London, U.K.) at room temperature. For microbial enumeration, 0.1 mL samples of serially dilutions (1:10, diluent, 0.1% peptone water) of fish homogenates was spread onto plates of various agar materials. Total aerobic mesophiles was determined using plate count agar (PCA, Oxoid, CM325) after incubation at 30 °C for 72 h. Aerobic pychrophiles was counted using plate count agar (PCA, Merck 1.05463, Merck, KgaA Darmstat, Germany) after incubation for 7-10 days at 5 °C. Yeast and mold counts were determined using Potato Dextrose agar (PDA, Merck 1.10130). Yeast and mold were incubated at 22 °C for 3-5 days. All colonies were counted and the data were reported as colony forming units (log cfu g^{-1}) (Harrigan,1998).

Sensorial evaluation

The attributes of trout (odor, color, appearance and overall acceptability) were evaluated by a panel of seven experienced panelists in the analysis days of sampling. Sensory evaluation was conducted in individual booths under controlled conditions of light, temperature and humidity. Sensory analysis was performed using the methods of (Altuğ Onoğur and Elmacı, 2011).

Panelists were asked to evaluate on a 5-point hedonic scale ranging from very poor (1) to very good (5) where: 1 – very poor, 2 – poor, 3 – normal, 4 – good and 5 – very good.

Statistical analysis

All measurements were accomplished in triplicate and the results are given as the mean and standard deviation. A one-way variance analysis (ANOVA) was applied by using the IBM-SPSS ® 22 version software (Chicago, Illinois, USA) and the Duncan's Multiple Range Test comparisons at P value of <0.05 were carried out to indicate significant differences (Özdamar, 2001).

RESULTS AND DISCUSSION

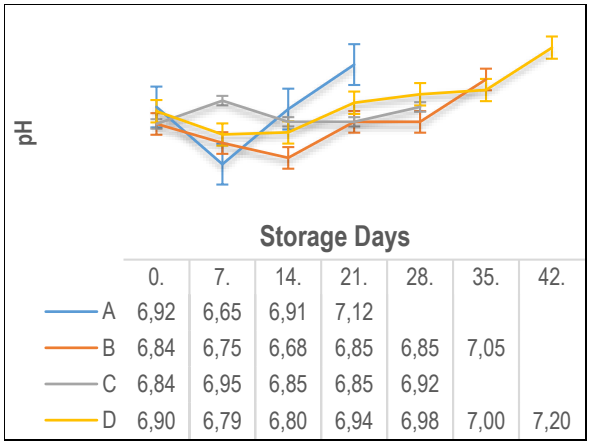
Chemical, microbiological and sensory changes of the rainbow trout fillets smoked with different sauces during the storage are shown in Figure 2-3-4.

Chemical changes

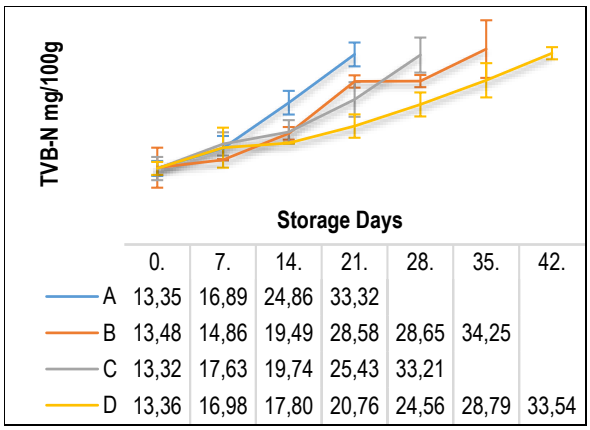
In all groups of rainbow trout fillets smoked with different sauces during storage, pH values decreased at the beginning while different changes were observed in the subsequent days of the storage (Figure 2). In group A, pH value, which was 6.92, increased to 7.12 at the end of the storage. In group B, pH value, which was 6.84 at the beginning, continued declining during the storage and rose to 7.05 at the 35th day when spoilage was detected. In group C, pH value, which was 6.84 at the outset, did not change much in time and was determined as 6.92 at the 28th day. Also difference between pH values during storage determined relative to groups in the study was not found statistically significant ($p>0.05$). In group D, pH value, which was 6.90, first decreased and then increased to 7.20. It is reported that pH value increases during storage of the products, and this results from trimethylamine, ammoniac and other nitrous compounds which develop due to microorganism activities (Tokur et al., 2006). In the study conducted with smoked fillets, Ünal (1995) determined that pH value changed between 6.05 and 6.26 in the sample stored in fridge conditions. These values confirm that the changes in the pH values of the rainbow trout fillet samples, which were smoked with different sauces and stored at 4 ±0.5°C, are not significant. Bilgin et al. (2007) reported that the pH value of *S. trutta macrostigma* samples which were hot smoked and stored at 4.0 ±0.5°C was 6.290 ±0.010 at the end of storage. This value is similar to the values found in this study.

As to the TVB-N values of the smoked sauced trout fillets, it was detected that increases occurred when compared to the initial values and, as the highest increase, the sample with the sauce D reached 33.54 mg/100 g at the 42nd day. The group with the sauce A spoiled at the end of the 21st day and TVB-N value was determined as 33.32 mg/100 g. Group B spoiled at the end of the 35th day with TVB-N value of 34.25 mg/100 g while the group with the sauce C spoiled at the 28th day with a TVB-N value of 33.21 mg/100 g (Figure 2). Also difference between the TVB-N values during storage determined within groups in the study was found statistically significant ($p<0.05$). It was reported that the TVB-N value can increase in smoked fish during storage and fish cannot be consumed when it TVB-N value exceeds 35 mg (Varlık et al., 1993). Bilgin et al. (2007) reported that the TVB-N values of the fillets changed within a range from 13.968 to 34.378 mg/100 g during the storage period. These values show similarity to our values.

As for the TBA value which is the measure of rancidity and emerges due to the oxidation of fats in fisheries, 1-3 mg MA kg^{-1} is defined as good quality while the range of 3-8 mg MA kg^{-1} is defined as low quality. When it reaches 8 mg MA kg^{-1}, the product is defined as inconsumable (Köse and Erdem, 2001; Varlık et al., 2000). When TBA values were examined in our study, while TBA values differed from 1.67 to 2.26 mg MA kg^{-1} in all groups at the beginning, they changed slightly during the storage period and TBA values were determined as 3.85 mg MA kg^{-1} at the 21st day for the group A, 3.26 mg MA kg^{-1} at the 35th day for the group B, 2.60 mg MA kg^{-1} at the 28th day for the group C and 2.52 mg MA kg^{-1} at the 42nd day for the group D, in which the latest spoilage was observed (Figure 2). According to the statistical assessments, difference between the control group and the groups in which sauces were used after the 2nd week was significant ($p<0.05$). In the groups where the sauce contained thyme, TBA values increased less than the other groups. This result can be explained with the antioxidant nature of thyme. Ünlüsayın et al. (2003) reported that the TBA values of *C. auratus* which were hot smoked and stored for 28 days at 4°C, increased. These results are parallel to our values. Salama and Khalafalla (1993) conducted a study on conger eel (*A. vulgaris*) and used two different salt concentrations as 7.5 % and 15 %. They examined the changes during storage after the samples were smoked. They reported that the TBA values displayed irregular changes and that the samples with higher salt concentrations spoiled less.



	0.	7.	14.	21.	28.	35.	42.
A	6,92	6,65	6,91	7,12			
B	6,84	6,75	6,68	6,85	6,85	7,05	
C	6,84	6,95	6,85	6,85	6,92		
D	6,90	6,79	6,80	6,94	6,98	7,00	7,20



	0.	7.	14.	21.	28.	35.	42.
A	13,35	16,89	24,86	33,32			
B	13,48	14,86	19,49	28,58	28,65	34,25	
C	13,32	17,63	19,74	25,43	33,21		
D	13,36	16,98	17,80	20,76	24,56	28,79	33,54

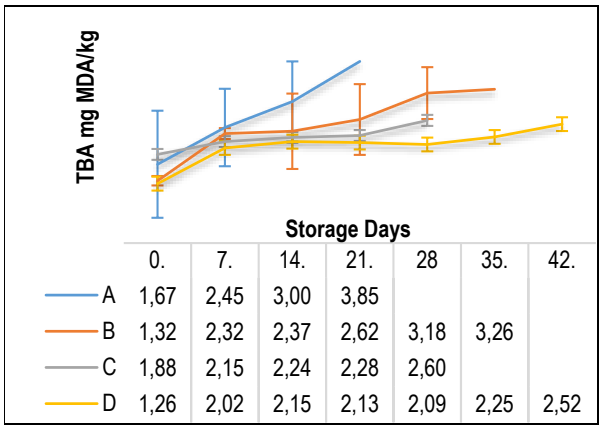


Figure 2. The chemical changes of smoked rainbow trouts with different sauces

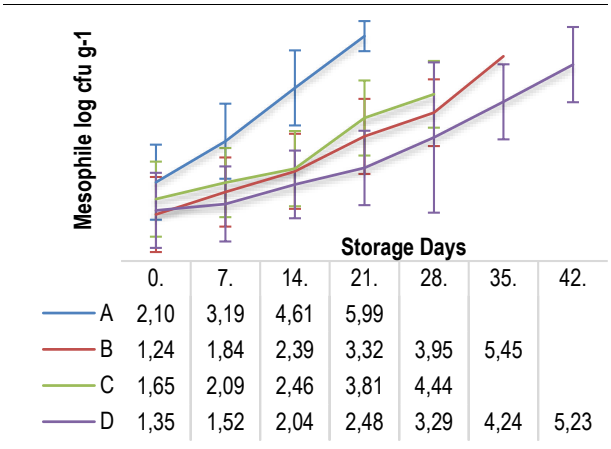
Microbiological determinations

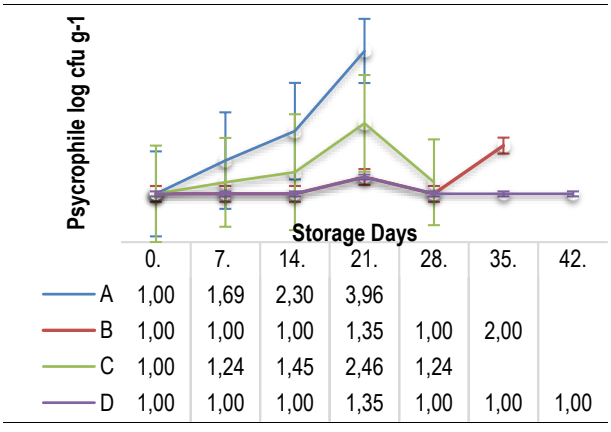
When microbiological analyses of the trout fillets sauced and smoked in different ways were examined, increases in numbers of mesophile psicrophile bacteria and yeast-mold were observed in all analysis groups depending on the storage duration (Figure 3).

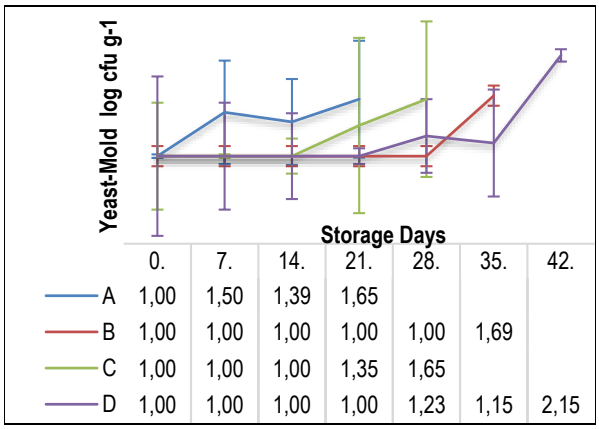
While aerobic mesophiles were 2.10 log cfu g^{-1} in group A at the outset, aerobic mesophile numbers were lower in the other groups. At the end of the storage period, aerobic mesophile numbers increased and reached 5.99 log cfu g^{-1}, 5.45 log cfu g^{-1}, 4.44 log cfu g^{-1} and 5.23 log cfu g^{-1} in group A, group B, group C and group D, respectively. In the control group, the differences among the storage days were found significant ($p<0.05$). Although aerobic mesophile numbers increased in the groups where sauces were used during the storage, these increases were not as high as in the control group (Figure 3). The differences between the control group and the groups where sauces were used was found to be statistically significant ($p<0.05$) while the difference between group C and group D at the 28th day was found significant ($p<0.05$). Dondero et al. (2004) reported that increases in aerobic mesophile numbers were associated with storage duration and temperature. Kolsarıcı and Özkaya (1998) reported that aerobic mesophile number of hot smoked trout samples was 4.32 log cfu g^{-1} at the beginning of the storage while it was determined as 7.36 log cfu g^{-1} at the end of storage at +4±1°C. These values are similar to our findings. Schulze (1985) reported that aerobic psychrophile number increased depending on the storage duration in trout samples which were smoked in whole and as fillets and stored at 4°C and 10°C.

The number of psychrotrophic bacteria can increase in the food products stored in the fridge conditions and may lead to food-related diseases. Some researchers have reported that there are pathogens frequently encountered in the smoked products stored in fridge conditions. In this study, it was determined that the aerobic psychrophile number was far below the limit value of 6 log cfu g^{-1}. The number of psychrotrophic bacteria, which was 1 log cfu g^{-1} at the beginning, did not show statistically significant differences among the groups and the storage days until the 14th day of the storage (Figure 3). At the 21st day of the storage, statistically significant differences were observed between the control group and the groups where thyme and garlic were added ($p<0.05$). In the control group, differences were observed between the 21st day and the other days. In the groups where the sauce contained thyme, differences of the days following the 21st day were significant. Deng et al. (1974) reported that aerobic psychrophile numbers in the smoked fish might increase slightly during storage.

When yeast and mold values were examined, while they were around 1.00 log cfu g^{-1} in all groups at the beginning, they displayed slight increases in time. At the end of storage, they were determined as 1.65 log cfu g^{-1}; 1.69 log cfu g^{-1}; 1.65 log cfu g^{-1}; and 2.15 log cfu g^{-1} in group A, group B, group C and group D where the latest spoilage was observed (Figure 3). Dondero et al. (2004) reported that yeast and mold values might increase slightly.







	0.	7.	14.	21.	28.	35.	42.
A	1,00	1,50	1,39	1,65			
B	1,00	1,00	1,00	1,00	1,00	1,69	
C	1,00	1,00	1,00	1,35	1,65		
D	1,00	1,00	1,00	1,00	1,23	1,15	2,15

Figure 3. The microbiological changes of smoked rainbow trouts with different sauces

A: Olive oil **B:** Olive oil + Garlic **C:** Olive oil + Thyme **D:** Olive oil + Garlic + Thyme

Sensory evaluation

Rainbow trout fillets, which were smoked with different sauces, were assessed in terms of sensory changes during the storage period such as taste, smell and general acceptability and were scored between 1 and 5, and it was determined that they are highly popular products. After all sensory assessments, it was concluded that the samples of the group D were liked at most ($p<0.01$). The least favorite ones were the samples of the group A (Figure 4). Results of the sensory assessments conducted by Deng et al. (1974), Gökoğlu and Varlık (1992) and Kolsarıcı and Özkaya (1998) on the smoked fish are consistent with the findings of the present study.

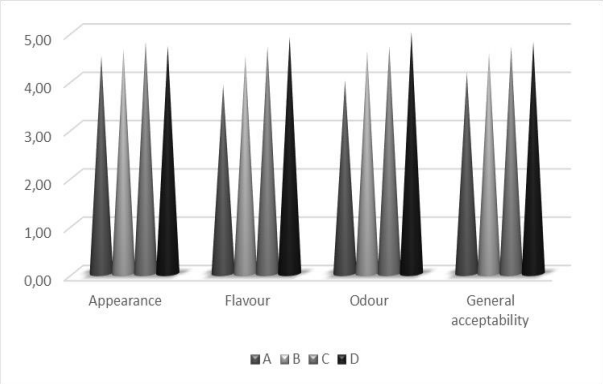


Figure 4. Sensory changes of samples during storage

A: Olive oil **B:** Olive oil + Garlic **C:** Olive oil + Thyme **D:** Olive oil + Garlic + Thyme

As a result, the qualities of chemical, microbiological and sensorial of the smoked samples prepared in our study were examined. When the data obtained were evaluated, the shelf life was determined as 14 days for A, 28 days for B, 21 days for C and 35 days for D with sauces.

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Su Ürünleri Dergisi (2018)
DOI: 10.12714/egejfas.2018.35.1.09

RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Halacarid mites of the genus *Agauopsis* (Acari: Halacaridae) from West Coast of Antalya, Turkey

Batı Antalya (Türkiye) sahilinden *Agauopsis* (Acari: Halacaridae) cinsine ait halacaridler

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Abstract: Five *Agauopsis* species were determined at 8 sampling stations, various depths and habitats in the West Mediterranean Sea Coast of Antalya, Turkey. Among them *Agauopsis nonornata* is new for the Mediterranean Sea, *Agauopsis brevipalpus*, *Agauopsis conjuncta*, *Agauopsis ibssi* and *Agauopsis pteropes* are new for the Eastern Mediterranean Sea. Each species is illustrated, briefly described here with their worldwide geographical distributions and habitat informations.

Keywords: *Acari, Halacaridae, Agauopsis, Turkey, Antalya*

Öz: Bu çalışmada, Antalya'nın Batı Akdeniz kıyılarındaki 8 istasyonda çeşitli derinlik ve habitatlardan 5 *Agauopsis* türü tespit edilmiştir. Bu türlerden *Agauopsis nonornata*, Akdeniz için, *Agauopsis brevipalpus*, *Agauopsis conjuncta*, *Agauopsis ibssi* ve *Agauopsis pteropes* Doğu Akdeniz kıyıları için yenidir. Her bir türün illustrasyonları yapılmış, kısa tanımları, habitat bilgileri ve dünyadaki dağılımları verilmiştir.

Anahtar kelimeler: *Acari, Halacaridae, Agauopsis, Türkiye, Antalya*

INTRODUCTION

Halacaridae is a family of aquatic (freshwater, brackish and marine) ecosystems, meiobenthic and covered by chitinous cuticle. To date, about 1120 species of halacarids have been reported worldwide, from habitats including macroalgae, sponge colonies, hydrozoans, bryozoans, barnacles, mussels, polychaetes, mud, and sandy habitats (Bartsch, 2006). They live in sediments from the littoral zone to the deep sea (Bartsch, 1989). The family are distributed on 64 genera. Of them *Agauopsis* Viets is the one of the richest in genera which has more than 80 species (WoRMS, 2017).

MATERIALS AND METHODS

Sandy deposits (detritus-riched, fine to coarse), various macroalgae, marine phanerogams (*Cymodosa nodosa* and *Posidonia oceanica*), bivalves (*Mytilus galloprovincilalis* and *Ostrea* sp.) samples were collected by hand intertidally or various depths (0-30 m) usually using SCUBA or snorkelling diving at localities along the West Coast of Antalya. Immediately after collection, mites were extracted by washing the substrates. The meiofauna retained in the set of sieves (63 µm, 500 µm, 1 mm) was sorted under binocular microscope (Nikon SMZ 10A). In the laboratory, mite specimens were cleared in lactic acid and mounted in glycerine jelly. Figures were drawn with the aid of a camera lucida (Nikon Eclipse E400). The specimens were kept in the first author's personal collection in Antalya.

The following abbreviations used in the text and figure legends: AD, anterior dorsal plate; AE, anterior epimeral plate; dp-1 to dp-4,dorsal gland pores numbered from anterior to posterior; ds-1 to ds-6, dorsal setae (excluding those on posterior epimeral plate) numbered in sequence from anterior to posterior; GA, genitoanal plate; GO, genital opening; OC, ocular plate; PD, posterior dorsal plate; PE, posterior epimeral plate; P-2 to P-4, second to fourth palpal segments; I-IV, leg I to leg IV.

RESULTS

A total of 152 *Agauopsis* specimens belonging to five species were found along the West Mediterranean Sea Coast

of Antalya, Turkey: *Agauopsis brevipalpus* (137 indiv.), *Agauopsis conjuncta* (8 indiv.), *Agauopsis ibssi* (2 indiv.), *Agauopsis nonornata* (2 indiv.) and *Agauopsis pteropes* (3 indiv.). The descriptions of the species that will be presented as follows:

Systematics

Class	ARACHNIDA	Cuvier,	1812
Subclass	ACARI	Leach,	1817
Family	HALACARIDAE	Murray,	1877

Genus AGAUOPSIS, Viets, 1927

***Aguopsis brevipalpus* (Trouessart, 1889)** Figs. 1,2,11,12

Material examined: Ten females, five males among *Corallina officinalis* (2m depth), *Jania rubens* (3m) at Örnekköy Beach (36°50'49"N; 30°48'18"E); twenty females, seventeen males, four deutonymphs and two protonymphs among *Amphiora rigida* (3m), *C. officinalis* and *J. rubens* (1m), *Laurencia viscida* (6m) at Yakamoz Beach (36°50'44"N; 30°47'57"E); two females, two males from fine sand (5m) at Bilem Beach (36°51'17"N;30°44'38"E); twelve females from *Cystoseria barbata, Ostrea* sp., *Mytilus galloprovincialis* (5m) at Kemer (36°35'56"N; 30°34'29"E); six females, four males, two deutonymphs from *C. officinalis* (3m), *C. barbata*, (7m) at Faselis (36°31'30"N; 30°33'8"E); eleven females, six males from *Galaxura oblongata* (2m), *J. rubens* (5m) at Finike (36°16'44"N; 30° 8'25"E); twelve males from *Mesophyllum expansum* (10m) at Kaş (36° 9'25"N; 29°37'42"E); twenty two females from *Bryopsis plumosa*, *Cladophora* sp. (1m), *Padina pavonica* (3m) at Kalkan (36°15'43"N; 29°24'41.54"E).

Short description: Length of females 330-525 µm, of males 300-400 µm. Length of deutonymphs 350-390 µm, protonymphs 280-290 µm long. Idiosoma wide and heavily armed in adults. AD and PD with slightly raised longitudinal costae; costae with canaliculi. AD with small frontal process and with distincly raised H-like costa. Gland pores small. ds-2, ds-3 and ds-4 are small and their position on integument of idiosoma. ds-5 on PD. AD of female 175 µm long, 150 µm wide and has one pair of gland pores. Pair of ds-1 level with gland pore on AD. OC of female 95 µm long, 90 µm wide, with two cornea. OC with rounded angles. PD of female 200 µm long, 175 µm wide. AE of female 200 µm long, 370 µm wide. PE of female 200 µm long, 75 µm wide. GA of female 150 µm long, 175 µm wide. Female GA with 3 pairs of perigenital setae. Gnathosoma 200 µm long, 112 µm wide, slender. Total palp lenght is 125 µm. Rostrum about as long as gnathosomal base. Leg I much wider and longer than adjoining segments. Telofemur I, 2.5 times longer than high, with two ventral spines (Figs. 1, 2, 11 & 12).

Distribution: *A. brevipalpus* is one of the most encountered species in the genus of *Agauopsis*. It has been commonly found on the coast of North Atlantic and its adjacent basins (Mediterranean Sea, Black Sea) (Bartsch, 2009). It was recorded first time from Turkey, (Black Sea-Sinop) by Bartsch (2004). In this study, we recorded it from Antalya, Turkey. This is the second record from Turkey.

Remarks: With regard to the external morphological characters, the specimens are correspond with Black Sea (Sevastapol) (Bartsch, 1996) and Mediterranean Sea (Croatia) (Viets, 1940) specimens.

***Agauopsis conjuncta* Viets, 1940** Figs. 3,4,13,14

Material examined: Four females, four males from *Cymodocea nodosa* (15 m) at Kaş (36°09'25"N, 29°37'42"E).

Short description: Length of females 355-360 µm, of males 325-330 µm. Ds-1 on AD, ds-2 on OC, ds-3,4 on PD. AD of female 130 µm long, 95 µm wide. Its shape like "horse shoe". OC of female 100 µm long, 50 µm wide, each with 2 cornea and eyespot. PD of female 125 µm long, 100 µm wide, two-three rosette pores wide in most of their lenght. AE of female 112 µm long, 212 µm wide. GA of female 162 µm long, 112 µm wide. PE of female 162 µm long, 63 µm wide. Gnathosoma 88 µm long, 50 µm wide. Total palp length of females 63 µm. Telofemur I ventrally with one spine seta (25 µm long), dorsally with 3 spine setae (Figs. 3, 4, 13 & 14).

Distribution: This species was described by Viets (1940) for the first time from Adriatic Sea (Croatia-Rovinj and Split). Later on, it recorded from Tyrrhenian Sea (Livorno) by Morselli and Mari (1985). After 32 years, this is the third record of this species from the world.

Remarks: *A. conjuncta* was originally described by Viets (1940) from the various habitats which was collected from the Adriatic Sea (Croatia-Rovinj and Split). When compared with the original description, our specimens are exhibit all the characters of the type species.

***Agauopsis ibssi* Bartsch, 1996** Figs. 5,6,15,16

Material examined: One female, one male from fine sand (12 m) at Kaş (36°09'25"N, 29°37'42"E).

Short description: Length of female 415 µm, of male 350 µm. Dorsal plates are punctate and slender. Each rosette pore with wide and shallow, pit-like ostium and, in deeper integumental layers, 6-10 canaliculi. Gland pores inconspicuous. AD of female 150 µm long, 175 µm wide, very weakly developed H-like costa. OC of female 95 µm long, 85 µm wide. PD of female 262 µm long, 187 µm wide. AE of female 162 µm long, 300 µm wide. GA of female 162 µm long, 150 µm wide. PE of female 162 µm long, 85 µm wide. Gnathosoma 162 µm long, 75 µm wide. Palps slender, total palp length of female 87 µm (Figs. 5, 6, 15 & 16).

Distribution: Records of this species are presented only from Black Sea (Crimea, Sevastopol) (Bartsch, 2004).

Remarks: *A. ibssi* is distinguished from the *A. brevipalpus* by the following characters: PD is uniformly porose, tarsus I and the spines of leg I are longer than *A. brevipalpus*. The two species also differ in their habitats, *A. brevipalpus* lives

amongst dense scrubs of algae whereas *A. ibssi* is psammophilous (Bartsch, 1996).

***Agauopsis nonornata* Bartsch, 1999** Figs. 7,8,17,18

Material examined: Two females from detritius riched sediment with *Posidonia oceanica* (12 m) at Bilem Beach (36°51'17"N, 30°44'38"E).

Short description: Length of females 350-385 µm. AD of female 145 µm long, 110 µm wide with a small dome shaped areola posterior to frontal spine on AD. Costae on AD and PD with polygons, each polygon with alveolus, about 3 µm wide. OC of female 85 µm long, 25 µm wide, each with 2 corneae, posterior portion with small cauda. PD of female 195 µm long, 135 µm wide. AE of female 125 µm long, 212 µm wide, garland-like areolae on AE. GA of female 137 µm long, 112 µm wide. PE of female 125 µm long, 37 µm wide. Gnathosoma 100 µm long, 63 µm wide. Palps 4-segmented, total palp lenght is 45 µm. Leg I stout and longer than following legs. Basifemur I with prominent distoventral lamella. Telofemur I ventrally with proximal and middle lamellar protuberances equipped with spine (Figs. 7, 8, 17 & 18).

Distribution: *A. nonornata* had been known only from Galapagos Islands since 1977. In this study, the species is recorded for the first time from Turkey.

Remarks: *A. nonornata* belongs to the *ornata* group. This species can be easily distinguished from other *Agauopsis* species by the presence garland-like arranged porose polygons (garland-like areolae) on AE and the presence distoventral lamella on basifemur I.

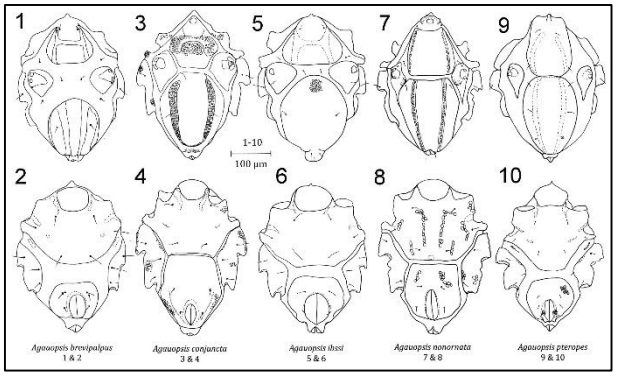
***Agauopsis pteropes* Bartsch, 1986** Figs. 9,10,19,20

Material examined: Three females from detritus-riched sediment with *P. oceanica* (12 m) at Bilem Beach (36°51'17"N, 30°44'38"E).

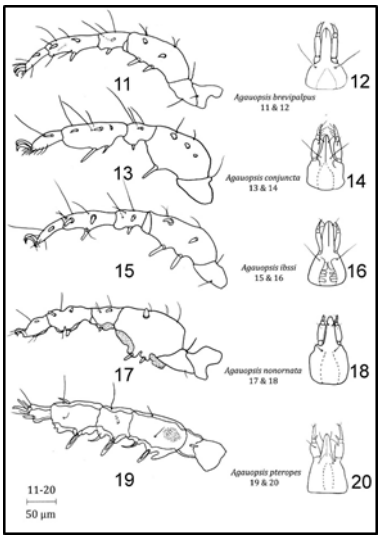
Short description: Length of females 350-385 µm. AD of female 145 µm long, 110 µm wide, anterior margin of AD with frontal process which is not sharply. OC of female 85 µm long, 25 µm wide with a pair of cornea. PD of female 195 µm long, 135 µm wide. AE of female 175 µm long, 250 µm wide. GA of female 125 µm long, 125 µm wide. PE of female 150 µm long, 62 µm wide. Gnathosoma 100 µm long, 75 µm wide. Total palp lenght is 63 µm. Leg I stout and longer than following legs.

Distribution: This species was found first time from Gulf of Lion (France-Mediterranean Sea). This is the second record for the Mediterranean Sea.

Remarks: This species can be easily distinguished from other *Agauopsis* species by having fin like cuticular lamellae on telofemura III, IV and tibia III, IV.



Figures 1-10. Dorsal and ventral views of five female *Agauopsis* species



Figures 11-20. Shape of leg I (lateral view) and gnathosoma (ventral view)

DISCUSSION

So far, only eight species of *Agauopsis* have been recorded from the Mediterranean Sea. These are: *Agauopsis brevipalpus*, *Agauopsis conjuncta*, *Agauopsis ibssi*, *Agauopsis marinovi*, *Agauopsis microrhyncha*, *Agauopsis pteropes*, *Agauopsis spinipes* and *Agauopsis tricuspis* (Trouessart, 1889; Police, 1909; Viets, 1940; Petrova, 1976; Bartsch, 1986;1996 and 1999). Only two records of *Agauopsis* have been recorded from the Turkish waters up to date. These are: *A. brevipalpus* and *A. microhyncha*. First one reported from Sinop (Black Sea) by Bartsch (2004). The latter reported from Antalya (Mediterranean Sea) by Durucan & Boyacı (2016). Their distribution and habitats are outlined (Table 1).

The present records of *A. nonornata* brings the total number of known species in the genus *Agauopsis* from Mediterranean Sea 8 to 9. With the present study, the number of *Agauopsis* species in Turkey has raised from 2 to 6.

Table 1. List of all Mediterranean *Agauopsis* species with additional information *This study

Species	Distribution	Habitats	References
Agauopsis brevipalpus	**Northeastern Atlantic:** Le Croisic (France), UK, Ireland, Spain, Azores, Canary Islands **Mediterranean and Black Sea:** Tunusia; Algeria; Sozopol, Burgas, Anchialo, Mesemvria (Bulgaria); Rovinj, Split (Croatia); Livorno, Salento (Italy); Vama Veche, Costinesti, Agigea, Mamaia (Romania); Caucasian Coast (Russia); Odessa, Crimea, Sevastapol (Ukraine);Sinop, Antalya* (Turkey)	bryozoan colonies, phanerogamae, sand, various algae, *Aplysina aerophoba, Arca noae*, *Geodia* sp., *Ostrea* sp.	Trouessart, 1889; Morselli and Mari, 1982;1985; Bartsch, 2004
Agauopsis conjuncta	**Mediterranean Sea:** Rovinj, Split (Croatia); Livorno (Italy); Antalya*(Turkey)	sand, various algae, *Arca noae*, *Geodia* sp., *Cymodosa nodosa* (15 m), *Zostera* sp.	Viets, 1940; Morselli and Mari, 1985
Agauopsis ibssi	**Mediterranean and Black Sea**: Crimea, Sevastopol (Ukraine); Antalya* (Turkey)	coarse sand (5-12m), fine sand (12m)	Bartsch, 1996
Agauopsis marinovi	**Northeastern Atlantic:** Île-Grande (France) **Mediterranean Sea:** Italy **Black Sea:** Crimea, Sevastopol (Ukraine); Cap Galata (Bulgaria)	coarse sand (45-55 cm)	Bartsch, 1984; 1996; 2004
Agauopsis microrhyncha	**Northeastern Atlantic:** Manche Channel (France); Spain **Mediterranean Sea:** Rovinj, Split (Croatia); Monaco; Italy; Antalya* (Turkey)	algae,sponge and bryozoan habitat (58m), fine sand (12m)	Trouessart, 1889 Viets, 1940; André, 1946; Durucan and Boyacı, 2016
Agauopsis nonornata	**Northwestern Atlantic and Caribbean Sea:** Caribbean Sea; **Pacific:** Galapagos Islands; **Mediterranean Sea:** Antalya* (Turkey)	intertidal and upper sublittoral habitats, *P. oceanica* (12m)	Bartsch, 1977;1999
Agauopsis pteropes	**Northeastern Atlantic:** Canary Islands **Mediterranean Sea:** Gulf of Lion (France), Antalya* (Turkey)	sediment with detritius (37m,45 m), *P.oceanica* (12m)	Bartsch, 1986
Agauopsis spinipes	**Mediterranean Sea:** Naples, (Italy)	algae (3m)	Police, 1909
Agauopsis tricuspis	**Northeastern Atlantic:** Spain to UK and Ireland **Mediterranean Sea:** Adriatic Sea (near Venice)	algae, barnacles, mussels	Benard, 1962; Green and MacQuitty, 1987

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

First observation of the zebra mussel (*Dreissena polymorpha* (Pallas, 1771)) on the narrow-clawed crayfish inhabiting in some water sources of Turkey

Zebra midyesinin (*Dreissena polymorpha*'nın (Pallas, 1771)) Türkiye'nin bazı su kaynaklarında yaşayan dar kıskaçlı kerevitler üzerinde ilk olarak gözlenmesi

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Abstract: The zebra mussel, *Dreissena polymorpha* (Pallas, 1771) is considered as a harmful invasive epibiont species for hydroelectric and nuclear power plants as it reduces or blocks water flow in the plant systems. Although *D. polymorpha* is reported that it cleans the water, increases water visibility, and filters out pollutants, it has likewise negative impacts on the population and size of some fish and aquatic species. In the present study, zebra mussels were observed for the first time. On the narrow-clawed crayfish living in some water sources in Turkey. Specimens were collected from two natural lakes (Çıldır Lake, Eğirdir Lake) and five ponds (Altınyazı Dam Lake, Keban Dam Lake, Küçükçekmece Lake, Karpuzlu Dam Lake, Kadıköy Dam Lake) in Turkey. Attachments of the zebra mussel to the different body parts of the narrow-clawed crayfish were documented in the present study. Cochran's Q test results showed that the numbers of mussels clinging to the different parts of the crayfish varied (P=0.000) (P <0.001). The difference between the holding regions of zebra mussels on crayfish specimens may cause some adverse effects on the host. Particularly the intensive grip on the carapace partially obstruct the movement, feeding, mating, avoiding predators, and shelter. mussel individuals in the pleopodal region may have difficulty holding and transporting eggs. This study is the first report about the occurrence of *D. polymorpha* on *Astacus leptodactylus* in Turkish waters.

Keywords: *Dreissena polymorpha, Zebra mussel, Astacus leptodactylus, body colonization, Turkey*

Öz: Zebra midyeleri, *Dreissena polymorpha* (Pallas, 1771) hidroelektrik ve nükleer güç sistemlerinde su akışını engellediğinden zararlı bir istilacı epibiont türü olarak kabul edilir. *D. polymorpha* suyun temizlenmesi, su görünürlüğünün arttırılması ve kirleticilerin filtrelenmesi olarak rapor edilmesine rağmen, bazı balıkların ve sucul türlerin popülasyonu ve büyüklüğü üzerinde olumsuz etkilere sahiptir. Bu çalışmada, zebra midyesi Türkiye'deki bazı su kaynaklarındaki tatlısu ıstakozu üzerinde ilk defa gözlemlenmiştir. Bireyler Türkiye'deki iki doğal göl (Çıldır Gölü, Eğirdir Gölü) ve beş göletten (Altınyazı Baraj Gölü, Keban Baraj Gölü, Küçükçekmece Gölü, Karpuzlu Baraj Gölü, Kadıköy Baraj Gölü) toplanmıştır. Bu çalışmada, kerevitlerin farklı vücut bölümlerine zebra midyesinin tutunması belgelenmiştir. Cochran's Q test sonuçları; kerevitin değişik bölümlerine tutunan midye sayılarının farklılık gösterdiğini ortaya koydu (P=0.000) (P <0.001). Zebra midyelerin tatlısu ıstakozlarının üzerinde tutunma bölgeleri arasında farklılığın tespit edilmesinin konakçı açısından bazı olumsuzluklara neden olabileceği düşünülmektedir. Özellikle carapax bölgesinde yoğun tutunmaların; hareket (beslenme, çiftleşme, predatörlerden kaçınma ve barınma). Pleopodal bölgedeki midye bireyleri ise yumurta tutunumu ve taşınımını zorlaştırabilir. Bu çalışma Türkiye sularındaki *Astacus leptodactylus* üzerinde *Dreissena polymorpha*'nın varlığı ile ilgili ilk rapordur.

Anahtar kelimeler: *Dreissena polymorpha, Zebra midyesi, Astacus leptodactylus, vücut kolonizasyonu, Turkey*

INTRODUCTION

Invasions and their negative impact on native communities are considered as important threats to biodiversity (Geiger et al. 2005). Invasive species may change the behavior and habitat use of native species. Population structure, distribution and abundance of the species are affected by invasive species (Simon and Townsend, 2003). Zebra mussel, *Dreissena polymorpha* (Pallas, 1771) is an invasive Ponto-Caspian bivalve and has invaded the European's river and channel systems during the last two centuries (Gonçalves et al. 2013). It has been introduced to the northwestern Russia, the southern Scandinavia, Britain, Ireland and the north America (Gonçalves et al. 2013; Minchin and Rosenthal, 2002) and found the east into the western Asia and the south into Turkey (Mackie et al. 1989). These invasions cause dramatic changes on benthic ecology and have both negative and positive effects on benthic ecosystem. Zebra mussel increases colonies of gastropod, but

limits their body size. *D. polymorpha* has positive effect on deposit feeding taxa and negative effect on filter-feeding taxa (Ward and Ricciardi 2007).

Environmental and anthropogenic factors affect the spread of *D. polymorpha* in a new area. Water quality, alkalinity and high levels of calcium in fresh water increase the populations of zebra mussel juveniles. The levels of pH, temperature, and potassium in water positively affect colonization and population structure of the zebra mussel (Stier et al. 2001). The narrow-clawed crayfish, *Astacus leptodactylus* is a suitable substrate for the settlement of fouling organisms. Livings such as cyanobacteria and chlorophyta, ciliata, corixid eggs, mites, ostracods, oligochaetes, polychaetes, rhabdocoel flatworms, rotifers, Argulus eggs, bryozoans, and zebra mussels are settle down on crusts of freshwater crayfish (Alderman and Polglase 1988; Amato, 2001; Brazner and Jensen 2000; Cannon and Jennings 1987; Ďuriš et al. 2007; Edgerton et al. 2002; Lamanova, 1971; Romero and Jiménez 2002; Morado, 1995; Harlıoğlu, 1999; Sprague and Couch, 1971; Şaşı and Berber, 2005; Quaglio et al. 2006). The zebra mussels modify the natural movement of crayfish and they may affect the anthropogenic structure (Ahne, 1985; Feist et al. 2001; Molloy et al. 1997; Mühlegger et al. 2009). Due to the zebra mussels are colonized on crayfish, the specimens of crayfish spend more energy. These factors (feeding, nursing, mating, molting etc.) lead to a reduction in life chances (Brazner and Jensen 2000). This study was aimed to describe the effects of microhabits on the crusts of *A. leptodactylus* specimens found in two lakes and five dam lakes in Turkey.

MATERIALS AND METHODS

Sampling stations

A total of 228 specimens of *A. leptodactylus* were collected August 2009 - December 2009 from two lakes (Eğirdir Lake (38°3'24"N-30°51'58"E), Çıldır Lake 41°1'20"N-43°13'55"E) and five dam lake (Altınyazı Dam Lake (41°3'28"N-26°35'27"E), Keban Dam Lake (38°50'39"N-39°10'30"E), Küçükçekmece Lake (41o00'59"N-28o74'89"E), Karpuzlu Dam Lake (40°49'58"N-26°17'38"E), Kadıköy Dam Lake (40°47'38"N-26°46'26"E)) located of Turkey. Crayfish specimens were sampled using the single-entry two pints fyke nets of 34 mm mesh size by researchers. Sampled crayfish were separated to sex. Then, the body parts of crayfish were divided according to the zebra mussel's attachment. The zebra mussels were observed in the different parts of crayfish were photographed. It was observed whether the individuals of *D. polymorpha* removed from holding parts caused any damage on crusts of *A. leptodactylus* specimens. All crayfish specimens with the zebra mussels were proportionally recorded. Cochran Q test and MDS (Multidimensional Scaling Analysis) were applied to determine the chances in the cling aspects of *D. polymorpha* on the crusts of *A. leptodactylus*.

The Q statistic is distributed approximately as chi- square with (a-1) degree of freedom (Zar, 1999).

Cochran Q-test:

Test statistic for Cochran Q test:

$$Q = \frac{(a-1)\left(\sum_{i=1}^{a} G_i^2 - \frac{\left(\sum_{i=1}^{a} G_i\right)^2}{a}\right)}{\sum_{j=1}^{b} B_j - \frac{\sum_{j=1}^{b} B_j^2}{a}}$$

Where; a is the number of group, b is the number of block, Gi is the sum of the 1's in group I, Bj is the sum of the 1's in block j

RESULTS

A total of 228 individuals of crayfish individuals were captured from the different locations in Turkey. The body length range of the crayfish was between 99.28 and 146.14 mm. The mean body length of the crayfish is 138.02±2.063 mm in Altınyazı Dam Lake, 118.2±4.56 mm in Keban Dam Lake, 129.06±5.68 mm in Çıldır Lake, 115.28±1.61 mm in Küçükçekmece Lake, 116.39±4.44 mm in Eğirdir Lake, 133.46±2.68 mm in Karpuzlu Dam Lake and 125.72±2.61 mm in Kadıköy Dam Lake. Although the zebra mussels prefer the different body parts of crayfish, the carapace is the most attached part with a ratio of 25.6%. Totally, 28 specimens of the zebra mussel were observed on the carapace. The lowest rate (0.73%) was recorded on the oviducts of crayfish. Only one individual clung to the oviduct. The body lengths of *D. polymorpha* specimens clunged to the bodies of crayfish are mostly less than 5 mm (Table 1).

Table 1. The body part preference on the body of crayfish by *D. polymorpha*.

Sampling sites	N	N'	M	F	C	R	AD	CV	An	CD	T	P	O
Altınyazı Dam Lake	18	3	3	-	1	1	1	1	0	2	1	1	0
Keban Dam Lake	51	3	3	-	1	0	0	0	1	3	0	1	0
Çıldır Lake	34	3	3	-	2	1	1	0	1	1	0	1	0
K.Çekmece Dam Lake	26	12	2	10	5	5	5	0	4	8	7	0	0
Eğirdir Lake	48	1	-	1	1	1	0	0	1	0	0	0	0
Karpuzlu Dam Lake	24	13	10	3	3	1	3	2	0	3	6	10	0
Kadıköy Dam Lake	27	14		9	4	0	7	4	1	11	1	0	1
Total	228	49	26	23	17	9	17	7	8	28	15	13	1

N: number of crayfish examined, N': number of crayfish carrying *D. polymorpha*, M: Male, F: Female, C: Chela, R: Rostrum, AD: Abdomen, CV: Carapace ventral, An: Antenna, CD: Carapace dorsal, T: Telson, P: Pleiopod, O: Oviduct

Crayfish specimens show reactions with respect to the change of the body regions invaded by the zebra mussels (Fig. 3). Holding locations on the crayfish by the zebra mussels are no accidental for both sexes of *A. leptodactylus*. According to the results of the MDS analysis, sexuel difference in crayfish have a decisive effect about holding of zebra mussels. The body length of crayfishes in both sexes is decisive in choosing the region to be attached by *D. polymorpha* (Fig. 1, 2).

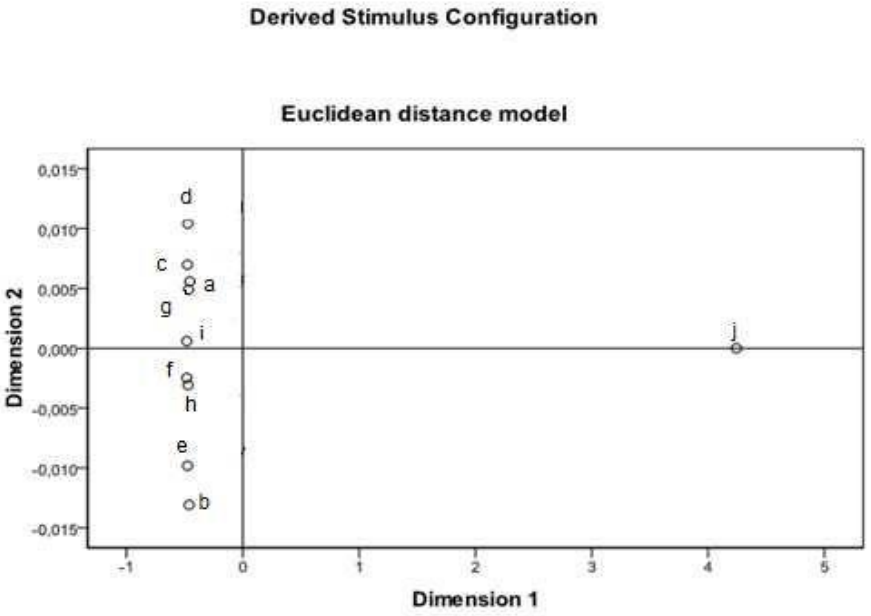

Figure 1. Multidimensional scaling analysis for female crayfish, a: carapace dorsal, b: abdomen, c: antenna, d: rostrum, e: carapace ventral, f: oviduct. g: chela, h: telson, I: pleopod; j: length.

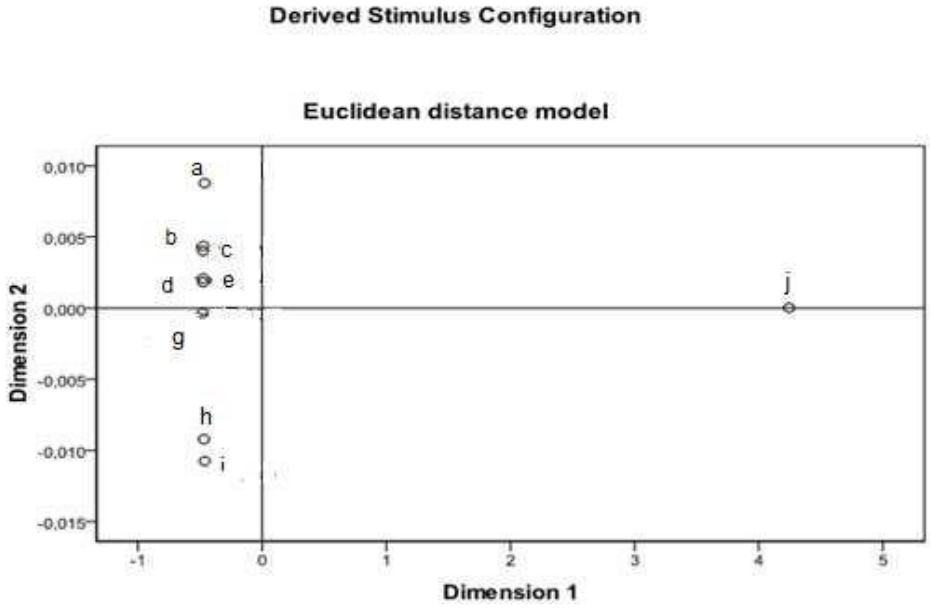

Figure 2. Multidimensional scaling analysis for male crayfish, a: carapace dorsal, b: abdomen, c: antenna, d: rostrum, e: carapace ventral, g: chela, h: telson, i: pleipod, j: length.

Figure 3. Zebra mussel specimens on the various body parts of crayfish, *A. leptodactylus*.(A, C, D, G: on carapace dorsal, B, E: on eyes, F: on carapace ventral and pleiopod, H: on cheliped)

DISCUSSION

D. polymorpha composes dense populations on any available hard substrate. Its veliger larvae settles predominantly on shells or near older zebra mussels (Griffiths et al. 1989). The specimens of *D. polymorpha* can also settle on a crayfish exoskeleton (Rogers et al. 2003). The first observation of *D. polymorpha* as host on crayfish was given by Laurent and Suscillon (1962) from male specimens of *D. polymorpha* on *O. limosus* observed in France. This phenomenon was confirmed for the Lake of Geneva (Lac Léman) by Laurent (1994) on *O. limosus*. Lamanova (1971) reported the zebra mussels on crust of crayfish, *Astacus leptodactylus cubanicus* co-inhabiting to the original distribution area of the zebra mussel.

Smietana (1996) reported the occurrence of the zebra mussels on *O. limosus* in the Dąbie Lake (Poland). Lajtner et al. (2005) reported the specimens of *D. polymorpha* attached to the carapace of crayfish, *O. limosus* in Croatia. While rare, a similar phenomenon has been observed in Lake Michigan (the North America) (Brazner and Jensen 2000) and the individuals of *D. polymorpha* occurred on the body of the rusty crayfish, *Orconectes rusticus*.

D. polymorpha was introduced to Czech waters via two directions (by the Danube and Morava rivers) (Beran, 2002). Petrusek *et al.* (2006) carried out a study on the invasion of *O. limosus* by *D. polymorpha* in about 60 localities of Czech Republic in 2003-2004. According to Petrusek et al. (2006), the carapace of specimens of crayfish were colonized by mussels and this manner shows that this phenomenon is rather rare. Besides, this unusual situation clarifies the lack of available hard substrates for larval veliger settlement, although other environmental variables such as nutrients, water temperature, and chemistry measured are optimal for the zebra mussel population. The high calcium ion concentration, pH, summer temperatures up to 25°C, absence of spring algal bloom and round-year clean water indicate moderate tropic relations. All these environmental variables are well comparable with existing knowledge on *D. polymorpha* requirements (McMahon, 1996; Bowman et al. 1998; Toomay et al. 2002).

The microhabitats used by the zebra mussel for colonization are interesting. Brazner and Jensen (2000) refer that *D. polymorpha* mostly colonized the carapace of *O. rusticus* rather than the parts of the body such as chelae, telson, and uropod. Ďuriš et al. (2007) reported that the mussel specimens of one-year old were concentrated mainly on the anterior dorsal surface of the abdomen, although some remained on both the ventral abdomen and telson, and the anterior dorsal of cephalothorax.

Due to the zebra mussels colonize on crayfish, crayfish specimens spend more energy. Besides, crayfish can be easily recognized by the predators (Brazner and Jensen 2000). Moreover, *D. polymorpha* clinked to the different parts of crayfish inhibit the movement, sight, prey capture, reproduction, and molting ability (Lamanova, 1971; Bauer, 1989; Brazner and Jensen 2000).

This study showed that the females of crayfish invaded by *D. polymorpha specimens* have no fertilized eggs and this is another negative effect. On the other hand, the zebra mussels prefer especially the bodies of crayfish on soft-bottoms (Ďuriš et al. 2007). Thus, due to erosion in inland water resources the bottom structure change and it can be soft (Quinn and Janssen 1989).

Toomey et al. (2002) reported that the small (5-10 mm) specimens (%55 of total population) of the zebra mussel are more navigate in their environment when compared to bigger individuals (10-20 mm). Toomey et al. (2002) concluded that the reason of this is the small mussels produce the smaller byssus and these small specimens leave more often from their substrate. In the present study it was recorded that the most of *D. polymorpha* clinked to crayfish in this study are small.

According to previous studies, the most of *D. polymorpha* attached to the crayfish had a length that is less than 5 mm and these specimens were younger than 1 year old (Ackerman et al. 1994; Ďuriš et al. 2007).

When the regional distributions of the species are considered approximately 50% of crayfish captured in Kadıköy Dam Lake, Karpuzlu Dam Lake, and Küçükçekmece Dam Lake have zebra mussels on them. Due to intensive fisheries activities in the areas cited, we think that larvae of Zebra mussels may be transported to near lake systems by fishing gears. In Turkey, transport of fishing gears used in inland water fishery is frequently observed between the lakes, ponds and reservoirs. This manner facilitates the transport of many disease agents and fouling organisms between locations. Also, uncontrolled fish and freshwater lobster infestations can cause similar results. Especially *Dreissena polymorpha* can stay alive for a long time outside of water (Altınayer et al., 2001). In particular, the research and fishing activities carried out by fishermen in the areas close to each other in Thrace Region have facilitated the transport of *Dreissena polymorpha*.

Our statistical results shows, that difference of holding regions on crayfish specimens is so important, regarding the cling ability of the mussels on the body parts of the crayfish. Furthermore, the clinging regions of the mussels on the crayfish's body sections are no accidental. The females of crayfish exhibit mostly the keeping behavior during their nest periods and are less active. Therefore, the zebra mussels have a better hold to the female crayfish. Differences between the sticking places of the zebra mussels were also observed (Duris et al., 2007). Ďuriš et al. (2007) stated that these differences are based on the parts cited are easily cleaned by individual crayfish.

Although the zebra mussels are consumed by crayfish, they have many unfavorable effects on crayfish. Consequently, the similar studies on invasion of Zebra mussel in various

geographical areas of Turkey should be carried out to have more detailed information on the subject in future.

Studies on its distribution and invasion should be increased to have more information about ecological effects of *Dreissena polymorpha*. In DNA studies, the origins, differences and similarities of the populations at locations can be determined (Rohfritsch et al., 2013). Recently, it has been determined which populations are present in geographical areas invaded by *D. polymorpha*. In addition, it can be determined from which gene pool these populations are distributed (Lalias et al., 2015; Anglès d'Auriac et al., 2017).

Thanks to the results of such studies, more knowledge is available about limiting effects of characteristics such as growth and reproduction of Zebra mussels on crayfish populations and interaction of species with each other. This present work deals with the presence of Zebra mussels on crayfish specimens.

CONCLUSION

Because of its role in the food chain, *Dreissena polymorpha* has positive effects on feeding, growing and population structure of many species. Yet, *D. polymorpha* is important to increase water clarity because of its filtration feature. Due to their high adaptation to environmental conditions and rapid reproduction, *D. polymorpha* specimens have very negative effects on other species in reservoirs. For that reason, an action plan on this species which causes billions of dollars of damage in the world should be prepared. Particularly, the methods (biological, chemical and physical) blocking the distribution of *D. polymorpha* should be determined. Furthermore, informative studies on reservoirs should be made.

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

The catching efficiency of light traps and morphometric characteristics of the native species from Barito river, Indonesia

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Abstract: Various fishing gears are being used for harvesting fish and shrimp in Barito River, Indonesia. However, the use of lighted traps is still poorly studied. A set of fishing gears associated with light emitting diode (LED) and incandescent lamps was used as sampling tools. The trials consisted of 113-trap hauls/lamp type using 1-night submersion time of 15 h. The light traps were standardized to a catch per unit effort (CPUE). The light traps sampling accounted for 397 specimens assigned to 11 species of 7 families. There was highly significant difference in the number of catches between shrimp and fish (P<0.001). Shrimp sizes ranged of 24–85 mm total length and 0.3–10 g weight, while for fish 27–310 mm and 0.4–101 g. Yellow and red LED light traps seemed to be effective in catching Macrobrachium rosenbergii as well as white LED ones for Oxyeleotris marmorata. Both species solely showed positive allometric growth type (b = 3.42 and 3.28), while other species displayed negative allometric growth pattern (b = 0.82–2.71) with the condition factor (K) values ranged of 0.36–1.56. A new native species Macrobrachium sp. were found and considered as multichromatic species. The size and shape of the light traps did not affect number of catch. The mean CPUEs for incandescent and LED light traps were 0.07±0.06 and 0.13±0.20 fish net-1 night-1. No significant difference in the relative catching efficiency between both light trap types was observed.

Keywords: *Allometric growth, incandescent lamp, LED lamp, Macrobrachium sp., condition factor, traps, Barito River*

INTRODUCTION

South Kalimantan is one of the five provinces in Kalimantan (formerly called Borneo) with capital city of Banjarmasin. It is bordered with East Kalimantan at the north, with Makassar Strait at the east, with Java Sea at the south and with West Kalimantan and Central Kalimantan at the west. South Kalimantan is also often known as Province with a thousand-river where the Barito River is the largest and the longest river in Indonesia with more than 6.000 km long. Barito River has the depths of 8–10 m and a width of 400–750 m. It is the main river that is mutually associated with creeks and swamps vicinity; about 90% are still affected by the tidal Java Sea. The Barito River allows for transportation, drinking water sources, floating market and fisheries activities. A great attention has been devoted by academicians and researchers to expose the characteristic habitats and fish species in the river (MacKinnon et al., 1996; Prasetyo et al., 2005; Asyari, 2006), the abundance and diversity of plankton types (Rahman, 2008), as well as fishing activities (Utomo and Prasetyo, 2005; Rupawan, 2006; Utomo and Asyari, 2007; Rosadi et al., 2016).

Local people usually collect fish and shrimp in Barito River using hook and line, gill net, lift net and traps, among others. In the past, a total of 350 species was found in this river, but now it is estimated only about 150 species (Hortle, 1995). Prasetyo and Asyari (2003) reported that the number of fish species in this river was to become 140 species. Some important fish species like Arowana *Scleropages formosus*, clown knifefish *Notopterus chitala*, mad barb *Leptobarbus hoevenii* and the greater bony lipped barb *Osteocheilus melanopleura* seemed to disappear from the river. They are extremely vulnerable to the destructive fishing as well as water pollution from plywood industry and dockyard. Therefore, fishing technology development that environmentally friendly and efficient, should be promoted. The use of lights would be a promising option for responsible fishing practices.

Light trap is one of the good examples for collecting many species of different habitats when other fishing gear like towed net are not useful (Brogan, 1994; Hernandez and Shaw, 2003). The LED lamp is one of the most recent advance lamps being promoted in light fishing-based fisheries (Yamashita et al., 2012; Hua and Xing 2013; Mills et al., 2014; Puspito et al., 2015) instead of incandescent, halogen, and metal halide illuminations (Baskoro et al., 2002; Matsushita et al., 2012) or chemical light sticks (Kissick, 1993; Marchetti et al., 2004). As for the difference in light sources, each lamp has its unique optics and intensity output even same electrical power use.

The use of lighted traps in Barito River is still poorly studied (Ahmadi, 2012). Therefore, several potential biases should be

deliberated before light traps ready to be used quantitatively. We performed this study to address the following questions, e.g. how effective traps with low-powered lights applied in highly turbid water? What species will be attracted to the light traps? Are individual species collected in different numbers using specific colors/relative intensities of light? Do size and shape of the light trap affect number of catch? We updated and extended database on the light traps testing to get more knowledge in this area of study. The information obtained may be useful for both commercial purpose and fisheries management.

MATERIALS AND METHODS

Study area

Trapping experiments with lights were carried out in Barito River of South Kalimantan Province (Figure 1), located on 03°19'S 114°34'E and 03°20'S 114°36'E determined with the GPS 60 (Garmin Co. Ltd., Taiwan).

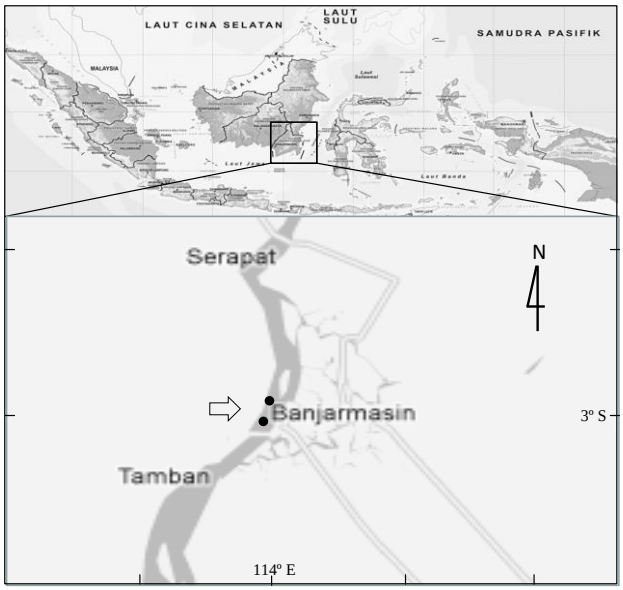

Figure 1. The map showing the study sites for trapping experiment with lights in Barito River

The experimental conditions encompassed highly turbid water (total suspended solids ranged from 182–567 mg L^{-1}), slow flowing, blocked water, and rarely vegetated habitat with water depths from 2–4 m. The transparency of water varied from 45 to 55 cm (Secchi-disk reading at noon). The surface water temperature was recorded daily and ranged from 27 to 29 °C throughout the trials. The experimental designs were described as follows:

Traps and lamps used

Experiment 1: Collapsible trap fishing with different light intensities of incandescent lamps. The four collapsible box-shaped traps were constructed with iron rod frame (80×60×28 cm), covered with polyethylene netting and had two slit all-web entrances at the ends consisting of two netting panels forming a horizontal "V" with 58 cm slit at the narrow end (Kagotoku Shiroyama Kenmousha, Ise, Japan). Each of the four traps has one incandescent lamp. The lamps used were (i) Japanese squid fishing tackles (Yo-zuri Co. Ltd. Japan) consisting of (squid fishing light/SIL–1 (10×3 cm; 0.45 W) and SIL-2 (16×3 cm; 0.9 W) powered by 1.5 and 3.0 V dry-cell batteries respectively, and, (ii) acrylic box-shaped lamps consisting of DIM (dimmed) and LIGHT, of which a 4.5 W lamp was placed inside a waterproof acrylic box (14□8□15 cm) generated by 6 V dry-cell batteries. For DIM, the walls of the box were lined with a white-paper. Light intensity of each lamp was 215 lx (SIL–1), 398 lx (SIL–2), 1010 lx (DIM) and 2050 lx (LIGHT) determined in air using an illuminometer (IM-2D, Topcon, Ltd. Tokyo).

Experiment 2: Collapsible trap fishing with different coloured incandescent or LED lamps. Five collapsible box-shaped traps were modified in their funnel entrances by replacing the two slit all-web entrances at the ends with two open slackness nylon monofilaments 23 mm mesh size. Additional net bag was placed at the bottom of the trap to prevent juveniles from dropping. Each of the five traps was assigned with one colour of LED Torpedo flashers (24×5 cm, Yuli Co. Ltd. China) or one colour of incandescent lamps YL/YS–1 (22×5 cm, Yuli Co. Ltd. China), consisting of blue, green, yellow, red and extra white.

Experiment 3: Wire-square trap fishing with different coloured LED lamps. Five wire-square traps were made of iron-wire frame (25×25×22 cm), covered with black 3/5 inch hexagonal mesh wire (16 gauge PVC-coated wire), and had four entry funnels located on each side with a 5 cm inside ring entrance. A trap door on top (23×24 cm) was used to release the catches. Each of the five traps was assigned with one colour of LEDs. Each colour (blue, green, yellow, red and extra white) was placed inside the squid lamp case (SIL–2) powered by 3 V dry-cell batteries (0.06 W). Light intensity of LEDs was set at equal quanta intensities by placing a grey fibreglass window screen (Dio Chemicals, Ltd., Tokyo) inside of the lamp to standardize the lights used.

Experiment 4: The acrylic-square trap fishing with different coloured LED lamps for sampling juvenile species. Five acrylic-square traps were constructed with 3 mm acrylic plates and had 8 entrance slits with 1 cm wide opening on each side. The acrylic plates were attached vertically with two sheets of PVC (24×24 cm) top-down and reinforced with four iron rods (25 cm long) on each corner. The trap was equipped with two floats at the surface, four wire-stairways (23×23 cm) attached to lower part of PVC sheet on each side and a collection wire-jar at the bottom (18×18×7 cm). A lamp was placed downright in the middle of trap. Each of the five traps was assigned with one colour of LEDs following the same procedure in Experiment 1. Traps and lamps used in the present study are shown in Fig 2.

Experiment 5: Various traps fishing with the white LED and incandescent lamps. Four traps with different sizes and shapes were investigated. These traps were: (1) PVC box-shaped trap:

PVC rod frame (67×53×20 cm) covered with black 150 mm hexagonal mesh wire (16 gauge PVC-coated wires); ten entry funnels are located on each side of the trap with a 5.2 cm inside ring entrance; (2) Wire fish trap: heart-shaped, 45 cm high and 40 cm wide, with 1.2 cm square mesh wire and 2.5 cm wide opening of entrance slit; (3) Bamboo fish trap: heart-shaped, 42 cm high and 30 cm wide with horizontal gap 1.5 cm and 2.5 cm wide opening of entrance slit; and (4) Minnow nets: cylindrical-shaped, 60 cm long by 30 cm wide, covered with 1.3 cm polyethylene netting and 7 cm inside the ring entrance. Each of the four traps was associated with 0.06 W white LED or 1.5 W incandescent squid fishing lamp (SIL–2; Experiment 1).

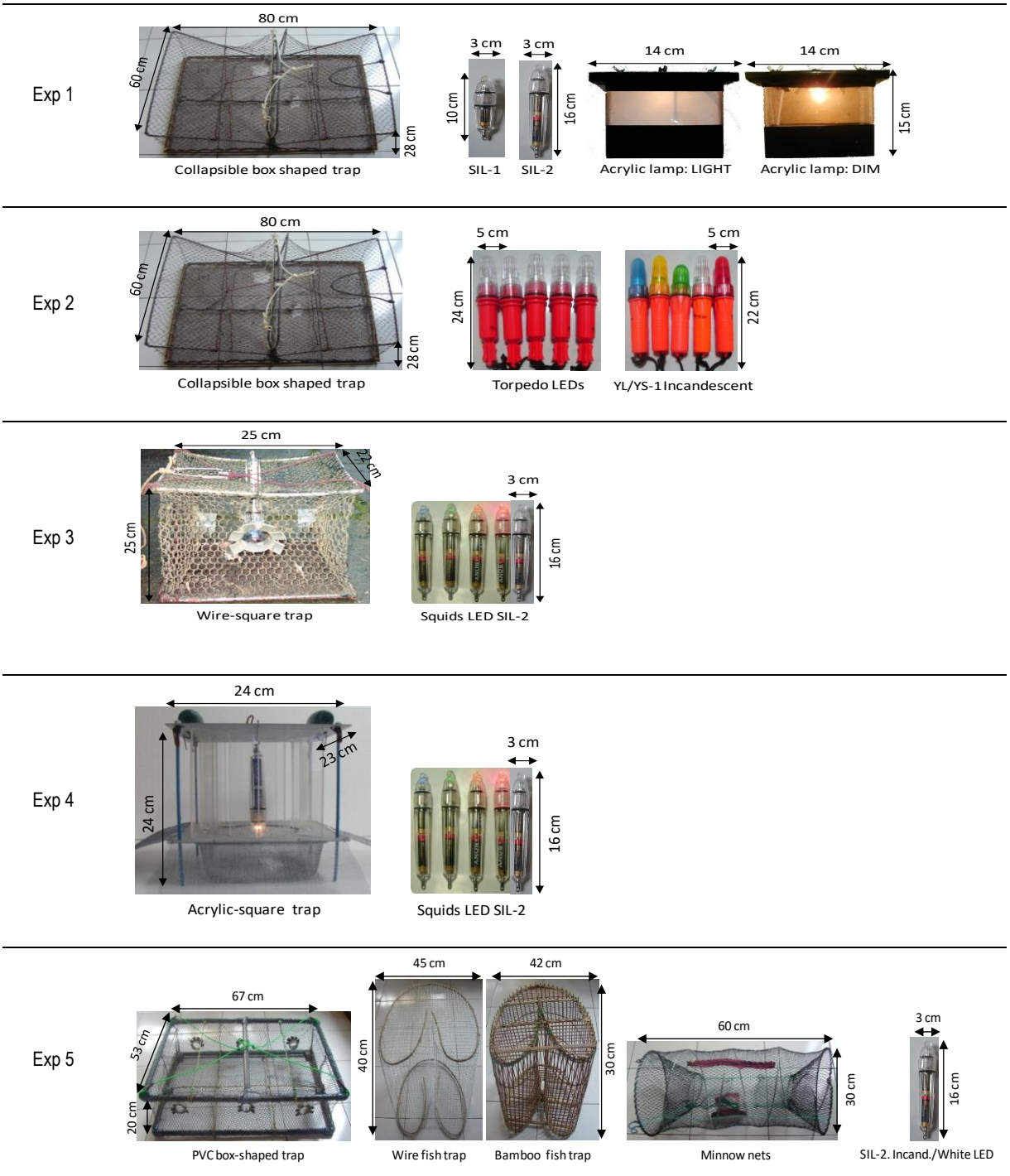

Figure 2. The traps and lamps used to sample shrimps and fish from Barito River

Sampling and data analysis

The light traps with constant light pattern were deployed randomly at the bottom of the riverbank and illumination began 1 h before sunset and retrieved the next morning. On each sampling date, each trap was separated from the others about 2.5 m to minimize any significant light contamination between traps. Such trap arrangement was considered sufficient for the existing turbidity conditions and illumination intensities. Each experimental group was repeatedly used for 6-night fishing. The trials consisted of 113-trap hauls/lamp type using 1-night soaking time of 15 h. Both incandescent and LED light traps were standardized to a catch per unit effort (*CPUE*) of total catch per night-trip. After retrieval, the catches were counted and identified for species and sex, and measured for total length (TL) in mm and weight (W) in g.

The length-weight relationships of species were estimated by using the equation: $W = {}_aL^b$. The parameters *a* (intercept) and *b* (slope) were estimated by linear regression of the transformed equation: log W = log a + b * log L. The *b* values were calculated to find out whether the species was growing allometrically or isometrically. The exponent *b* values of length-weight relationship of species were compared to the hypothetical value of 3. When the *b* value is greater than 3 indicating positive allometric, less than 3 is negative allometric, and equal to 3 is isometric (Anderson and Neumann, 1996).

Positive allometic means that weight increases more than length. Negative allometric means that length increases more than weight. Isometric means that length and weight are growing at the same rate. The parameter *b* is also known as allometry coefficient that has an important biological meaning, indicating the rate of weight gain relative to growth in length. The condition factor of species was calculated using Fulton's condition factor, $K = 100W/L^3$ (Gayanilo and Pauly, 1997), where: L = total length (cm) and W = weight (g). In addition, the Mann-Whitney test was employed to compare the number of catch between two light traps. Kruskal-Wallis test was used to investigate if there were significant differences in the total catches among the lighted traps. A post-hoc analysis test was performed using the Multiple Comparison to see which catch differed significantly among the traps. Lastly the t-test was used to evaluate the relative catching efficiency of incandescent and LED light traps across all trials. All tests were analysed at the 0.05 level of significance using SPSS-16 software.

RESULTS

A total of 397 native specimens belong to 11 species comprised 344 shrimps (1 family) and 53 fishes (6 families) collected from a series of trapping experiments with lights in Barito River as presented in Table 1.

Table 1. Catch species composition sampled from Barito River using the lighted traps.

Group/Family	Species	Incandescent lamps				LED lamps		Total catch
		Ordinary	%	Colour	%	Colour	%	
Shrimps								**344**
Palaemonidae	*Macrobrachium* sp	65	19	51	15	223	66	339
Palaemonidae	*M. rosenbergii*	0	0	1	20	4	80	5
Fish								**53**
Gobiidae	*Glossogobius giuris*	5	26	4	21	10	53	19
Eleotridae	*Oxyeoleotris urophthalmus*	4	24	0	0	13	76	17
Eleotridae	*Oxyeoleotris marmorata*	1	14	1	14	5	71	7
Pleuronectidae	*Flounder pleuronectes*	2	67	1	33	0	0	3
Mastacembelidae	*Mastacembelus erythrotaenia*	1	33	1	33	1	33	3
Cyprinidae	*Puntioplites bulu*	1	50	0	0	1	50	2
Cyprinidae	*Osteochilus melanopleura*	0	0	1	100	0	0	1
Bagridae	*Mystus gulio*	1	100	0	0	0	0	1
Crab								**2**
Parathelphusidae	*Parathelphusa convexa*	0	0	0	0	2	100	2

The shrimp was dominated by the long arms shrimp *Macrobrachium* sp. (98.55 %) with the sizes ranged of 24–85 mm TL (58.1±15.15 mm) and 0.3–10 g W (3.2±2.57 g), and the rest of catch was giant river prawn *M. rosenbergii* (1.45%) with the sizes ranged of 71–75 mm TL (56.8±17.63 mm) and 0.5–5 g (2.6±2.27 g). The fish comprised tank goby *Glossogobius giuris* (35.85 %, 135.7±19.68 mm TL, and 31.3±9.08 g), Sinuous gudgeon *Oxyeleotris urophthalmus* (32.08 %, 123.6±42.06 mm TL, and 29.5±23.48 g), Marble gudgeon *Oxyeleotris marmorata* (13.21 %, 140.5±23.35 mm TL, and 41.0±22.82 g), Flatfish *Flounder pleuronectes* (5.66 %, 100.7±37.90 mm TL and 17.0±14.11 g), Spotted fire eel *Mastacembelus erythrotaenia* (5.66%, 278.3±38.84 mm TL, and 76.7±22.05 g), Bulu barb *Puntioplites bulu* (3.77 %, 70.1±14.14 mm TL and 2.5±2.12 g), greater bony lipped barb *Osteochilus melanopleura* (1.89 %, 170 mm TL, and 64 g), Long whiskers catfish *Mystus gulio* (1.92 %, 40 mm, and 1 g). The sizes of fish captured varied from 27 to 310 mm TL and from 0.4 to 101 g. The body sizes of each species caught are given in Table 2.The four collapsible box-shaped traps fishing

with different light intensities of incandescent lamps in Experiment 1 were evaluated. A total of 46 specimens were collected from this trial. The *CPUEs* of individual trap ranged from 0.14±0.16 to 0.44±0.46 fish net^{-1} night^{-1} (Table 3). There was no significant difference in the total number of catches among the four traps (χ^2=1.184, df=3, *P*>0.05). The overall, the traps had some success in catching *Macrobrachium* sp (total 39), *Glossogobius giuris* (5), *Mystus gulio* (1) and *Mastacembelus erythrotaenia* (1). The LIGHT and DIM traps collected the same number of *Macrobrachium* sp. (13) were observed. The average total length of *Macrobrachium* sp ranged from 63.8±21.24 mm to 73.3±3.06 mm, while the average weight varied from 5.4±3.84 g to 6.4±2.08 g.

The five collapsible box-shaped traps containing different coloured incandescent or LED lamps were investigated in Experiment 2. The light traps sampling accounted for 211 specimens (total 60 for incandescent lamp and 151 for LED lamp). The *CPUEs* of incandescent light trap ranged from 0.78±0.51 to 2.78±1.39 fish net^{-1} night^{-1}, while for LED light trap ranged from 3.00±4.33 to 3.67±6.06 fish net^{-1} night^{-1} (Table 3). There were no statistically significant differences in the total number of catches among the five traps (χ^2=2.970, df=4, *P*>0.05). The colour of lights had strong effects on the number of shrimp and fish collected especially *Macrobrachium* sp. and *Glossogobius giuris*. The use of traps with coloured LED lamps seemed to be more effective in catching *Macrobrachium* sp. (total 138) than incandescent ones (total 51) (T=1.412, *P*<0.05). The average weight of catches for incandescent and LED lighted traps was 5.22±11.64 g and 5.32±13.17 g respectively. Furthermore, sex ratio of male to female *Macrobrachium* sp. was 1:2.3 indicating many more females caught than males. We collected 48 egg-bearing females during the whole sampling period. From the length measurement, male chelae were 1.5 times of its total length and 1.3 times for females of the same body size.

Table 2. Descriptive statistic of length-weight relationships of catch species sampled from Barito River. N = number of catch, TL = total length, W = weight, a = intercept, b = slope, R^2 = coefficient of determination, K = condition factor.

Species	N	TL (mm)			W (g)			W/TL	a	b	R^2	K
		Min	Max	Mean±SD	Min	Max	Mean±SD					
Macrobrachium sp	339	24	85	58.1±15.15	0.3	10	3.2±2.57	0.06	10^{-5}	3.04	0.85	1.31
Macrobrachium rosenbergii	5	38	74	56.8±17.63	0.5	5	2.6±2.27	0.05	2×10^{-6}	3.42	0.97	1.05
Glossogobius giuris	19	95	165	135.7±19.68	9	44	31.3±9.08	0.23	10^{-4}	2.51	0.90	1.15
Oxyeoleotris urophthalmus	17	27	194	123.6±42.06	0.4	90	29.5±23.48	0.24	5×10^{-5}	2.71	0.99	1.29
Oxyeoleotris marmorata	7	115	172	140.5±23.35	19	77	41.0±22.82	0.29	3×10^{-6}	3.28	0.99	1.36
Flounder pleuronectes	3	60	135	100.7±37.90	4	32	17.0±14.11	0.17	10^{-4}	2.51	0.99	1.46
Mastacembelus erythrotaenia	3	235	310	278.3±38.84	58	101	76.7±22.05	0.28	4×10^{-3}	1.75	0.81	0.36
Puntioplites bulu	2	60	80	70.1±14.14	2	5	2.5±2.12	0.04	2.84	0.82	1.00	0.95
Osteochilus melanopleura	1	170	170	170	64	64	64	0.38	N/A	N/A	N/A	1.30
Mystus gulio	1	40	40	40	1	1	1	0.03	N/A	N/A	N/A	1.56

The similar results were demonstrated in Experiment 3. There were no significant differences in the total number of catches among the five wire-square traps with different coloured LED lamps (χ^2=1.368, df=4, *P*>0.05). A total of 82 individuals collected from lighted traps. The *CPUEs* of individual trap ranged from 0.31±0.19 to 0.50±0.60 fish net^{-1} night^{-1} (Table 3). The shrimp was dominated by *Macrobrachium* sp. (total 65), while the fish was represented by *Oxyeleotris urophthalmus* (10). The least number of catch was *Glossogobius giuris* (1) caught by red trap. The average weight of catches was 7.84±9.11 g.

Unexpected results were found in Experiment 4 where the trials with the five acrylic-square traps containing different coloured LED lamps had no success in catching both fish and shrimp juveniles. The only three juveniles of *Macrobrachium* sp. were collected from the blue and yellow light traps due to the considerable breakage on the entrance slits of traps, which allowed the animals to escape from the traps. The mean weight of the catches was 2.27±2.37 g. Total *CPUE* obtained was 0.60±0.00 shrimp net^{-1} night^{-1} (Table 3).

The performance of PVC box-shaped trap, wire fish trap, bamboo fish trap, and minnow nets associated with incandescent lamp (SIL–2) or white LED was examined in Experiment 5. There were no significant differences in the total catch among the respective four traps (χ^2_{LED}=1.737, χ^2_{INC}=6.978, df=3, *P*>0.05). Overall, the minnow nets were most effective among the traps (total 14 for LED lighted trap and 20 for incandescent ones) especially for catching *Macrobrachium* sp. The other traps collected less number of catch for all trials. The mean weight of catches for LED and incandescent light traps were 7.33±8.02 g and 7.15±8.63 g respectively. The mean *CPUEs* of incandescent light trap ranged from 2.22±1.95 to 0.89±0.51 fish net^{-1} night^{-1}, while for LED light trap ranged from 0.22±0.19 to 1.56±0.19 fish net^{-1} night^{-1} (Table 3).

Table 3. Total catch and Mean±SD of *CPUEs* of each light trap group by experimental order

Exp-1	Total			**Incandescent Lamp**			
	catch	SIL-1	SIL-2	DIM	LIGHT	Total	
Total	46	1.83	0.83	2.33	2.67	1.92	
Mean *CPUE*	8±7.20	0.31±0.27	0.14±0.16	0.39±0.50	0.44±0.46	0.32±0.30	
Exp-2	Total			**Incandescent Lamp**			
	catch	Blue	Green	Yellow	Red	White	Total
Total	60	2.33	4.67	8.33	2.33	2.33	4.00
Mean *CPUE*	20±11.53	0.78±0.77	1.56±1.07	2.78±1.39	0.78±0.77	0.78±0.51	1.33±0.77
Exp-2	Total			**LED Lamp**			
	catch	Blue	Green	Yellow	Red	White	Total
Total	151	11.00	10.33	9.00	10.33	9.67	10.07
Mean *CPUE*	50±67.31	3.67±6.06	3.44±4.03	3.00±4.33	3.44±3.98	3.22±4.22	3.36±4.49
Exp-3	Total			**LED Lamp**			
	catch	Blue	Green	Yellow	Red	White	Total
Total	82	1.83	2.83	3.00	3.00	3.00	2.73
Mean *CPUE*	14±8,24	0.31±0.19	0.47±0.52	0.50±0.26	0.50±0.60	0.50±0.47	0.46±0.27
Exp-4	Total			**LED Lamp**			
	catch	Blue	Green	Yellow	Red	White	Total
Total	3	1.00	-	2.00	-	-	0.60
Mean *CPUE*	3±0.00	1.00±0.00	-	2.00±0.00	-	-	0.60±0.00
Exp-5	Total			**Incandescent Lamp**			
	catch	Box-shaped trap	Wire-stage trap	Bamboo-stage trap	Minnow nets	Total	
Total	11	2.00	2.67	-	6.67	2.83	
Mean *CPUE*	11±3.21	0.67±1.15	0.89±0.51	-	2.22±1.95	0.94±0.27	
Exp-5	Total			**White LED Lamp**			
	catch	Box-shaped trap	Wire-stage trap	Bamboo-stage trap	Minnow nets	Total	
Total	7	0.67	1.33	0.67	4.67	1.83	
Mean *CPUE*	7±1.53	0.22±0.38	0.44±0.19	0.22±0.19	1.56±0.19	0.61±0.13	

Table 4. The daily total catch and *CPUEs* of Incandescent and LED light traps

Sampling Day	**Daily Total Catch**		**Daily *CPUE***	
	Incandescent	**LED**	**Incandescent**	**LED**
1	18	28	0.115	0.167
2	15	16	0.096	0.095
3	7	16	0.045	0.095
4	3	6	0.019	0.036
5	2	8	0.013	0.048
6	1	8	0.006	0.048
7	9	6	0.058	0.036
8	15	9	0.096	0.054
9	10	7	0.064	0.042
10	9	14	0.058	0.083
11	19	9	0.122	0.054
12	32	128	0.205	0.762
Total	140	255	0.897	1.518
Mean ± SD	12 ± 8.79	21 ± 34.20	0.07 ± 0.06	0.13 ± 0.20
Σ no of trap	13	14	-	-
Σ fishing trial	12	12	-	-

The results clearly confirmed that *Macrobrachium* sp. showed isometric growth type (*b*=3.04), while *M. rosenbergii* exhibited positive allometric growth pattern (*b*=3.42). The R^2 values of 0.85 and 0.97 indicated that variations in weight of shrimp were influenced by variation in the length of shrimp by 85% and 97% respectively. The K values (condition factor) for both shrimps were 1.31 and 1.05 respectively. Among the fish group, the only *Oxyeleotris marmorata* displayed positive allometric growth pattern (*b*=3.28, K=1.36), while the other fish species showed negative allometric growth pattern (*b*=1.75–2.71 and K = 0.36–1.56). The R^2 values ranged of 0.81–1.00 which meant that variations in weight of fish were influenced by variation in the length of fish by 81–100 % (Table 2).

The relationship between the relative catching efficiency and the ratio of *CPUEs* to lamp type of incandescent and LED light traps were expressed in the following logarithmic equations: y = 0.1672Ln(x)+1.019 (R^2=0.8932) and y = 0.1777Ln(x)+0.9847 (R^2=0.7266), respectively (Figure 3). Although the mean *CPUE* of LED light traps (0.13±0.20 fish net^{-1} night^{-1}) was higher than that of incandescent light traps (0.07±0.06 fish net^{-1} night^{-1}), however, no statistically significant difference was observed (t=-0.848, df=22, *P*<0.05). The comparative daily total catch and *CPUE* of both light traps are given in Table 4

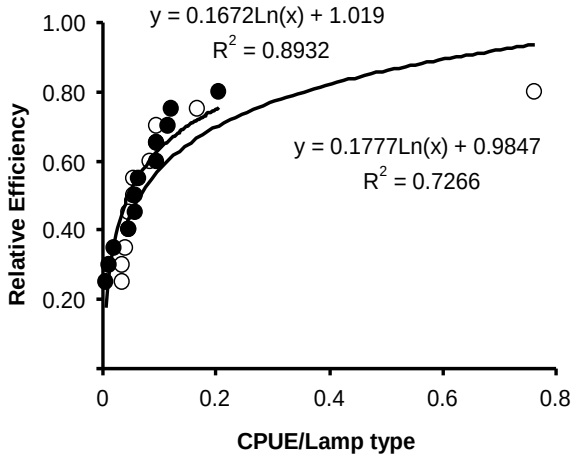

Figure 3. The relationship between relative catching efficiency and the ratio of daily *CPUE* to lamp type of incandescent (●) and LED (◯) light traps

DISCUSSION

Fish and other aquatic species have colour receptions in their eyes that could recognize various intensities of light that lead to their aggregation in the lighted areas (Arimoto et al., 2010). The present study clearly demonstrates that trapping with low-powered underwater lamps are adaptable applicable in high turbid water of Barito River. Data on phototactic response showed that the colours or relative light intensity of incandescent and LED lamps uses in this study had strong effects on the number of catches sampled, where LED light traps are outperformed to the incandescent ones. It is a good starting point in view of commercial purposes where yellow and red LED light traps seemed to be effective in catching *M. rosenbergii*, as well as white ones for catching *Oxyeleotris marmorata*. In this case, *M. rosenbergii* were less active in responding to the lights compared to *Macrobrachium* sp. of the same genus. Among the catches, the only *M. rosenbergii* (*b*=3.42) and *Oxyeleotris marmorata* (*b*=3.28) showed positive allometric growth type. This means that the both species are considered healthy and in good shape. Kunda et al. (2008) reported isometric growth (*b*=3.075) of *M. rosenbergii* in rice field of India. While Sampaio and Valenti (1996) observed high *b* value of 3.43 (positive allometric) for *M. rosenbergii* under culture environment in Brazil. Wider ranges of size need to be investigated in order to determine how the relationships change with shrimp size or life stage (Chow and Sandifer, 1991). The ratios of W/TL for *Macrobrachium* sp. (0.06) and *M. rosenbergii* (0.05) in the present study (Table 5) were more or less found in other shrimp species from different geographical areas (Okayi and Iyorkyaa, 2004; Nwosu and Wolfi, 2006; Lalrinsanga et al., 2012; Gopalakrishnan et al., 2014; Gautam et al., 2014; Wong et al., 2015). Compared to other species such as *Macrobrachium felicinium* and *Atya gabonensis* in Nigeria (Okayi and Iyorkyaa (2004), *Metapenaeus monoceros* and *Penaeus monodon* in India (Dineshbabu, 2006; Gopalakrishnan et al., 2014), *Macrobrachium lamarrei* in Bangladesh (Ara et al., 2014) and *Acetes indicus* in Malaysia (Wong et al., 2015), these ratios were lower than those presented in this research.

In the current study, the *b* values were generally in good agreement with the results obtained from other geographical areas (Table 5). Variation in *b* values of animals living in this river will also help understand why certain species are able to survive in the waters. For example, *Macrobrachium* sp. was abundantly found in this river and they could be considered as multichromatic species because of showing photopositive for all colours. They are most likely support higher biomass in the aquatic food web as the whole. Experimental evidence showed that female-biased attraction to the lights. The sex ratio of male to female was 1 : 1.1, indicating that females were more responsive to the tested colours than males over trapping experiment periods. This implies that light traps could be potentially used for broodstock purposes, especially to collect them from the wild. About 40% of total female caught by light traps was the egg-bearing females. In many cases, females carrying the eggs are usually inactive during the breeding season and are not attracted to food or bait (Richards et al., 1996; Holdich, 2002; Faller et al., 2006), however, the light traps can do. As for comparison, it is interestingly noted that at the same body size (72 mm), the male of *Macrobrachium* sp. (112 mm long) has chelae twice longer than that of *M. Australiense* (51 mm; Short, 2000).

Table 5. Comparative parameters of length and weight relationship of *Macrobrachium* sp. from Barito River and other shrimp species from different geographical areas. N = number of catch, TL = total length, W = weight, a = intercept, b = slope, R^2 = coefficient of determination, A+ = positive allometric, A- = negative allometric, I = isometric

Species (pooled)	N	W/TL	a	b	R^2	Growth Type	Country	References
Macrobrachium sp	339	0.06	10^{-5}	3.040	0.850	I	Indonesia	Present study
M. rosenbergii	5	0.05	$2x10^{-6}$	3.420	0.970	A+	Indonesia	Present study
M. rosenbergii	733	0.00	$8.8x10^{-2}$	3.389	0.949	A+	India	Lalrinsanga et al. (2012)
M. lamarrei	1018	0.13	10^{-3}	2.845	0.945	A-	Bangladesh	Ara et al. (2014)
M. felicinium	55	1.04	$1.6x10^{-3}$	3.003	0.998	I	Nigeria	Okayi & Iyorkyaa (2004)
Atya gabonensis	150	1.74	$1.4x10^{-2}$	2.989	0.990	I	Nigeria	Okayi & Iyorkyaa (2004)
M. vollenhovenii	1069	0.00	0.000	3.483	0.993	A+	Nigeria	Nwosu & Wolfi (2006)
Metapenaeus monoceros	363	0.34	$6x10^{-3}$	3.085	0.907	I	India	Dineshbabu (2006)
Litopenaeus vannamei	313	0.02	$6x10^{-4}$	3.458	0.999	A+	India	Gautam et al. (2014)
Penaeus monodon	633	0.66	-1.340	2.609	0.778	A-	India	Uddin et al. (2016)
P. monodon	873	1.59	-1.811	2.721	0.707	A-	India	Gopalakrishnan et al. (2014)
P. monodon	249	0.18	$4x10^{-3}$	3.218	0.966	I	Sri Langka	Piratheepa et al. (2013)
Acetes Sibogae	53	0.14	0.001	3.403	0.931	A+	Malaysia	Wong et al. (2015)
Acetes japonicas	74	0.12	0.005	2.883	0.850	A-	Malaysia	Wong et al. (2015)
Acetes serulatus	381	0.20	0.009	2.749	0.829	A-	Malaysia	Wong et al. (2015)
Acetes indicus	604	0.56	0.007	2.829	0.941	A-	Malaysia	Wong et al. (2015)

The *K* value 1.31 for *Macrobrachium* sp. from this study were slightly higher than *M. rosenbergii* (1.09) under rice fields (Kunda et al., 2008), *Atya gabonensis* (1.014) from river (Okayi and Iyorkyaa, 2004) or *P. monodon* (0.727) under cultured (Gopalakrishnan et al., 2014). Meanwhile, the K values of 0.36–1.56 for fish are also commonly found in some fish species from other habitats. These values showed that most of the species in this river were in good condition. Variation in the value of the mean *K* may be attributed to biological interaction involving intraspecific competition for food and space (Arimoro and Meye, 2007) and the difference in aggressive behaviour (Deekae and Abowei, 2010) between shrimps. On the other hand, the factors affecting the variation values of *K* may include sex, stages of maturity, and state of stomach contents (Gayanilo and Pauly, 1997; Abowei et al., 2009).

For internal evaluation, the use of incandescent squid fishing tackle with diamond shape in its surface (e.g. SIL–1, 0.45 W) in Experiment 1 was able to increase the distribution of the amount of lights and showed an equal effective to the acrylic box-shaped lamps with all directional luminous (Dimmed/Lighted, 4.5 W). The SIL–1 or SIL–2 seemed to be more effective when operated in clear water than turbid water. Whenever they are applied in turbid water the use of higher intensities is recommended and the results are still open for discussion. The use of acrylic box-shaped lamps for sampling *Macrobrachium* sp. from Barito River is reflected to be similarly effective for catching American crayfish (*Procambarus clarkii*) from a pond in Japan (Ahmadi et al., 2008).

It is beyond our expectation that acrylic-square light traps in Experiment 4 were only used for one night fishing due to impracticability during their operation. The acrylic entrance slits apart from the trap body because of losing adhesiveness when soaked and from water pressure. In consequence of this problem, the traps caught insignificant number of juvenile shrimp and none of fish was caught. Acrylic-square trap was initially tested in indoor tank belonging to the Faculty of Fishery, Kagoshima University Japan and had some success in catching the juvenile of *P. clarkii*. We used the trap to pronounce their exploratory behaviour in the tank under light-adapted conditions, and later explored to collect the animal from a pond (unpubl. data). For further use, a redesign of the current acrylic-square trap is required to improve the function of its catch efficiency.

In summary, trapping with low-powered underwater lamps is applicable in high turbid water of Barito River. The colours of lights had strong effects on the number of shrimp collected. The size and shape of the light traps did not affect number of catch. The use of LEDs is considered more advantage than incandescent bulbs, because they are more energy efficient, more colours available, and more durable. For further research, it is necessary to determine which important species to be targeted by the lighted traps, so that the issues on the bycatch could be pointed out.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Anadolu endemiği sekiz *Pseudophoxinus* türünün boy-ağırlık ilişkisi

Length-weight relationship of eight endemic *Pseudophoxinus* species to Anatolia

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Öz: Bu çalışmada, Cyprinidae familyasından *Pseudophoxinus* genusuna ait, Anadolu içsuları için endemik olan 8 türün (*P. alii, P. anatolicus, P. antalyae, P. burduricus, P. crassus, P. hittitorum, P. fahrettini, P. meandricus*) boy-ağırlık ilişkileri belirlenmiştir. Bu amaçla, 8 türe ait toplam 481 adet birey incelenmiştir. Eğim "*b*" değeri 2,793 (*P. anatolicus*) ve 3,742 (*P. meandricus*) arasında değişmektedir. Büyüme tipi, *P. anatolicus* türünde negatif allometrik, diğer türlerin tamamında ise pozitif allometrik olarak belirlenmiştir.

Anahtar kelimeler: *Cyprinidae, Pseudophoxinus, kırmızı liste, büyüme tipi*

Abstract: In this study, length–weight relationships (LWRs) of 8 endemic fish species to Anatolia from *Pseudophoxinus* genus belonging to Cyprinidae family (*P. alii, P. anatolicus, P. antalyae, P. burduricus, P. crassus, P. hittitorum, P. fahrettini, P. meandricus*) are presented. To this end, a total of 481 individuals was examined. The slope "*b*" values varied between 2.793 (*P. anatolicus*) and 3.742 (*P. meandricus*). The slope (*b*) of the LWRs indicated positive allometry in all species with the exception of *P. anatolicus*, which indicated negative allometry.

Keywords: *Cyprinidae, Pseudophoxinus, red list, growth type*

GİRİŞ

Cyprinidae familyası üyelerinden olan *Pseudophoxinus* genusu, son yıllarda tanımlanan yeni türlerle birlikte içsularımızda 21 türle temsil edilmektedir (Çiçek vd. 2015). *Pseudophoxinus* cinsine ait türler, Türkiye dışında Lübnan, Suriye, Balkan Yarımadası, İsrail, Ürdün, İran ve Azerbaycan sularında dağılım göstermektedir (Atalay, 2005). Türlerin Anadolu içsularındaki dağılımı ise ülkenin güneybatı bölümünde yoğunlaşmıştır. Söz konusu türlerin hemen hemen tamamı sadece Anadolu içsularına özgü olup, endemik özellik taşımaktadırlar. *Pseudophoxinus* cinsi balıklar, genelde küçük cüsseli balıklar olduklarından insan gıdası olarak tüketilmemekle birlikte, yöresel olarak tüketilen türleri de vardır (Geldiay ve Balık, 2007). Üzerlerinde avcılık baskısı olmamakla birlikte, yaşam alanlarının oldukça sınırlı olması, bilinçsiz su kullanımı, barajlar, kuraklık, yabancı türler ve alan kurutma gibi tehditler dolayısıyla türlerin büyük çoğunluğun nesli tehlike altındadır (IUCN, 2017).

Boy-ağırlık ilişkisine ait bulgular, balık biyolojisi açısından son derece önemlidir. Boy-ağırlık ilişkisi parametreleri (*a* ve *b*), balığın boyundan ağırlığının tahmin edilmesine, kondisyon indeksinin hesaplanmasına, farklı habitatlardaki populasyonların morfolojilerinin ve yaşam süreçlerinin karşılaştırılmasına imkan verir (Petrakis ve Stergiou, 1995).

Bu çalışmada, Anadolu içsularına özgü olmaları dolayısıyla, biyolojik zenginliğimiz için önemli yeri olan *Pseudophoxinus* türlerinden sekizinin (*P. alii, P. anatolicus, P. antalyae, P. burduricus, P. crassus, P. hittitorum, P. fahrettini, P. meandricus*) boy ve ağırlık ilişkilerinin belirlenmesi ve bu vesileyle nesli tehlike altında olan bu türlerin korunmasına yönelik çabalara yardımcı olunması amaçlanmıştır.

MATERYAL VE METOT

Çalışmada elde edilen veriler, farklı çalışmalar kapsamında Eğirdir, Sütçüler, Şarkikaraağaç-Isparta, Kepez, Kırkgöz, Manavgat-Antalya, Beyşehir, Bozkır, Cihanbeyli, Çumra, Seydişehir-Konya, Bozdoğan-Aydın ve Yarışlı-Burdur'dan toplanıp, Ege Üniversitesi Su Ürünleri Fakültesi Müzesi İçsu Balıkları Koleksiyonunda korunmakta olan balık örneklerine aittir. Balıkların örneklenmesinde akarsularda "SAMUS 725 G" model elektroşoker cihazı, göllerde ise hamsinoz gözlü tül ığrıp kullanılmıştır. Elde edilen balık örnekleri fotoğraflanıp, yüksek

dozda fenoksietanole (1 ml/L) maruz bırakılarak ötenazi yapıldıktan sonra formalin ile tespit edilmiştir. Balıkların tür teşhislerinde, Bogutskaya (1992), Freyhof ve Özuluğ (2009, 2010), Küçük (2007), Küçük vd. (2012, 2013)'nin yaptıkları çalışmalardan yararlanılmıştır.

Örneklerin boy ölçümleri, büyük boylu bireylerde 1 mm hassasiyetteki balık ölçüm tahtası, küçük boylu bireylerde dijital kumpas ile, ağırlık ölçümü ise 0,01 g hassasiyetteki dijital terazi ile yapılmıştır.

Boy-ağırlık ilişkisinin incelenmesinde $W=aL^b$ denkleminden yararlanılmıştır (Ricker, 1975). Burada 'W' gram cinsinden balığın total ağırlığını, 'L' cm cinsinden balığın total uzunluğunu, "*a*" ve "*b*" katsayıları ise regresyon parametrelerini ifade etmektedir. Büyümenin izometrik ya da allometrik olduğuna karar vermek için, hesaplanan *t*-test değeri tablodaki kritik değerle karşılaştırılmıştır.

BULGULAR

Pseudophoxinus genusundan 8 farklı türe ait 481 bireyin incelendiği çalışma sonucunda türlere ait total boy ve total ağırlık değerleri ile regresyon parametreleri; kesişim "*a*", eğim "*b*" değeri ile eğimin standart hatası "se(*b*), korelasyon katsayısı "r" ve büyüme tipleri tespit edilmiştir (Tablo 1).

P. hittitorum ve *P. crassus* türlerinin, total boy ve ortalama boy bakımından diğer türlerden daha büyük değerlere sahip olduğu görülmektedir. Birey sayısı az olmakla birlikte, *P. burduricus* türü de en küçük boy değerlerine sahiptir (Tablo 1).

Büyüme tipi açısından bakıldığında sadece *P. anatolicus* türünün negatif allometrik, geriye kalan 7 türün ise pozitif allometrik büyüme gösterdikleri belirlenmiştir (Tablo 1).

Tablo 1. *Pseudophoxinus* türlerinin boy-ağırlık ilişkisi parametreleri (n: birey sayısı, TL: Total boy, W: Ağırlık, SH: standart hata, *a* ve *b*: regresyon parametreleri, SH(*b*): eğimin standart hatası, r: korelasyon katsayısı, A-: negatif allometrik (*t*-test; $-t > t_{0,05}$, n>200 = 1,65), A+: pozitif allometrik (*t*-test; $t > t_{0,05}$, n>200 = 1,65)
Table 1. The Length-weight relationship parameters of *Pseudophoxinus* species (n: number of fish sample, TL: total length, W: weight, SH: standart error, *a* and *b*: parameters of relationship, SH(*b*): standard error of slope (*b*), r: correlation coefficient, A-: negative allometric (*t*-test; $-t > t_{0,05}$, n>200 = 1,65), A+: pozitive allometric (*t*-test; $t > t_{0,05}$, n>200 = 1,65)

Tür	n	TL (cm) Min-Mak (Ort±SH)	W (g) Min-Mak (Ort±SH)	*a*	*b*	SH(*b*)	r	*t*-test
P.alii	42	4,80-11,80 (7,89±0,308)	1,70-27,35 (8,34±1,066)	0,0077	3,259	0,132	0,939	1,969^{A+}
P.anatolicus	306	4,00-11,30 (6,07±0,101)	0,56-18,04 (3,29±0,169)	0,0173	2,793	0,037	0,950	-5,616^{A-}
P.antalyae	7	3,80-8,30 (4,66±0,568)	0,65-9,85 (2,16±1,188)	0,0073	3,410	0,107	0,995	3,813^{A+}
P.burduricus	7	2,00-4,40 (3,09±0,305)	0,10-1,25 (0,50±0,156)	0,0089	3,352	0,121	0,994	2,912^{A+}
P.crassus	29	3,80-17,60 (9,74±0,526)	0,61-92,15 (19,03±3,309)	0,0066	3,370	0,056	0,993	6,604^{A+}
P.hittitorum	27	5,80-21,90 (11,81±0,957)	2,26-172,02 (36,14±8,602)	0,0075	3,216	0,035	0,997	6,143^{A+}
P.fahrettini	53	4,60-10,50 (8,40±0,193)	1,08-15,33 (7,84±0,475)	0,0067	3,273	0,076	0,973	3,590^{A+}
P.meandricus	10	6,50-8,90 (7,43±0,244)	3,50-12,45 (6,80±0,845)	0,0035	3,742	0,203	0,977	3,662^{A+}

TARTIŞMA VE SONUÇ

P. alii, dağılım alanı, Antalya civarındaki Aksu çayı, Ilıca ve Kömürcüler dereleri ile sınırlıdır (Küçük, 2007). IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Türün varlığını tehdit eden unsurlar; su kullanımı, barajlar, kirlilik ve iklim değişikliğinin neden olduğu yağış azalışının yanı sıra bölgedeki hızlı ekonomik gelişme sonucu suya olan ihtiyacın artmasıdır. Populasyonun büyüklüğü bilinmemekle birlikte, azalışta olduğu; ancak korumaya yönelik bir çalışma olmadığı bilinmektedir (Freyhof, 2014). Türe ait en büyük total boy 14,3 cm olarak rapor edilmiştir (İnnal, 2013). Çalışmamızda Düden, Manavgat ve Kepez'den türe ait 42 birey incelenmiş olup, total boy dağılımı 4,8-11,8 cm arasında değişim göstermiştir. İki çalışmadaki eğim "*b*" değeri *t*-testi ile karşılaştırılmış ve farklılık saptanmıştır (*t*-test; $t > t_{0,05}$) (Tablo 2).

P. anatolicus, Ereğli'deki Akgöl, Beyşehir ve Suğla gölleri havzalarından bilinmektedir. IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Türün varlığını tehdit eden unsurlar; su kullanımı, barajlar, iklim değişikliğinin sonucu olarak aşırı kuraklık ve yabancı tür istilasıdır. Akgöl ve Suğla göllerinin kurumuş olması, Beyşehir gölünde ise *Sander lucioperca*'nın varlığı büyük tehdit

oluşturmaktadır. Populasyonun büyüklüğü bilinmemekle birlikte, azalışta olduğu tahmin edilmektedir. Beyşehir Gölü milli park olmakla birlikte, korumaya yönelik bir çalışma olmadığı bilinmektedir (Freyhof, 2014). *P. anatolicus* türüne ait iki farklı çalışma sonucunda total boy değerinin 12,5-23,4 cm arasında değiştiği bildirilmiştir (Yoğutçuoğlu vd. 2016; Demirci, 2016). Bu çalışmada ise, Beyşehir civarından toplanmış 306 bireye ait en büyük total boy değeri 11,3 cm olarak belirlenmiştir. Eğim "*b*" değeri önem kontrolüne göre çalışmamızda bulunan değer, diğer iki çalışmadaki değerlerden farklılık göstermiştir (*t*-test; $t > t_{0,05}$). Bu farklılık incelenen birey sayısı veya çalışmaların farklı zaman/mevsimlerde yapılmış olması ile açıklanabilir (Tablo 2).

P.antalyae, Antalya civarındaki Kırkgöz ve Düden kaynakları ile Kırkgöz kaynağından Anatalya körfezine kadar olan alanda yaşamaktadır. IUCN Kırmızı listede (VU: Vulnerable) Hassas kategorisinde yer almaktadır. Yaşam alanlarını oluşturan kaynaklar için şu an için herhangi bir tehdit olmamakla birlikte, Kırkgözden akan derenin kanala dönüştürülmesi ve tarımsal kirlilik sorun oluşturabilir. Türün populasyonu kaynaklarda zengin olmakla beraber azalma eğilimindedir. Türe yönelik herhangi bir koruma faaliyeti bulunmamaktadır (Freyhof, 2014). *P. antalyae* türü için en büyük boy değeri 17,0 cm olarak bildirilmiştir (Erk'akan vd. 2013). Çalışmamızda Kırkgöz-Antalya'dan 7 bireye ait boy dağılımı ise 3,8-8,3 cm arasında değişmektedir. Regresyon parametre önem kontrolü test edilmiş ve her iki çalışmanın sonuçları benzer çıkmıştır (*t*-test; $t < t_{0,05}$) (Tablo 2).

P. burduricus, Burdur Gölü ve Salda Gölü havzaları ile Değirmendere deresi, Karamanlı Deresi, Düğer Bahar, Sazak Bahçesi Yarışlı Gölü ve çevresinde dağılım göstermektedir. IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Su kullanımı, kirlilik ve iklim değişikliği türü etkileyen önemli tehdit unsurlarıdır. Bölgedeki barajlardan akan derelerin yaz döneminde kuruması ve kuraklık türün devamlılığı için sorun teşkil etmektedir. Populasyonun büyüklüğü bilinmemekle birlikte, yaşam alanlarını etkileyen kuraklık ve su kayıpları nedeniyle son 20 yılda habitat kayıpları olmuştur ve bu şekilde devam ettiği takdirde populasyonların azalması olasıdır. Türün korunmasına yönelik bir çalışma bulunmamaktadır (Freyhof, 2014). *Pseudophoxinus* türleri içerisinde küçük cüsseli olanlardan biri olan *P.burduricus* için en büyük standart boy değeri 8,7 cm olarak rapor edilmiştir (Küçük vd. 2013). Çalışmamızda Yarışlı Gölü'nden, türe ait 7 birey incelenmiş olup, total boy dağılımı 2,0-4,4 cm olarak belirlenmiştir. Regresyon parametre önem kontrolü test edilmiş ve sonuçlar arasında fark olmadığı tespit edilmiştir (*t*-test; $t < t_{0,05}$) (Tablo 2).

P. crassus, Tuz Gölü Havzasındaki Cihanbeyli deresi ile, Gökgöl, Eşmekaya'nın güneyindeki kaynaklar, Niğde ve Aksaray civarındaki derelerden bilinmektedir. Ayrıca, günümüzde tamamen kurutulmuş olan Samsam Gölü'nden de varlığı rapor edilmiştir. IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Samsam Gölü drenajı ve iklim değişikliğine bağlı yağış azalması ile birlikte aşırı su çekimi tür için en büyük tehditlerdir. Türün populasyon yapısı bilinmemekle birlikte, bölgedeki birçok tehdit nedeniyle azalmış olabileceği ve hala da azalmakta olduğu düşünülmektedir. Türün korunması yönünde herhangi bir eylem planı bulunmamaktadır (Freyhof, 2014). Türe ilişkin en büyük total boy değeri 19,8 cm olarak kaydedilmiştir. (Yoğutçuoğlu vd. 2016). Bu çalışmada da İnsuyu-Cihanbeyli'den 29 birey incelenmiş ve en büyük total boy değeri 17,6 cm olarak belirlenmiştir. Regresyon parametre önem kontrolü sonucunda her iki çalışmada elde edilen değerlerin birbirine benzer olduğu belirlenmiştir (*t*-test; $t < t_{0,05}$) (Tablo 2).

P. fahrettini, Köprü Çayı'nın memba sularından bilinmektedir. IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Türün yaşam alanlarından su çekimi, barajlar tarafından su tutulması ve iklim değişikliğine bağlı olarak yağış azalması sonucu kuraklığın şiddetinin artması önemli tehdit unsurlarıdır. Türün populasyon durumu bilinmemekle birlikte, tehditler nedeniyle yavaş da olsa azalışta olduğu düşünülmektedir. Türün korunmasına yönelik çalışma bulunmamaktadır (Freyhof, 2014). *P. fahrettini* türü, genus içerisinde iri cüsseli olanlardan biridir ve en büyük çatal boy değeri 28,1 cm olarak bildirilmiştir (Koca ve Ölmez, 2013). Bu çalışmada Köprüçayı-Isparta'dan incelenen 53 örneğin en büyük total boy değeri ise 10,5 cm olarak ölçülmüştür. Regresyon parametreleri önem kontrolü için yapılan test sonucu her üç çalışmada elde edilen değerlerin birbirlerinden farklılık gösterdiği belirlenmiştir (*t*-test; $t > t_{0,05}$). Bu farklılık, incelenen birey sayısı ve boy değerlerinin oldukça geniş bir aralıkta dağılım göstermesi ile açıklanabilir (Tablo 2).

P. hittitorum, Beyşehir Gölü'nün doğusunda yer alan Eflatunpınarı kaynağı ve gölün güneyindeki Bakaran deresinden bilinmektedir. IUCN Kırmızı listede (EN: Endangered) Tehlike kategorisinde yer almaktadır. Bu tür için de diğerleri ile benzer şekilde, ortamdan su çekimi, barajlar tarafından su tutulması, kirlilik ve iklim değişikliğinden kaynaklanan yağış azalması büyük tehdittir. Tehditler nedeniyle yavaş da olsa azalışta olduğu düşünülmekle birlikte populasyon büyüklüğü bilinmemektedir. Yaşam alanı olan Eflatunpınarı kaynağı, içerisinde bulunan anıtlar nedeniyle koruma altında olsa da bu koruma biyoçeşitliliğin korunmasına yönelik değildir (Freyhof, 2014). *P. hittitorum* türü için rapor edilmiş en büyük boy, 10,4 cm standart boy değeridir (Freyhof ve Özuluğ, 2010). Çumra ve Bozkır-Konya'dan türe ait 27 bireyin incelendiği çalışmamızda en büyük total boy değeri 21,9 cm olarak ölçülmüştür. Boy-ağırlık ilişkisi ile ilgili olarak herhangi bir çalışma bulunmadığından çalışmamızda hesaplanan parametre değerleri tür için ilk özelliği taşımaktadır (Tablo 2).

P. meandricus, Afyon Sandıklı civarındaki Karadirek deresi ile, Işıklı Gölü kaynağı ve Hotamış Gölü'nden bilinmektedir. Ancak, Hotamış populasyonu bataklığın boşaltılması nedeniyle yok olmuştur (Freyhof, 2014). IUCN Kırmızı listede (CR: Critically Endangered) Kritik Düzeyde Tehlike kategorisinde yer almaktadır. Özellikle Karadirek deresinden yapılan su çekimi,

barajlar tarafından su tutulması, kirlilik ve iklim değişikliğinden kaynaklanan yağış azalması tür için tehdit oluşturmaktadır. Populasyonun büyüklüğü hakkında bilgi bulunmazken, tehditler nedeniyle yavaş da olsa azalmakta olduğu düşünülmektedir. Korunmasına yönelik bir eylem bulunmamaktadır. Ancak, türün kritik olarak tehlikede olması bir an önce korumaya yönelik tedbir alınması gerektiğinin göstergesidir (Freyhof, 2014). *P. meandricus* için en büyük total boy değeri 9,4 cm olarak bildirilmiştir (Ladiges, 1960). Çalışmamızda Bozdoğan-Aydın'dan türe ait 10 adet birey incelenmiş olup, total boy dağılımı 6,5-8,9 cm arasında değişmiştir. Büyüme parametrelerine ilişkin günümüze değin bir çalışma yapılmamış olması dolayısıyla elde edilen veriler *P. meandricus* için ilk özelliğindedir (Tablo 2).

Tablo 2. Farklı çalışmalardaki *Pseudophoxinus* türlerine ait boy, ağırlık değerleri ve büyüme parametreleri. (n: birey sayısı, TL: Total boy, W: Ağırlık, *a* ve *b*: regresyon parametreleri, SH(*b*): eğimin standart hatası, r: korelasyon katsayısı, A-: Negatif Allometrik, A+: Pozitif Allometrik.
Table 2. The length, weight values and growth parameters of *Pseudophoxinus* species in different studies. (n: number of fish sample, TL: total length, W: weight, *a* and *b*: parameters of relationship, SH(*b*): standard error of slope (*b*), r: correlation coefficient, A-: Negative Allometric, A+: Pozitive Allometric).

Tür	n	TL (cm) Min-Mak	W (g) Min-Mak	a	b	SH(b)	r	Yazar
P.alii	105	3,4-14,3	0,40-38,10	0,0117	3,012	--	0,988	İnnal, 2013
	42	**4,80-11,80**	**1,70-27,35**	**0,0077**	**3,259**	**0,132**	**0,939**	**Bu çalışma**
P.anatolicus	36	15,0-23,2	36,40-154,90	0,0041	3,380	---	0,952	Yoğurtçuoğlu vd. 2016
	52	12,5-23,4	37,4-179,5	0,0500	2,680	---	0,940	Demirci, 2016
	306	**4,00-11,30**	**0,56-18,04**	**0,0173**	**2,793**	**0,037**	**0,950**	**Bu çalışma**
P.antalyae	39	5,3-17,0	1,60-94,50	0,0070	3,338	---	0,993	Erk'akan vd. 2013
	7	**3,80-8,30**	**0,65-9,85**	**0,0073**	**3,410**	**0,107**	**0,995**	**Bu çalışma**
P.burduricus	25	2,9-6,8	0,30-4,40	0,0079	3,290	---	0,994	Yoğurtçuoğlu vd. 2016
	7	**2,00-4,40**	**0,10-1,25**	**0,0089**	**3,352**	**0,121**	**0,994**	**Bu çalışma**
P.crassus	91	5,2-19,8	1,80-133,10	0,0075	3,280	---	0,990	Yoğurtçuoğlu vd. 2016
	29	**3,80-17,60**	**0,61-92,15**	**0,0066**	**3,370**	**0,056**	**0,993**	**Bu çalışma**
P.fahrettini	151	5,3-19,3	---	0,0044	3,401	---	0,971	Ayyıldız vd. 2015
	771 (ÇB)	6,5-28,1	5,25-265,64	0,0300	2,610	---	0,962	Koca ve Ölmez, 2013
	53	**4,60-10,50**	**1,08-15,33**	**0,0067**	**3,273**	**0,076**	**0,973**	**Bu çalışma**
P.hittitorum	**27**	**5,80-21,90**	**2,26-172,02**	**0,0075**	**3,216**	**0,035**	**0,997**	**Bu çalışma**
P.meandricus	**10**	**6,50-8,90**	**3,50-12,45**	**0,0035**	**3,742**	**0,203**	**0,977**	**Bu çalışma**

Sonuç olarak, son kayıtlara göre içsularımızdan tanımlanmış olan 21 türden (Çiçek vd. 2015) *P. kervillei* ve *P. zeregii* haricindeki türlerinin tamamı Anadolu içsularına özgü olan (Küçük vd. 2012) *Pseudophoxinus* cinsi balıklar Türkiye içsu biyolojik çeşitliliğinde oldukça önemli bir yer tutmaktadır. Ancak, yukarıda da değinildiği gibi, yaşam alanlarının sınırlı olması, özellikle tarımda bilinçsiz su kullanımı, barajlar, iklim değişikliği sonucu oluşan kuraklık, tarım alanı açmak amaçlı olarak sulak alanların kurutulması ve yaşam ortamlarına yabancı türlerin (*Sander lucioperca, Carassius gibelio, Pseudorasbora parva* vb.) girmesi gibi nedenlerle türlerin hemen hemen tamamının nesli ciddi olarak tehdit altındadır. Öyle ki, Eğirdir Yağ balığı olarak bilinen *P. handlirschi* türünün doğada neslinin tükendiği (Küçük, 2012), *P. elizavetae, P. meandricus* ve *P. ninae* türlerinin kritik derecede tehlikede, geriye kalan türlerden de 10'unun tehlikede olduğu (IUCN, 2017) bilinmektedir.

Tüm bu bilgiler ışığında, *Pseudophoxinus* türlerinin korunması adına, yaşam alanlarının korunması, su kullanımının daha bilinçli yapılması, ortamlara yabancı tür girişlerinin kontrol altına alınması gibi tedbirlerin karar verici merciler tarafından hayata geçirilmesi önem taşımaktadır. Bunun yanında, türlerin birçoğu için üreme zamanı, yumurta verimlilikleri, beslenme davranışları gibi biyolojik verilerin eksikliği de bu yönde yapılacak bilimsel çalışmalarla ortaya çıkarılmalıdır.

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Gillnet and trammel net selectivity for Prussian carp (*Carassius gibelio*) in Marmara Lake, (Turkey)

Marmara Gölü (Türkiye)'ndeki Gümüşi havuz balığı (*Carassius gibelio*) için sade ve fanyalı uzatma ağları seçiciliği

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Abstract: This study aimed to determine the selectivity properties of multifilament gillnets and trammel nets for Prussian carp (*Carassius gibelio* Bloch,1782) in Marmara Lake (Manisa, Turkey). A total of 36 fishing trials were performed with three different stations on a monthly in 2012. Nets with same mesh sizes (4, 6, 8 and 10 cm) and characters were used in gillnets and trammel nets. SELECT method was utilized to estimate the selectivity parameters. Normal scale and normal location model gave the best fit for gillnet and trammel nets respectively. A total of 2234 *Carassius gibelio* were caught ranges between 8.80-27.50 cm in total lengths. The model length for 4 cm mesh size was estimated as 12.24 cm for gillnets and 12.63 cm for trammel nets. No statistical differences were found between estimated model lengths for different sex groups. Model lengths are much higher than first maturity size which 11.5 cm was given by different authors. This situation makes it impossible combating with this invasive species. Therefore, special fishing equipment or devices are needs to be investigated just for caught *C. gibelio.* In addition, *C. gibelio* was the second species by production rate in Turkey inland fisheries; therefore, it should be economically evaluated using different processing techniques.

Keywords: *Gillnet selectivity, trammel net selectivity, Prussian carp, Carassius gibelio, Marmara Lake*

Öz: Bu çalışmada, Marmara Gölü'ndeki gümüşi havuz balığı (*Carassius gibelio* Bloch, 1782) için multifilament sade ve fanyalı uzatma ağlarının seçicilik özelliklerinin belirlenmesi amaçlanmıştır. Araştırma 2012 yılında, aylık olarak 3 farklı istasyonda toplam 36 balıkçılık denemesi ile gerçekleştirilmiştir. Çalışmada aynı göz açıklıklarına (4, 6, 8 ve 10 cm) ve teknik özelliklere sahip sade ve fanyalı uzatma ağları kullanılmıştır. Seçicilik parametrelerinin tahmininde SELECT metot'dan yararlanılmıştır. En düşük sapmayı vermesinden dolayı sade ağlar için normal scale, fanyalı ağlar içinde normal location en uygun model olarak değerlendirilmiştir. 8,80-27,50 cm total boy aralığında toplam 2234 *C. gibelio* yakalanmıştır. 4 cm ağ göz açıklığı için model boyu sade ağlar için 12,24 cm fanyalı ağlar için 12,63 cm tahmin edilmiştir. Farklı cinsiyet grupları için tahmin edilen model boyları arasında istatistiksel olarak bir fark bulunamamıştır. Tahmin edilen model boyları, farklı yazarlar tarafından verilen 11,5 cm'lik ilk üreme boyundan oldukça yüksektir. Bu durum, istilacı bir tür olan *C. gibelio* ile uzatma ağları kullanarak mücadele etmeyi imkânsız kılmaktadır. Bu nedenle, sadece *C. gibelio* yakalaması için özel balıkçılık ekipmanlarının veya cihazlarının geliştirilmesi gerekmektedir. Ek olarak, *C. gibelio* üretim oranı itibariyle Türkiye'de iç su balıkçılığında ikinci sıradadır; bu nedenle, farklı işleme teknikleri kullanılarak ekonomik olarak değerlendirilmesi gerekmektedir.

Anahtar kelimeler: *Sade ağ seçiciliği, fanyalı ağ seçiciliği, gümüşi havuz balığı, Carassius gibelio, Marmara gölü*

INTRODUCTION

In recent years, habitat destruction, pollution, overfishing and unconscious fishing give rise to decrease fishing population and this reflects the yield production. The proportion of assessed fish stocks fished within biologically sustainable levels declined from 90% in 1974 to 71.2% in 2011, when 28.8 percent of fish stocks were estimated as fished at a biologically unsustainable level. Of the stocks assessed in 2011, fully fished stocks accounted for 61.3% and underfished stocks 9.9% (FAO, 2014). Overfishing and low selectivity fishing gears is indicated as the most important reason for this condition (Alverson *et al*., 1994). For sustainable fishery, fish should spawn at least once time during the lifetime. Therefore, adequate fishing management requires selectivity. Selectivity is the ability to select captured fish by species, size or a combination of these during fishing operations. Size selectivity; fishing gears catch adult fish and allow juvenile fish to escape (Armstrong *et al*., 1990; Wileman *et al*., 1996).

A set gillnet consists of a single netting wall kept more or less vertical by a floatline and a weighted ground line. A

trammel net consists of two/three layers of netting with a slack small mesh inner netting between two layers of large mesh netting within which fish will entangle (FAO, 2017). Both are passive fishing gears and used commonly marine and inland fishermen all around world and as well as in Turkey. Planning an experiment involves prior knowledge of the factors that can affect gear selectivity. Holst *et al*. (1998) published manual for gillnet selectivity and they presented that parameter; related to gears (gang and net dimensions, mesh size, hanging ratio, vertical slack, twine characteristics, floatation and weight, soaking time and arrangement of nets in the fleet - sequence and joining between nets), related to the fish (fish abundance, fish availability to the net, fish behaviour towards the net, fish size, fish shape (girth at different body points), presence of by-catch, presence of predators, net saturation, patchy distribution in the net) and fishing operations (dimension of boats (low-lying vs. high-lying boats), net handling techniques, environmental parameters, light level, sea state and currents, seabed type, depth, occurrence of water/bottom debris).

There are many selectivity studies conducted on both gill and trammel nets. Moth-Poulsen (2003) investigated seasonal variations of trammel nets selectivity for *Pleuronectes platessa* in the Danish demersal fishery. Significant seasonal differences reported in selectivity by researcher. Carol and García-Berthou (2007) studied gillnet selectivity and its relationship with body shape for eight freshwater fish species in Catalonia (NE Spain). It was found that percent in depth and percent in girth have significant positive correlation and both showed information about fish shape. Ayaz *et al*. (2010) investigated effects of hanging ratio on gill net selectivity for *Diplodus annularis.* There is no effect of hanging ratios on size selectivity of *D. annularis* by this study result. Ayaz *et al*. (2011) researched effect of twine thickness on selectivity of gillnets for *Boops boops* and authors reported that there is a differences in the size selectivity existed between gillnets with different twine thicknesses.

Carassius gibelio was first reported in Turkey (from Lake Gala, Thrace region of Turkey) by Baran and Ongan (1988). Over subsequent years, rapid increases in abundance and distribution have been observed in many parts of Turkey (Şaşı and Balık, 2003; Özcan, 2007; Ekmekçi *et al*., 2013; İlhan and Sarı, 2013; Özuluğ *et al*., 2013; Dereli and Dinçtürk, 2016). *C. gibelio* is the second in the most fishing species as 7652 tons in 2016 in inland waters of Turkey's (Anonymous, 2017). Due to the large quantities captured it has become an important income source for inland fishers, despite the low commercial values (0.42 USD/kg). There are some biological and selectivity studies conducted on the species. (Emiroğlu *et al*., 2010; Cilbiz *et al*., 2014a, 2014b; İlhan *et al*., 2014; Şaşı, 2008, 2015; Korkmaz and Kuşat, 2016). However, there is no study, affected of the sex factor, compared identical mesh size of gill and trammel net selectivity at same time experiments. In this study it was aimed that determination of the selectivity properties of gill and trammel net with 4, 6, 8 and 10 cm stretched mesh size, also researching effect of sex factor on gillnet and trammel selectivity.

MATERIALS AND METHODS

Study area

The study was conducted on Lake Marmara which altitude is 79 m and surface between 3200-6800 ha based on depth differences. Lake depth is changes coupled with year by year, it is about average 3-4 m (Arı and Derinöz, 2011). Experiments were carried out in the three different stations identified eastern, middle and western areas as in the longitudinal length of the lake (Figure 1). In order to ensure homogeneity between stations, twelve nets were used on each station (totally 36 nets) on a monthly basis in 2012.

Sampling and data collection

Multifilament gillnets and trammel nets were used in the fishing trial. Experimental gillnets have 4, 6, 8 and 10 cm stretched mesh size and 210 denier/2 twine thickness. Each panel has 35 m in length, 50 vertical meshes and 0.50 hanging ratio. Trammel nets inner panels have same character with gillnets. The outer panel has 210 denier/6 twine thickness, vertical mesh number 7 meshes and stretched mesh size was 25 cm.

All nets were connected each other with float line and lead line randomly and set at the bottom of sampling station in the afternoon and was hauled the following day. Average fishing time for per catching operation was 16 hours. Caught fish were classified to the nets and total lengths were measure with 1 mm precision measurement board.

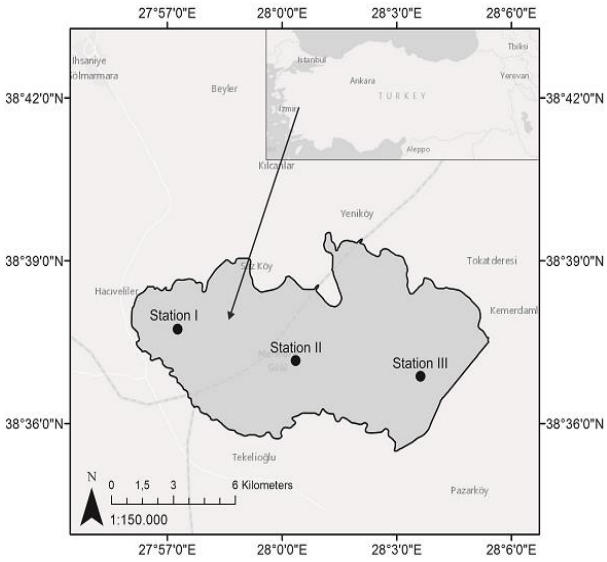

Figure 1. Study area

Selectivity analysis

As indirect estimation method, SELECT (Share Each Length's class Catch Total) method was used to determine selectivity (Millar, 1992; Millar and Holst 1997; Millar and Fryer, 1999). Data obtained from experiments were analysed by R (3.4.2) based RStudio (1.0.136) (R Development Core Team 2017). *R-codes* are developed by Millar (2009) and Millar (2010). Length selectivity of each mesh size was described by five different models (normal location, normal scale, gamma, lognormal and bi-normal) of the SELECT method (Millar and Fryer, 1999; Park *et al*., 2011). The equations for each model are given in below.

Normal Location:

$$\exp\left(-\frac{\left(L-k.m_j\right)^2}{2\sigma^2}\right)$$

Normal Scale:

$$\exp\left(-\frac{\left(L-k_1.m_j\right)^2}{2k_2^2.m_j^2}\right)$$

Log-Normal:

$$\frac{1}{L}\exp\left(\mu+\log\left(\frac{m_j}{m_1}\right)-\frac{\sigma^2}{2}-\frac{\left(\log\left(L\right)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2\sigma^2}\right)$$

Gamma:

$$\left(\frac{L}{(\alpha-1).k.m_j}\right)^{\alpha-1}\exp\left(\alpha-1-\frac{L}{k.m_j}\right)$$

Bi-modal:

$$\exp\left(-\frac{\left(L-k_1.m_j\right)^2}{2k_2^2.m_j^2}\right)+c.\exp\left(-\frac{\left(L-k_3.m_j\right)^2}{2k_4^2.m_j^2}\right)$$

The most suitable model was chosen taking into account the lowest deviation value. The Kolmogorov-Smirnov (K-S) test was used to compare the catch size frequency distributions of different sex groups caught by same mesh size of gillnets and trammel nets (Karakulak and Erk 2008; Siegel and Castellan 1989). One-way ANOVA with Tukey and t-test were utilized for multi comparing and binary comparing, respectively. RStudio (1.0.136) software was used all statistical calculations.

RESULTS

A total of 2234 *C. gibelio* was caught with the total length and weight ranging from 8.80-27.50 cm and 10.9-378.4 g, respectively. A total catch consists of 47.6% gillnet and 52.4%, trammel nets specimens. Mean total lengths are 14.35±0.10 cm for gillnet and 14.98±0.10 cm for trammel nets. Significant differences were found between the mean lengths of gill and trammel nets ($p < 0.001$). Mean weights are 55.14±1.46 g for gillnet and 63.98±1.41 g for trammel nets. Also significant differences were found between the mean weights of gill and trammel nets ($p < 0.001$) (Table 1).

Table 1. Lengths and weights of gillnets and trammel nets catch

Parameters	Gillnet			Trammel net			
	Mean±SE	Min.	Max.	Mean±SE	Min.	Max.	p
Total length (cm)	14.35±0.10	8.80	27.50	14.98±0.10	10.20	26.90	< 0.001
Total weight (g)	55.14±1.46	10.90	378.40	63.98±1.41	17.70	358.90	

Samples consist of 78.2% female and 21.8% male individuals. Inverse ratio was found between increasing mesh size and the ratio of male individuals in the total catch. Species male individuals were not caught either with 10 cm mesh sized trammel or gill nets.

The 4 cm is the most effective mesh size to catch fish for both gillnets and trammels net (Table 2). This situation might be due to the mean lengths of the specimens which caught in the 4 cm mesh size. When mesh size increases, catching ratios are decrease but mean length of the sizes are increases (Figure 2). Same mesh size of gill and trammel net mean lengths were found close each other. No clear differences were found ($p > 0.05$) between them except 4 cm mesh size ($p < 0.001$) (Table 2).

Table 2. Average total length of catch caught by different net type and mesh sizes

Mesh Sizes (cm)	Gillnets			Trammel nets			p
	N	N %	Mean±SE	N	N %	Mean±SE	
4	733	68.6	12.52±0.04[a]	696	59.5	12.79±0.07[a]	< 0.001
6	292	27.3	17.78±0.07[b]	424	36.2	17.70±0.08[b]	> 0.05
8	31	2.9	22.01±0.47[c]	47	4.0	22.10±0.29[c]	> 0.05
10	8	0.7	26.79±0.21[d]	3	0.3	25.97±0.63[d]	> 0.05

Length-frequency distributions are given in Figure 2. In general, it is observed that length intervals of fish individuals caught by gillnet are narrower than trammel net. For example; Caught fish individuals length interval was between 10-18 cm for 4 cm mesh size gill net, while same mesh size trammel nets catches length interval was found to be 10-22 cm.

Model length and selectivity parameters of gillnet and trammel nets were given in Table 3. From the table, normal scale and normal location gave the best fit for gillnet and trammel nets, respectively by the lowest deviance approach. Model length of gillnet and trammel nets for 4 cm mesh size were estimated 12.24 ± 0.13 and 12.63 ± 0.09 cm, respectively. From the result, it can be said that trammel nets caught smaller fish than gillnets.

Selectivity curves of gillnet and trammel nets and deviance residual plots of gillnets and trammel nets were given in Figure 3. There is no significant abnormality in the distribution.

The model estimated for 4 cm mesh size nets was tuned for nets with 6, 8 and 10 cm mesh size regarding to scale of length and spread values. Modelled lengths for different mesh size and gender groups were given in Table 4. As general tendency, modelled lengths were found too close each other. However, it was found that there is no significant different between groups (female, male and combined sex) of estimated models for 4, 6, 8 and 10 cm mesh size of the nets (F=0.002, p=0.998 for gillnets; F=0.018, p=0.982 for trammel nets).

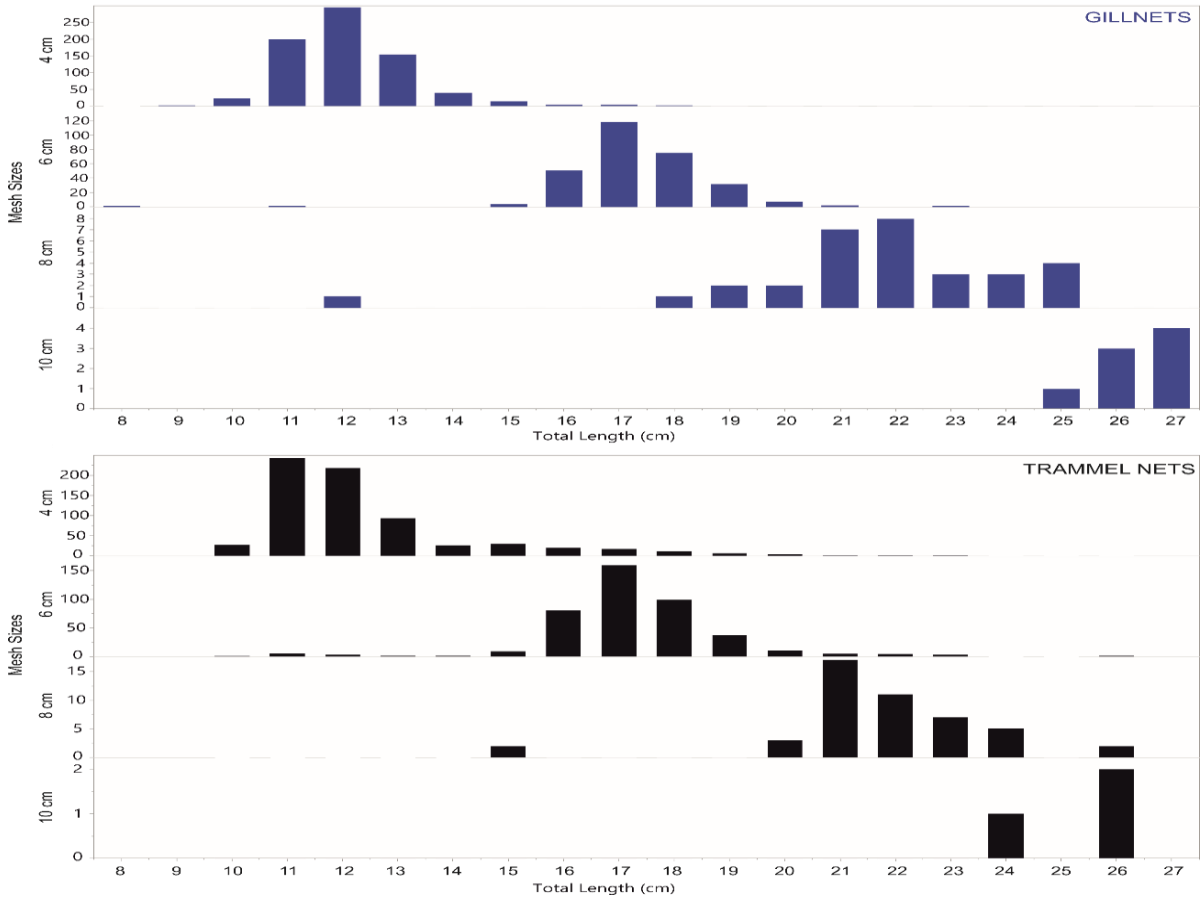

Figure 2. Length frequency distributions of *C. gibelio* by different net and mesh sizes

Table 3. Selectivity model parameters of *C. gibelio* and estimated selection curves for gillnets and trammel net with 4 cm mesh size

	Models	Parameters	Gillnets					Trammel Nets				
			Estimates	Mode 1	Spread 1	Deviance	df	Estimates	Mode 1	Spread 1	Deviance	df
Equal fishing power	Normal location	k σ	2.92(0.02) 1.93(0.09)	11.71(0.09)	1.93(0.09)	56.78	52	**3.15(0.02) 2.81(0.09)**	**12.63(0.09)**	**2.81(0.09)**	**108.09**	**52**
	Normal scale	k_1 k_2	**3.06(0.03) 0.09(0.01)**	**12.24(0.13)**	**1.25(0.07)**	**55.66**	**52**	3.40(0.02) 0.26(0.01)	13.60(0.09)	2.04(0.06)	163.40	52
	Lognormal	μ_1 σ	2.49(0.01) 0.11(0.005)	12.01(0.12)	1.39(0.08)	73.21	52	2.59(0.008) 0.16(0.005)	13.03(0.10)	2.23(0.08)	128.19	52
	Gamma	k α	0.03(0.004) 83.16(8.70)	12.09(0.12)	1.34(0.07)	65.69	52	0.08(0.005) 40.05(2.42)	13.22(0.10)	2.14(0.07)	134.10	52
	Bi-normal	k_1 k_2 k_3 k_4 c	No fit									
Fishing power α mesh size	Normal location	k σ	2.95(0.02) 1.96(0.10)	11.82(0.09)	1.96(0.10)	56.34	52	3.23(0.02) 2.87(0.09)	12.95(0.10)	2.87(0.09)	111.25	52
	Normal scale	k_1 k_2	3.09(0.03) 0.09(0.01)	12.37(0.14)	1.24(0.07)	55.55	52	3.47(0.02) 0.25(0.01)	13.90(0.10)	2.01(0.05)	164.38	52
	Lognormal	μ_1 σ	2.51(0.01) 0.11(0.005)	12.16(0.13)	1.41(0.08)	73.21	52	2.62(0.009) 0.16(0.005)	13.38(0.11)	2.29(0.08)	128.19	52
	Gamma	k α	0.03(0.004) 84.16(8.70)	12.24(0.13)	1.35(0.07)	56.34	52	0.08(0.005) 41.05(2.42)	13.56(0.10)	2.16(0.07)	134.10	52
	Bi-normal	k_1 k_2 k_3 k_4 c	No fit									

Table 4. Model length and spread values of *C. gibelio* for trammel nets and gillnets

Mesh size (cm)		(Female)		(Male)		(Combined sex)	
		Model Length (cm)	Spread Value (cm)	Model Length (cm)	Spread Value (cm)	Model Length (cm)	Spread Value (cm)
Gillnets	4	12.26	1.27	12.07	1.07	12.24	1.25
	6	18.39	1.91	18.11	1.61	18.36	1.88
	8	24.52	2.54	24.14	2.14	24.48	2.50
	10	30.65	3.18	30.18	2.68	30.60	3.13
Trammel Nets	4	12.02	0.76	12.35	2.76	12.63	2.81
	6	18.03	1.14	18.53	4.14	18.90	4.07
	8	24.04	1.52	24.70	5.52	25.20	5.42
	10	30.05	1.90	30.88	6.90	31.50	6.78

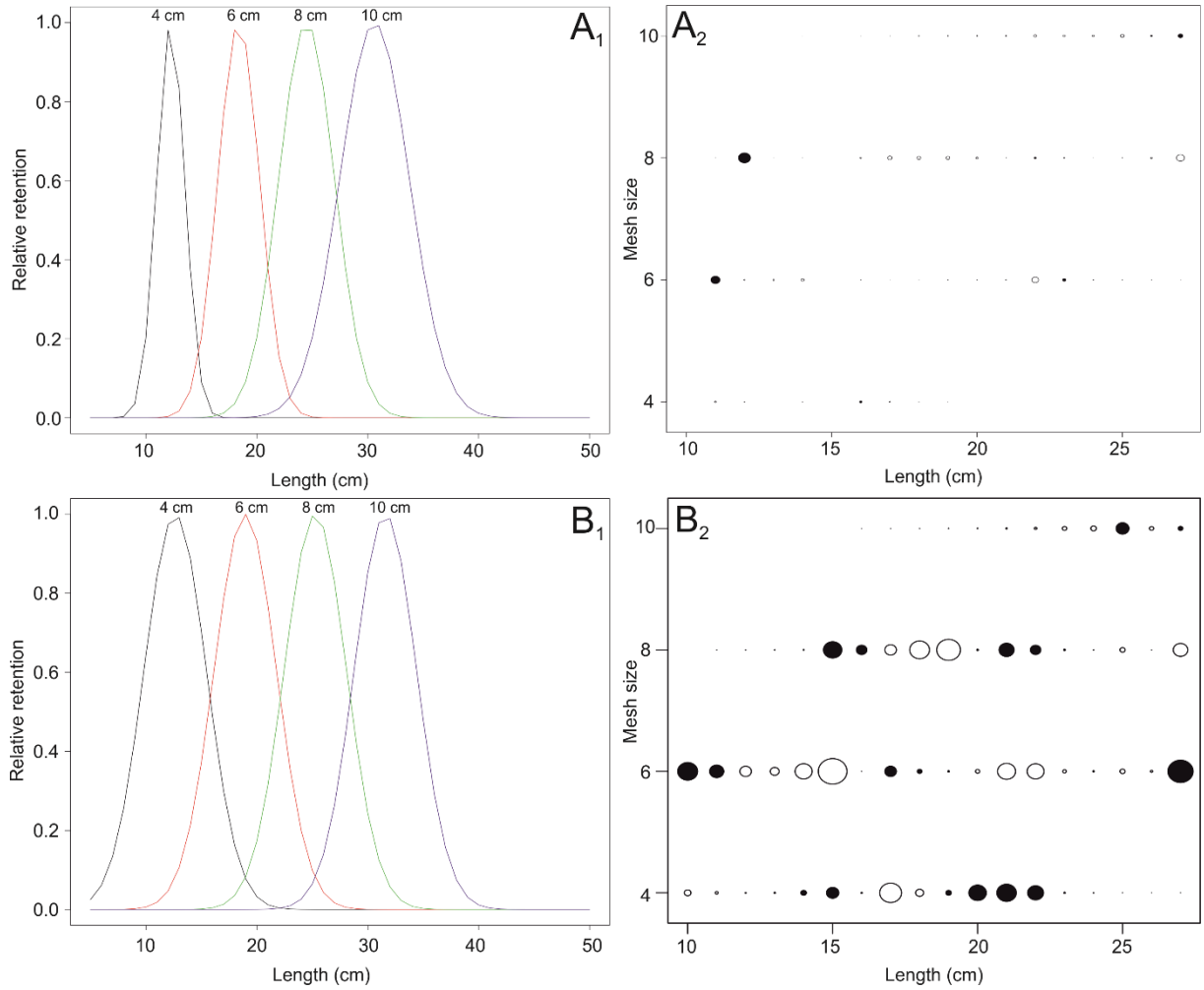

Figure 3. Selectivity curves and deviance residual plot of gillnets and trammel nets. (A: Gillnet; B: Trammel Net; $_1$: Selectivity curve ; $_2$: Deviance residual plot)

It is not found any difference between length frequency distributions of *C. gibelio*'s sex groups, which are caught by the same mesh size (6 cm) of gillnet, excluding comparison between males and combined sex (Table 5). There was not significant difference in length frequency distributions between all gender groups caught by 4 cm mesh size and females and combined sex of 6 cm mesh size of trammel-net, while there was significant difference between remaining comparisons.

Table 5. Kolmogorov-Smirnov (K-S) test result (F: female, M: male, C: combined sex)

Gillnet		D_{max}	C.V.	Decision	Trammel Nets		D_{max}	C.V.	Decision
4 (F)	4 (M)	0.2091	0.4554	H_0NotReject	4 (F)	4 (M)	0.3724	0.1631	H_0Reject
4 (F)	4 (C)	0.1243	0.4163	H_0NotReject	4 (F)	4 (C)	0.1618	0.1345	H_0Reject
4 (M)	4 (C)	0.1877	0.3908	H_0NotReject	4 (M)	4 (C)	0.2365	0.1486	H_0Reject
6 (F)	6 (M)	0.2833	0.3071	H_0NotReject	6 (F)	6 (M)	0.3683	0.2681	H_0Reject
6 (F)	6 (C)	0.0307	0.1390	H_0NotReject	6 (F)	6 (C)	0.0414	0.1235	H_0NotReject
6 (M)	6 (C)	0.3556	0.3345	H_0Reject	6 (M)	6 (C)	0.4152	0.2849	H_0Reject
8 (F)	8 (M)	0.8000	0.6569	H_0NotReject	8 (F)	8 (M)	0.4444	0.4995	H_0NotReject
8 (F)	8 (C)	0.1143	0.3384	H_0NotReject	8 (F)	8 (C)	0.0784	0.2834	H_0NotReject
8 (M)	8 (C)	0.6286	1.3793	H_0NotReject	8 (M)	8 (C)	0.1686	0.6373	H_0NotReject

H_o: There are no significant difference between length frequency distributions (α=0.05, K=1.36). C.V.= Critical Values

DISCUSSION

In this study, gillnets and trammel nets selectivity parameters were compared for Prussian carp (*Carassius gibelio* Bloch, 1782) in Marmara Lake (Manisa, Turkey). Trammel nets (52.43%) are more productive than gillnets (47.67%) in present study. However, it was presented that gill net (59.6 %) catch is higher than trammel net (40.4%) from Eğirdir Lake (Cilbiz et al., 2014a). This difference might be mesh size of the gears. Because they used different mesh size both in gill nets (32, 40, 50, 60, 70, 80 and 90 mm) and trammel (100, 110, 120,130 and 140 mm) nets. It is well known that increasing mesh size can lead to decrease catch size of given species. There are adverse relationship between increasing mesh size and retention of male individuals. Female specimens were caught three times more than male specimens same results were reported by Uysal et al., (2014); Emiroğlu (2008); Sarı et al., (2008). This was due to the female specimens ratio was higher than male specimens in advances age groups.

Selectivity results of 40, 50, 60, 70, 80 and 90 mm mesh size are 11.68, 17.52, 23.26 and 29.20 cm for gillnet, 11.68, 17.52, 23.36 and 29.20 cm for trammel net, respectively. These are close to presented by Cilbiz et al (2014a, b). Cilbiz et al. (2014a) found that 8.74, 10.92, 13.65, 16.38, 19.11, 21.84 and 24.57 cm for multifilament (210d/2 no) gillnet mesh size of 32, 40, 50, 60, 70, 80 and 90 mm and also 27.20, 29.92, 32.64, 35.36 and 38.08 cm for multifilament trammel nets (inner panel; 210d/2 no, outer panel; 210d/6 no) mesh size of 100, 110, 120, 130 and 140 mm, respectively, from the Eğirdir lake according to Bi-modal model. Besides, model lengths were estimated as 8.77, 10.96, 13.70, 16.44, 19.18, 21.92, 24.66 for 32, 40, 50, 60, 70, 80, 90 mm monofilament gill nets and 24.90, 27.39, 29.88, 32.37, 34.86 for 100, 110, 120, 130 and 140 mm monofilament trammel nets (Cilbiz et al., 2014b).

Table 6. Some selectivity study results for C. gibelio analysed with SELECT method for combined sex

Author	Location	Net type	Mesh size (cm)	Model length (cm)
Cilbiz *et al.* (2014a)	Lake Eğirdir, Turkey	Multifilament Gillnet	4.0	10.92
Cilbiz *et al.* (2014b)	Lake Eğirdir, Turkey	Monofilament Gillnet	4.0	10.96
Cilbiz *et al.* (2015)	Lake Manyas, Turkey	Monofilament Gillnet	4.0	11.76
Present study	Lake Marmara, Turkey	Multifilament Gillnet	4.0	11.66
		Multifilament Trammel Net	4.0	12.27

Generally model lengths obtained from trammel nets are higher than same mesh size of gillnet (Table 6). These differences might be due to between fishing principles of gill and trammel nets. Because size range of trammel nets specimens more wider/larger than gillnet specimens (Table 1).

There was no statistical difference between the predicted model sizes for different sex groups. In this context it can be thought that the sex factor is not important both gill and trammels net selectivity for *C. gibelio*. Despite difference between frequency distributions, it is thought that model lengths related to sex-related very close to each other. The main reason of the situation is that morphometric characteristic of male and female individuals (İlhan *et al*., 2014). Boroń *et al*., (2011) presented that *C. gibelio* maximum body depth, head depth and head width, which are very important gill/trammel net selectivity, are very close for both male and female individuals.

The first reproduction size is very important in fighting with *C. gibelio* through catching. Balık *et al*., (2004) reported that L_{50} maturation length of *C. gibelio* as 10.3 cm with fork length. Combatting with fish that after L_{100} all individual reached maturation length of approximately 15 cm must begin at least in this length. When fork lengths are converted to the total lengths according to the equations by Gaygusuz *et al*., (2006), (11.5 cm total length), the 50 mm or above multifilament mesh sizes should be used. However, to combat with the species through catching, lowered the legal mesh size up to 50-60 mm likely cause some negative results on the other species in the environment, so it is an issue that needs to be considered.

Even *C. gibelio* is not target species, it has been existed many inland waters as an invasive species from the first time introduced in Turkey. Marmara Lake has low altitude, shallow and temperate; this leads to a longer breeding period of *C. gibelio* and is more advantageous than many local varieties in population density. According to Anonymous (2017) data of five years, *C. gibelio* is the second species by production rate after (*Alburnus tarichi*) in inland waters of Turkey. Therefore, *C. gibelio* should be economically evaluated for alternative processing techniques. There is no minimum mesh size regulation for *C. gibelio*. However, 60 and 130 mm mesh size are obligators for *Esox lucius* and *Cyprinus carpio,* respectively in Manisa province.

According to our results, the optimal catch length of 60 mm mesh sizes are 18.36 and 18.90 cm for gillnet and trammel net, respectively. This situation makes it impossible combatting with this species. Therefore, special fishing equipment and devices are needs to be investigated just for catching *C. gibelio.*

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Estimating gillnet selectivity of Bluefish (*Pomatomus saltatrix*) by morphology

Lüferin (*Pomatomus saltatrix*) morfolojisiyle galsama ağı seçiciliğinin tahmini

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Abstract: The dataset of the study consists of total length, fork length, head girth, maximum girth and weight measurements of 136 bluefish. The relationship between the total length and fork length of the product was TL=1.1348×FL−0.8184; the relationship between the total length and weight was W=0.0103×$L^{2.97}$. The relationships between the total length and head girth and between the total length and maximum girth of the sample were linear: the relationship of the total length and head girth was G_{gill}=0.5092×TL−0.0874; the relationship of the total length and maximum girth was G_{max}=0.5989×TL−0.8540. The statistical relationship between length and girth was used to obtain a theoretical gillnet selectivity equation for the species. In conclusion, a relationship of $S(l)$=Φ[(C−G_{gill})/0.4952]×[1−Φ((C−G_{max})/0.4255)] was determined between the stretched size of the mesh used in bluefish fishing and the catch rate. Using this equation, and considering the legal length and length at first maturity, the minimum mesh size of the gillnet for sustainable fishery was determined.

Keywords: *Direct estimation, Sechin method, length-girth relationship, length-length relationship, length-weight relationship*

Öz: Çalışmanın veri setini, 136 adet lüfer balığı üzerinde yapılan; total boy, çatal boy, operkulum çevresi, vücut çevresi ve ağırlık ölçümleri oluşturmaktadır. Türün total boyu ile çatal boyu arasında TL=1,1348×FL−0,8184, total boyu ile ağırlığı arasında ise W=0,0103×$L^{2.97}$ şeklinde bir ilişki olduğu tespit edilmiştir. Örnekleme ait total boy-operkulum çevresi ve total boy-vücut çevresi arasında ise sırası ile G_{gill}=0,5092×TL−0,0874 ve G_{max}=0,5989×TL−0,8540 şeklinde doğrusal bir ilişkinin olduğu hesaplanmıştır. Boy ile çevre arasında kurulan istatistiksel ilişkiler kullanılarak, türe ait kuramsal uzatma ağı seçicilik denklemi elde edilmiştir. Sonuç olarak, türün avcılığında kullanılabilecek ağın tam göz boyu ile yakalanma oranları arasında $S(l)$=Φ[(C−G_{gill})/0,4952]×[1−Φ((C−G_{max})/0,4255)] şeklinde bir ilişkinin olduğu tespit edilmiştir. Elde edilen bu denklemden faydalanılarak, türün yasal ve ilk üreme boyları dikkate alınarak, sürdürülebilir bir avcılık için kullanılacak sade uzatma ağının minimum tam göz boyunun ne olması gerektiği belirlenmiştir.

Anahtar kelimeler: *Direkt tahmin, Sechin metodu, boy-çevre ilişkisi, boy-boy ilişkisi, boy-ağırlık ilişkisi*

INTRODUCTION

Bluefish (*Pomatomus saltatrix* Lin., 1766), the only member of the Pomatomidae family (Whitehead et al., 1986), is a rapidly migrating, pelagic and predatory species (Haimovici and Krug, 1996). Their distribution extends to a wide area including the Atlantic, Pacific and Indian Oceans, and they inhabit the continental shelves of warm and temperate seas (Wilk, 1977). They have a high commercial value around the world (Froese and Pauly, 2016). In Turkey, in addition to gillnets and hooks (Hoşsucu, 2000), they are also caught with purse seine and trawl. According to the statistics from the General Fisheries Commission for the Mediterranean (GFCM), the average fish production of Turkey in the last decade was 7,252.8±1,355.6 tons and the majority of the production was from the Black Sea and the Marmara Sea ($\bar{x}$±SE) (FAO, 2016).

The bluefish is a symbol for various non-governmental organizations committed to preserving marine life in Turkey; it is used in many campaigns regarding this issue. Discussions on its legal catch length have always reached an impasse and as a natural consequence of these long-lasting discussions, the legal length has undergone many changes: The first legal length was determined to be 15 cm fork length (FL) during the fishing season in 1986-1987; over time, the legal length reached 18 cm (FL) and 20 cm (TL). Until today, the lowest legal length was 14 cm (TL) during the 11-year long fishing season beginning in 2000; no length ban was implemented during the 1999-2000 fishing season. The length ban for the current fishing season is 18 cm total length (Anonymous, 2016).

In Turkey, in addition to its high economic value, bluefish is historically and traditionally highly valued. Few species that are similarly valued are also given names based on their lengths: bluefish are named "defneyaprağı" (<10 cm), "çinekop" (10-20 cm), "sarıkanat" (20-25 cm), "kofana" (35-40 cm) and "sırtıkara" (>40 cm TL) (Deveciyan, 1915; Türgan, 1959).

In this study, the theoretical catch rate of gillnet was determined by utilizing the morphological structure of bluefish, and by considering this rate mesh sizes of gillnet for fishing above the legal length and length at first maturity were calculated.

MATERIALS AND METHODS

The material of the study consists of morphological measurements obtained from 136 bluefish. The samples were collected from different fishing gears (line and net fishing) intended for sampling with large length range. Total length (TL), fork length (FL), head girth (G_{gill}) and maximum girth (G_{max}) of individual fish were measured at 0.1 mm and the total body weight was recorded at 0.01 g sensitivity.

Linear regression was used to determine the relationships between total length and fork length (TL-FL), total length and head girth (TL-G_{gill}), and total length and maximum girth (TL-G_{max}) of the samples:

$$y = b \times x + a$$

In the equation, x represents the independent variable, y represents the dependent variable, a and b represent the regression intercept and slope. The relationship between length and weight of the species was calculated with:

$$W = a \times L^b$$

In the equation, W represents the weight at each L length, while a and b represent the regression coefficient (Ricker, 1973). The intercept and slope parameters of the relationships were estimated by linear regression analysis on log-transformed length and weight data.

Growth type of the species was determined using the Student's t-test. The power of the correlation between established relationships was determined with the determination coefficient (R^2).

A theoretical selectivity model, which is based on the relationship between the fish length and girth, and is also known as the Sechin method, was used to estimate the selectivity parameters and selectivity curve (Sechin, 1969; Kawamura, 1972). This model is suited to species with a morphology that allows for gilled and wedged; and the model is based on determining two length groups ($G_{gill} \leq C \leq G_{max}$);

a) Determination of length groups small enough to get their heads into the mesh,

b) Determination of length groups large enough to be retained by the mesh.

In the study, the equations that were modified from Sechin (1969) by Reis and Pawson (1999) by simplifying and applying the equations to commercial fishery data were adopted:

$$P^{retained} = P\{G_{max} \geq C\} = 1 - \Phi\left(\frac{C - G_{max}}{\sigma_{max}}\right)$$

$$P^{passing} = P\{G_{gill} \leq C\} = \Phi\left(\frac{C - G_{gill}}{\sigma_{gill}}\right)$$

$$S(l) = P^{retained} \times P^{passing}$$

In the equations, S represents the estimated catch rate at each l length, C represents the mesh size (stretched mesh size×2), G_{max} and G_{gill} represent the maximum girth and head girth for each l fish length; Φ represents the cumulative normal standard distribution function, σ_{gill} and σ_{max} represent the standard deviation of the relationships between fish length-head girth and fish length-maximum girth. Using these equations, a normal distribution curve is obtained from two transverse sigmoid curves' combination. All calculations were carried out using MS-Excel® functions.

RESULTS

In the study, the total length of the smallest sample was 16.5 cm, whereas the total length of the largest sample was 35.3 cm. The average length of the samples was 23.25 cm and the standard error was ±0.34 cm. A relationship, W=0.0103×$L^{2.97}$ (R^2=0.987) was determined between the weight and length of the species. At 95% confidence interval, standard error of b (slope) value of this relationship was ±0.07, and therefore the growth type of the species was determined to be isometric (t-test). The linear and strong relationship between the fork length (FL) and total length (TL) of the samples was determined as TL=1.1348×FL−0.8184 (R^2=0.999).

A linear relationship, G_{max}=0.5989×TL−0.8540 (R^2=0.968, σ_{max}=0.4255) was determined between the total length and maximum girth of the bluefish. In addition, a linear relationship, G_{gill}=0.5092×TL−0.0874 (R^2=0.942, σ_{gill}=0.4952) was determined between the total length and head girth of the species (Figure 1).

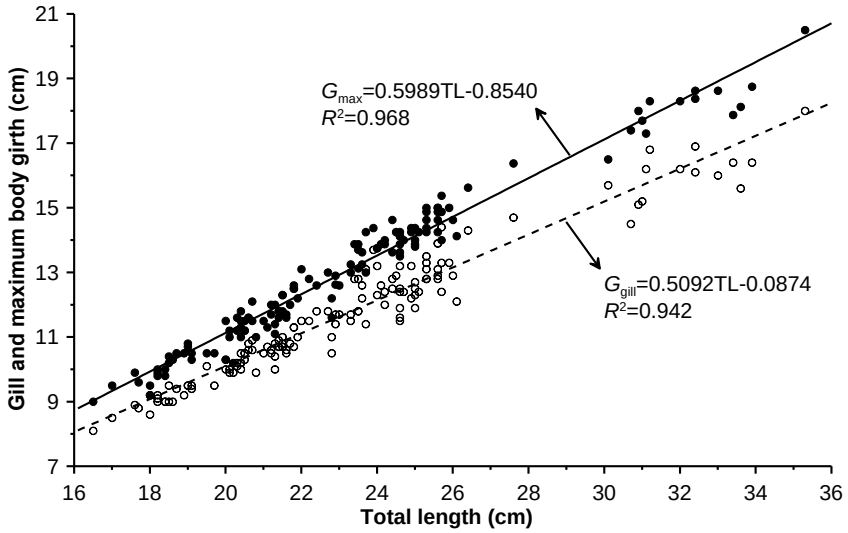

Figure 1. Total length-head girth and total length-maximum girth relationships of the bluefish (*Pomatomus saltatrix*) (● and |: TL-G_{max}; ○ and ¦: TL-G_{gill}).

The morphometric relationship between the length, head girth and maximum girth revealed the following relationship between the stretched mesh size and catch rate:

$$S(l)=\Phi\left(\frac{C-(0.5092\times \mathrm{TL}-0.0874)}{0.4952}\right)\times\left[1-\Phi\left(\frac{C-(0.5989\times \mathrm{TL}-0.854)}{0.4255}\right)\right]$$

This relationship showed that the stretched mesh size of the gillnet that allows for fishing above the 18 cm legal length was 55 mm. This mesh size, the probability of catching individuals at 18 cm legal length was 6‰, optimum catch length was 20.75 cm total length and catch rate at optimum catch length was 77.8% (Figure 2).

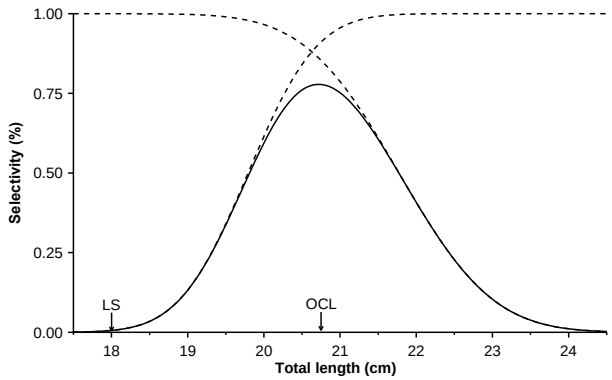

Figure 2. Estimated gillnet selectivity of 55 mm stretched mesh size for the bluefish (*Pomatomus saltatrix*) (LS: Legal size, OCL: Optimum catch length)

In Turkey, the length at first maturity was reported as 25.4 cm fork length (Ceyhan et al., 2007). Total length measurements are accepted as the main measurement standard in legal regulations; therefore, this value should be converted to total length for practical use. The relationship equation obtained in this study for total length and fork length revealed that the length at first maturity was 28.0 cm total length for bluefish. A gillnet with an 85 mm stretched mesh size allowed for fishing above the length at first maturity. Theoretically, with this mesh size, 5‰ of the individuals at first maturity length were caught, optimum catch length was 31.45 cm and the catch rate for individuals at optimum catch length was 97.5% (Figure 3).

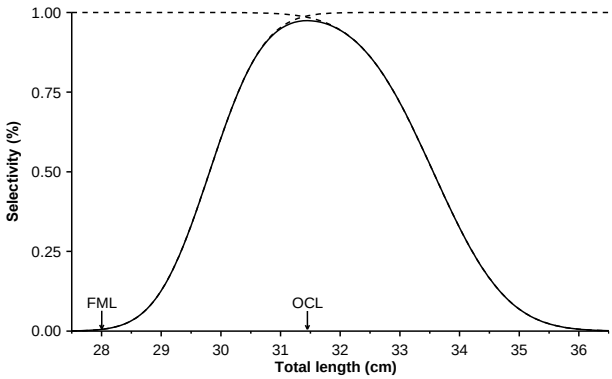

Figure 3. Estimated gillnet selectivity of 85 mm stretched mesh size for the bluefish (*Pomatomus saltatrix*) (FML: Length of first maturity, OCL: Optimum catch length)

DISCUSSION

The total length-fork length relationship established in this study was used to convert previous researchers' findings regarding fork length to the total length. Froese and Pauly (2016) reported that, based on the measurements of pictures of the species, the total length of the species was 1.0834 times the fork length. van der Elst (1976), for individuals inhabiting the South African coast, and Bal et al. (2015), for individuals sampled from the southern Marmara Sea, reported the relationship between the total length and fork length. The

findings of our study were mostly similar to the findings of Froese and Pauly (2016) and Bal et al. (2015), whereas the findings of van der Elst (1976) were considerably different from all of these studies (Table 1).

Table 1. Total length-total weight and total length-fork length relationships of the present and previous studies for the bluefish (*Pomatomus saltatrix*)

L-W	GT	LR	*L-L*	Study
			TL=1.0834×FL+0	Froese and Pauly, 2016
			TL=1.306×FL+3.06	van der Elst, 1976
$W=0.0388\times L^{2.56}$	–A			Erkoyuncu et al., 1994
$W=0.0130\times L^{2.8621}$	–A	13.2-21.7		Kalaycı et al., 2007
$W=0.0325\times L^{2.527}$	–A	10.6-24.0		Bök et al., 2011
$W=0.0107\times L^{2.9574}$	I	12.3-43.7	TL=1.13×FL–0.342	Bal et al., 2015
$W=0.0103\times L^{2.97}$	I	16.5-35.3	TL=1.1348×FL–0.8184	Present study

L-W: Total length-total weight relationships. GT: Growth types (I: Isometry, –A: Negative allometry). LR: Sampled length range (cm, TL). *L-L*: Total length-fork length relationships.

In addition, considering that equations for total length-fork length, total length-head girth and total length-maximum girth would not suffice to draw meaningful conclusions without the weight data of the species, length-weight relationship for the sample was also determined. Although the length-weight relationship determined in this study was similar to the findings of Bal et al. (2015), it completely differed from the findings of Erkoyuncu et al. (1994), Kalaycı et al. (2007) and Bök et al. (2011). The reason for finding negative allometric growth may be that the samples consisted of individuals of smaller sizes (Table 1). Such a result might be obtained if the datasets used for length-weight relationship calculations consist of juveniles that have not reached their mature body shape (Safran, 1992), or consist of old individuals that have lost their body shape due to fat deposition (Froese, 2006), or include an insufficient sample size of individuals with a very narrow length (İlkyaz et al., 2010).

The determination coefficients of the relationships between the total length-head girth and the total length-maximum girth revealed strong relationships between these parameters. These parameters directly affect the accuracy of the results obtained from the theoretical catch probability that forms the method of this study. Therefore, these strong relationships were considered to positively affect the results. In addition, steepness and width of the selectivity curves that were plotted with the model are closely associated with the morphology of species. Curves of fusiform fish species are narrow and steep, whereas curves of compressiform species are broad and flat (Hovgård and Lassen, 2000). This is also directly associated with the catch rate at optimum catch length calculated for the mesh size. In this study, the equation for mesh size length-catch rate generated a characteristic bell-curve suited to the morphology of the species.

van der Elst and Adkin (1991) reported that the length at first maturity for male individuals of the species inhabiting the Natal (South Africa) region was 24 cm, whereas the length at first maturity for female individuals was 25 cm fork length. Kailola et al. (1993) determined this parameter as 30 cm total length at 2 years of age for eastern coasts of Australia. Salerno et al. (2001) reported that the length at first maturity for male individuals of the species inhabiting the coasts of the USA was 33.9 cm, whereas the length at first maturity for female individuals was 33.4 cm fork length. It is expected for this parameter to differ between stocks from different environments and the established length value for the stock in Turkey is one of the lowest among the values established for different geographical conditions. The legal catch length for the species should be supported by scientific findings and indicate mature individuals that have completed their first reproductive cycle. However, the legal catch length implementation in Turkey is considerably below the required length.

In this study, due to the two different catch lengths for bluefish fishing obtained by a legal study and a scientific study, two different catch lengths were used in the calculations for bluefish fishing. By using the mesh size-catch rate equation given in this study, the catch rate of the desired mesh size for any length group can be calculated. Considering the legal catch length, the use of gillnets with a 55 mm stretched mesh size is deemed appropriate, whereas considering the scientific findings, the use of gillnets with an 85 mm stretched mesh size is appropriate. The optimum catch length of the gillnet that allows for fishing above the legal length is notably below the scientifically approved length at first maturity and even the largest fish length that can be captured with this length is below the scientific length (Figure 2). Since different names are used for different sizes in Turkey, individuals at 25 cm or above are called bluefish, however the size that the current legal regulation allows for fishing is “çinekop” (the name of the bluefish with a length between 10 and 20 cm TL). In other words, the fishing length allowed in Turkey is considerably below the fishing length that should be legally implemented for sustainable fishery. Gillnets with an 85 mm stretched mesh should be used to catch bluefish at acceptable sizes; that is, 28.0 cm total length or above.

Although direct estimation methods also allow for estimating gillnet selectivity parameters by using morphometric

measurements of many fish species (Sechin, 1969; Kawamura, 1972) or fishing individuals whose length-frequency information is known (İlkyaz, 2005), indirect estimation methods are mostly preferred for determining these parameters (Hovgård and Lassen, 2000). The direct estimation model ignores coincidentally captured individuals that were caught on other body parts. However, this method is suited to the bluefish with a morphology that allows for gilled and wedged because there are no extremities on the body. In addition, the direct estimation model does not consider whether or not the length groups suited to capture are in the fishing area. In practical environments, the lack of the length size classes can affect the result to a limited extent. On the other hand, Özekinci (2005) showed the similarity of direct and indirect selectivity estimation results.

In Turkey, by using indirect methods, Sümer et al. (2010) studied the selectivity of 40 and 44 mm monofilament and multifilament gillnets, while Acarlı et al. (2013) studied the selectivity of 44, 46, 50 and 56 mm multifilament gillnets. In the studies conducted in other geographical regions, Trent and Pristas (1977) studied gillnets with a mesh size of at least 63 mm in the St. Andrew Bay in Florida, USA, while Lucena et al. (2000) studied a 90 mm mesh size in the southern coasts of Brazil. Compared with the sizes used in these studies, considerably smaller mesh sizes have been used in the studies from Turkey. The reason for choosing smaller mesh sizes in Turkey is commercial fishers' effort to catch smaller individuals, the lack of legal repercussions and the researchers' interest in determining the catch performance of these mesh sizes used in commercial fishing.

In this study, theoretical catch rate of gillnet was determined by utilizing the morphological structure of bluefish, and its relationship with the legal length and length at first maturity in Turkey. In addition, findings on length-length and length-weight of the species were presented.

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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Marmara Denizi'ndeki Lüfer balığının *Pomatomus saltatrix* (Linnaeus, 1766) büyüme ve üreme özellikleri

Growth and reproductive characteristics of the Bluefish *Pomatomus saltatrix* (Linnaeus, 1766) in the Marmara Sea

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Öz: Bu çalışma, 2014 Yılı Ocak-Aralık dönemleri arasında lüfer *Pomatomus saltatrix* (Linnaeus, 1766) balığının büyüme ve üreme özelliklerini araştırmak için Marmara Denizi'nden aylık ticari balıkçılardan rastgele yöntemle örnekleme yapılarak toplam 1023 örnek incelenmiştir. Örneklerin total boy dağılımı 12,3-47,3 cm aralığında değişim gösterdiği belirlenmiştir. Tüm örnek bireylerin boy-ağılık ilişkisi $W=0,0107L^{2,9574}$ olarak hesaplanmıştır. Yapılan *t*-testi ile büyüme şeklinin izometrik (b=3, P>0,05) olduğu tespit edilmiştir. Yaş-boy değerleri kullanılarak von Bertalanffy boyca büyüme denklemi $L_t=48,7[1-e^{-0,247(t+1,677)}]$, büyüme performans indeksi (ϕ') ise 2,757 olarak hesaplanmıştır. Aylık Gonadosomatik indeksin (GSI) takibi ile üremenin ağırlıklı olarak Mayıs ile Ağustos ayları arasında gerçekleştiği ve Temmuz ayında zirveye ulaştığı tespit edilmiştir.

Anahtar kelimeler: *Lüfer, Pomatomus saltatrix, büyüme, üreme, Marmara Denizi*

Abstract: This study was carried out to investigate the growth and reproductive characteristics of bluefish *Pomatomus saltatrix* (Linnaeus, 1766) in Marmara Sea. A total 1023 samples, collected monthly from commercial fishermen between January and December 2014, was investigated. Total length distribution of the samples varied between 12,3-47,3 cm. The length-weight relation of all sample individuals is calculated as $W = 0,0107L^{2,9574}$. It was determined that the growth pattern was isometric (b=3, P>0,05) by the constructed *t*-test. Using the age-length values, the growth equation of von Bertalanffy was calculated as $L_t=48,7[1-e^{-0,247(t+1,677)}]$. Growth performance index (ϕ') was computed as 2,757 for all specimens. The monthly values of gonad somatic index (GSI) of females indicated that spawning occurred mainly between May and August with a peak in July.

Keywords: *Bluefish, Pomatomus saltatrix, growth, reproduction, Marmara Sea*

GİRİŞ

Pomatomidae familyası tek türle temsil edilmekte olup alt türleri yoktur. Lüfer *Pomatomus saltatrix* (Linnaeus, 1766), genellikle dünyanın kıta sahanlığındaki sıcak, ılıman sularında yayılım gösterir (Briggs 1960). Kuzey ve Orta Pasifik Okyanusu dışında bütün denizlerde kıtasal kenar ve haliçler içerisinde göç eden (Oseanodrom) bir türdür. Lüfer balıkları Atlantik Okyanusu'nun Amerika Kıta sahanlığı bölümünde yer alan Latin Amerika ülkelerinden Küba, Venezuela, Brezilya, Uruguay'dan Arjantin'e kadar olan bölgede yayılım gösterirler. Atlantik Okyanusunun Avrupa yüzüne bakan tarafta ise Avrupa kıtasında yer alan Portekiz kıyılarından başlamak üzere Batı Afrika kıyısında bulunan Senegal ve Güney Afrika kıtasında bulunan Angola'ya kadar olan bölgede dağılım göstermektedir. Hint Okyanusu bölümünde yer alan Güney Afrika'nın doğu kıyıları ile Güney ve Batı Avustralya'yı içerisine alan geniş bir alanda yayılım gösterirler (Briggs 1960; Wilk 1977). Ayrıca Akdeniz'in özellikle kuzey bölgelerinde olmak üzere tamamında ve Karadeniz ile Azak Denizi'nde bulunmaktadır (Slastenko 1956; Tortonose 1975).

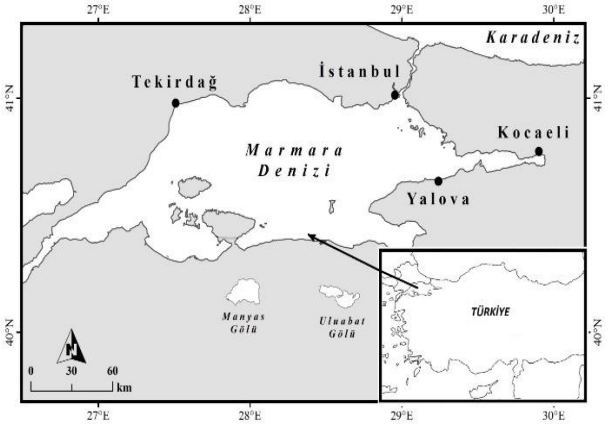
Ülkemiz, dünya üzerinde ılıman iklim kuşağında yer aldığından lüfer balığı *P. saltatrix* (Linnaeus, 1766) dört bölge denizimizde de bulunmakta, Karadeniz ile Ege arasında mevsimsel beslenme ve üreme göçü yapmaktadır (Bilecenoğlu vd., 2002). Ekonomik değeri yüksek olan bu tür ile ilgili yapılmış çeşitli çalışmalar mevcuttur (Türgan, 1959; Artüz, 2003; Bulut vd., 2004; Ceyhan, 2005; Turan vd., 2006; Ceyhan ve Akyol, 2006; Ceyhan vd., 2007; Cengiz vd., 2012; Bal vd., 2015; Özpiçak vd., 2017; Zengin vd., 2017; Bal vd., 2018).

Bu çalışma ile Marmara Denizi'ndeki Lüfer balıklarının

büyüme ve üreme özellikleri araştırılmış, ekonomik önemi yüksek olan bu türün stoklarının korunmasına ve bölge balıkçılığının yönetimine katkı vermesi amaçlanmıştır.

MATERYAL VE METOT

Çalışma materyalini teşkil eden lüfer balıkları *P. saltatrix* (Linnaeus, 1766) Marmara Denizi'nde (Şekil 1) avcılık yapan ticari teknelerden 2014 yılında Ocak-Aralık periyodunu kapsayan dönemde aylık olarak rastgele örnekleme yöntemi ile temin edilmiştir.



Şekil 1. Örnekleme alanı
Figure1. Sampling area

Laboratuvara getirilen örneklerin total boy ölçümleri 1 mm aralıklı balık ölçüm cetveli ile ağırlıkları ise 0,01 g hassasiyetli dijital terazi ile yapılmıştır. Boy ağırlık ilişkisi $W=a.L^b$ formülü kullanılarak hesaplanmıştır. Formüldeki *W* balığın g cinsinden toplam ağırlığını, *L* ise balığın cm cinsinden toplam boyunu ifade etmektedir. *a* ve *b* ise büyüme sabitleridir. Cinsiyet ve üreme döneminin tespiti için gonadlar incelenmiştir. Gonadosomatik indeks (GSI) değerleri; *GSI= Gonad ağırlığı/Vücut ağırlığı*100* formülü kullanılarak hesaplanmıştır (King, 1995).

Yaş belirleme işlemi için, güvenilir yapı olarak bildirilen otolitlerden yararlanılmıştır (Barger, 1990; Ceyhan ve Akyol, 2006; Yılmaz, 2006). Sagittal otolitler, incelemeye alınmadan önce %3'lük NaOH çözeltisine konarak üzerindeki yağ ve dokular temizlenmiştir (Chugunova, 1963). Temizlenen otolitler, daha sonra yapılacak yaş belirleme çalışması için sağ ve sol otolitler ayrı olacak şekilde eliza kaplarına yerleştirilmiştir. Yaş okumaları üstten aydınlatmalı trioküler mikroskopta (Leica M125), içerisinde %37'lik alkol bulunan siyah zeminli petriye yerleştirilerek distal yüzeyden 10x1,25 büyütmede okunmuştur. Yaş okumalarında hata oranını en aza indirmek için iki farklı okuyucu ile değerlendirilmiştir. von Bertalanffy büyüme denklemi $L_t=L_\infty[1-e^{-k(t-t0)}]$ kullanılarak örnek bireylerin, yaş boy ilişkisi belirlenmiştir. Burada; *L*: total boy (cm), *k*: brody büyüme katsayısı, L_t: *t* yaşındaki bir balığın boyu (cm), t_0: balık boyunun sıfır olduğu varsayılan teorik yaşı (yıl), L_∞ balığın ulaşabileceği maksimum (asimptotik) boyu (cm), *e* logaritma taban sabitidir (*e* =2,71828).

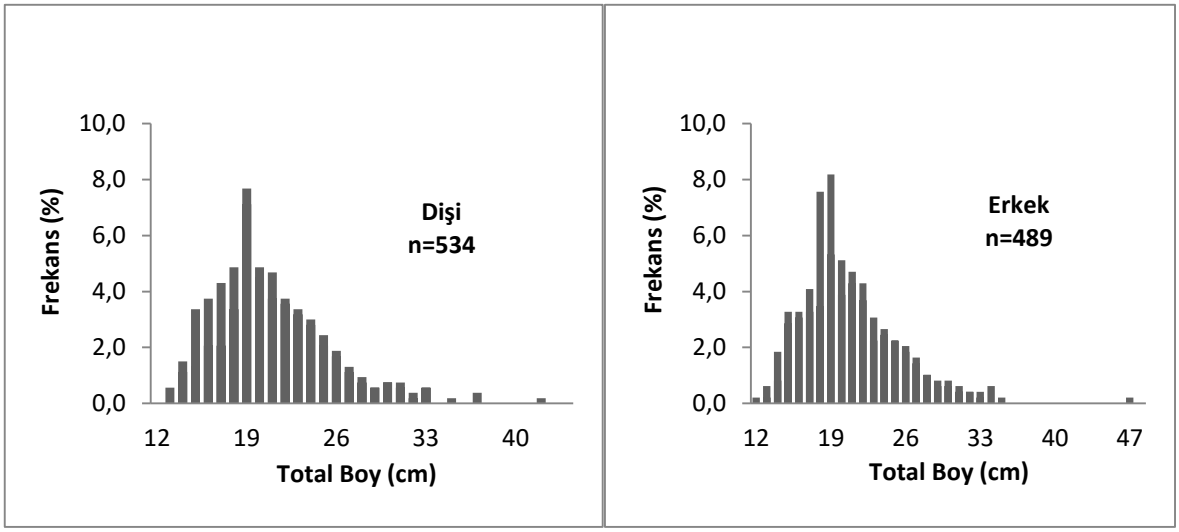
Balık stoklarının büyüme ve gelişim durumlarının başka bir göstergesi de büyüme performans indeksidir. Aynı türün farklı stokları arasında büyüme farklılığın belirlenmesinde kullanılan büyüme performans indeksi $\phi'=log_{10}(k)+2log_{10}(L_\infty)$ formülü kullanılarak hesaplanmıştır (Munro ve Pauly, 1983). Formüldeki ϕ' büyüme performansı indeksi, *W* ağırlık (g), *k* brody büyüme katsayısı, L_∞ balığın ulaşabileceği maksimum (asimptotik) boyu 'dur. *a* ve *b* parametreleri, denklemin logaritmik formunu kullanarak en küçük kareler yöntemiyle hesaplanmıştır. Büyüme türünün hipotezleri *t*-testi ile test edilmiştir. Bütün tanımlayıcı istatistikler ile grafik çizimleri Excel kullanılarak türetilmiştir (Microsoft Excel® 2010).

BULGULAR

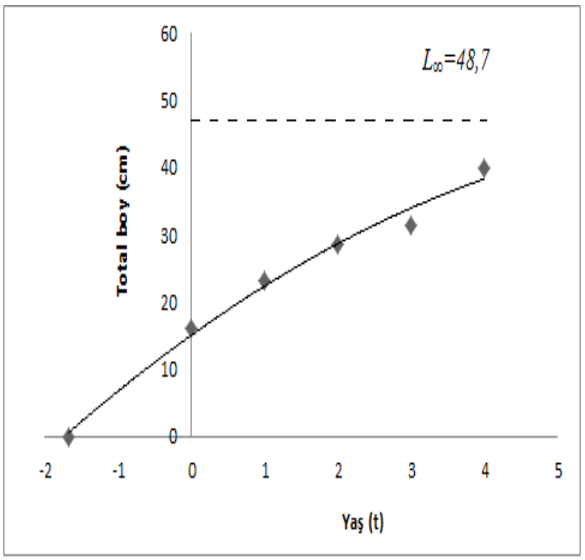
Çalışma kapsamında toplam 1023 adet lüfer balığı incelenmiştir. Araştırma süresince incelenen bireylerin minimum 12,3 cm ile maksimum 47,3 cm boy aralıklarında olduğu tespit edilmiştir. Boy dağılımlarına göre; 19 cm boyundaki bireylerin diğer boy gruplarına göre baskın olduğu ve örneklerin tamamının %7,5'lik kısmını teşkil ettiği belirlenmiştir. Çalışmada 20 cm boy değerinin altındaki birey sayısı araştırma boyunca incelenen örneklerin %74,5'ini oluşturduğu tespit edilmiştir. Genel olarak örneklerin tümü için boy-frekans dağılımları incelendiğinde total boy aralık değerlerinin daha çok 17-22 cm aralığında yoğunlaştığı belirlenmiştir. İncelenen bireylerin 534 adedini oluşturan dişi balıkların 13,1-42,2 cm boy aralıklarında dağılım gösterdiği ortalama boy değerlerinin 21,2±0,71 cm olduğu tespit edilmiştir. 489 adet olarak belirlenen erkek bireylerde ise boy dağılımları 12,3-47,3 cm aralığında olduğu, ortalama boy değerinin 20,9±0,67 cm olduğu belirlenmiştir. Çalışma boyunca incelenen örneklerin cinsiyet gruplarına göre boy-frekans dağılımları Şekil 2'de verilmiştir.

Araştırma alanı içinde örneklenen bireylerin boy-ağırlık ilişkisi, $W=0,0107L^{2,9574}$ olarak hesaplanmıştır. Yapılan *t* testi ile büyüme şeklinin izometrik (*b*=3, P>0,05) olduğu tespit edilmiştir. Otolitlerden yapılan yaş okumaları ile örnekleme alanı için bireylerin 0 ile IV yaş aralığında oldukları tespit edilmiş olup sırasıyla; 0 yaş, 255 adet ortalama 16,07±0,25 cm, I yaş 578 adet ortalama 23,54±0,36 cm, II yaş 145 adet ortalama 28.80±0.11 cm, III yaş 41 adet ortalama 31,60±0,18 cm, IV yaş 4 adet ortalama 39,90±0,45 cm olarak hesaplanmıştır (Şekil 3).

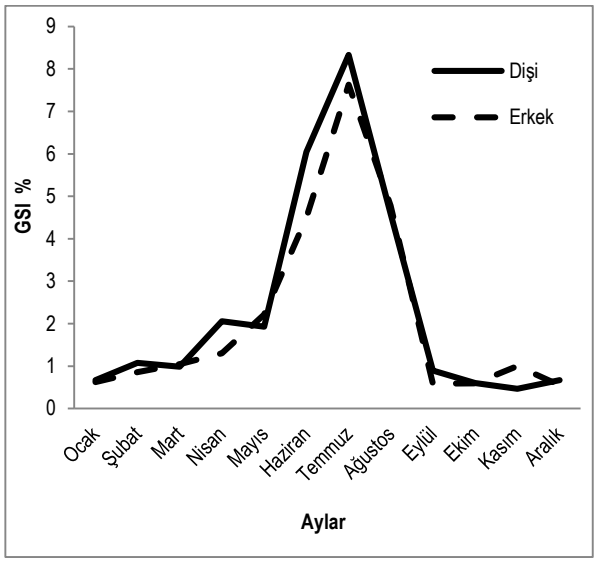
Yaşlara göre toplam örnek bireyler için von Bertalanffy boyca büyüme eşitliği $L_t = 48,7[1-e^{(-0,247(t-(-1,677))}]$, büyüme performans indeksi ise (ϕ') 2,757 olarak hesaplanmıştır.



Şekil 2. Cinsiyet gruplarına göre total boy-frekans (%) dağılımı
Figure 2. Total length-frequency (%) distribution by sex groups



Şekil 3. *Pomatomus saltatrix*'in büyüme eğrisi (Marmara Denizi)
Figure 3. Growth curve of *Pomatomus saltatrix* (Marmara Sea)



Şekil 4. Lüferin gonadosomatik indeks (GSI) değerlerinin aylık dağılımı
Figure 4. Monthly distribution of gonadosomatic index (GSI) values of bluefish

Üreme döneminin tespiti için toplam 1023 adet örneğin gonadı incelenmiştir. Aylık yapılan inceleme ile gonad ağırlıklarının deniz suyu sıcaklığının yükselmeye başladığı Mayıs ayından sonra artmaya başladığı, Temmuz ayında ise en yüksek değere ulaştıktan sonra hızlı bir ivme ile düşüşe geçtiği görülmüştür. Dolayısıyla, üreme döneminin gonadların boşalmaya başladığı Haziran ve Ağustos aylarını kapsayan dönemler olduğu tespit edilmiştir (Şekil 4).

Örneklemede aylık veriler dikkate alındığında en yüksek gonadosomatik indeks değerleri Temmuz ayında, dişilerde 8,333±1,182 erkeklerde ise 7,629±1,781 olarak hesaplanmıştır. En düşük değer ise dişilerde Kasım ayında 0,462±0,200, erkeklerde Aralık ayında 0,545±0,263 olarak hesaplanmıştır (Tablo 1). Aylık olarak dişi ve erkek bireyler arasındaki fark önemsiz bulunmuştur (P>0,05).

Tablo 1. Eşey gruplarına göre aylık gonadosomatik indeks değerleri
Table 1. Monthly gonadosomatic index values according to sex groups

	Dişi		Erkek		Toplam	
Aylar	**N**	**GSI±S.H.**	**N**	**GSI±S.H.**	**N**	**GSI±SH**
Ocak	96	0.666±0.384	77	0.625±0.409	173	0.648±0.395
Şubat	19	1.078±0.910	35	0.858±0.386	54	0.936±0.623
Mart	80	0.986±0.547	59	1.047±0.601	139	1.012±0.569
Nisan	21	2.054±1.194	18	1.299±1.523	39	1.706±1.390
Mayıs	56	1.929±2.901	68	2.216±3.721	124	2.087±3.360
Haziran	28	6.049±1.894	28	4.498±2.500	56	5.274±2.330
Temmuz	19	8.333±1.182	25	7.629±1.781	44	7.931±1.575
Ağustos	19	4.593±2.316	19	4.776±1.224	38	4.684±2.324
Eylül	54	0.897±0.745	54	0.587±0.529	108	0.742±0.662
Ekim	54	0.598±0.348	49	0.597±0.425	103	0.598±0.386
Kasım	11	0.462±0.200	15	1.000±1.088	26	0.772±0.867
Aralık	77	0.667±0.279	42	0.545±0.263	119	0.624±0.279
Toplam	**534**	**1.625±2.244**	**489**	**1.561±2.390**	**1023**	**1.594±2.308**

N: örnek sayısı; GSI: gonadosomatik indeks; S.H.: standart hata.

TARTIŞMA VE SONUÇ

Bu çalışmada, lüfer balığının Marmara populasyonunun büyüme ve üreme özellikleri araştırılmıştır. Örneklerin boy dağılımlarının 12,3-47,3 cm arasında değiştiği ve örnek dağılımı içerisinde 19 cm boyundaki bireylerin baskın olduğu tespit edilmiştir.

Ülkemizde ve Dünya'da lüfer balıkları ile ilgili yapılan çalışmalarda farklı araştırma alanları için boy aralıkları farklılık arz etmektir. Sonuçlar, genellikle bulgularımız ile paralellik göstermesine karşın farklı araştırma sonuçları da mevcuttur. Bölgeler arasında ortalama boy gruplarına karşılık gelen yaş değerlerinin farklı olduğu, bunun nedeninin büyümeyi etkileyen çevresel faktörlerden sıcaklık ve besin bolluğuna bağlı olarak aynı yaş gruplarının diğer bölgelere göre boyca ve ağırlıkça daha hızlı büyümeyle ilişkili olduğu düşünülmektedir (Dhieb, 2006). Tablo 2'de verilen farklı bölgelerde yapılmış önceki çalışma sonuçlarının tümünde boy ağırlık ilişkisinin derecesinin yüksek olduğu ancak büyüme katsayısı olan b değerinin ise birbirlerinden farklı olduğu görülmüştür. Boy-ağırlık ilişkisi parametrelerinden b değeri ile büyüme indeksi (ϕ') bölgeler arasında değişebildiği gibi aynı türlerin benzer habitatlar arasında da farklılık gösterebilir. Boy-ağırlık ilişkisi parametrelerinde görülen farklılıklar, habitatlar veya ekolojik koşullardaki değişikliklerden kaynaklanabilmektedir (Le Cren, 1951). Ayrıca, bu farklılıklar örnekleme büyüklüğüne, balıkçılık av ekipmanlarına, mevsime ve üremeye bağlıdır. Yaptığımız bu araştırma sonuçlarının Ceyhan (2005) ile uyumlu olduğu diğer araştırma sonuçları ile farklılık arz ettiği görülmüştür. Bunun başlıca sebebinin çalışma alanlarının benzer olması ile ilişkili olduğu tahmin edilmektedir. *P. saltatrix*' in boy ağırlık ilişkisi parametreleri ile büyüme indekslerinin farklı bölgelerde yapılmış önceki çalışma sonuçları Tablo 2 ve Tablo 3'te verilmiştir.

Tablo 2. Lüferin boy ağırlık ilişkisi parametreleri ile ilgili önceki çalışma sonuçları
Table 2. Previous study results of length-weight-relation parameters of bluefish

Araştırmacılar	Araştırma alanı	Boy (cm)	Ağırlık (g)	Boy-ağırlık ilişkisi parametreleri			
		Min.-Maks.	Min.-Maks.	a	b	r^2	n
Türgan (1959)	Marmara Denizi						2297
Alpaz ve Kınacıgil (1988)	İzmir Körfezi	15.0-40.5		0.0202	2.96		400
Oliver vd. (1989)	Güney Florida			0.0002	2.90		
Barger (1990)	Meksika Körfezi			0.0002	2.80		611
Barger (1990)	Atlantik Okyanusu			0.0001	2.77		588
Bernardes ve Rossi (2000)	Güney Brezilya	15-20.7		6.0E-06	3.05	0.91	24
Morato vd. (2001)	Atlantik Okyanusu	8.6-91		0.091	3.01		
Frota vd. (2004)	Brezilya Kıyıları	48.0-75.5	977.8-3143	0.0595	2.50	0.96	67

Ceyhan (2005)	Kuzey Ege ve Marmara Denizi	8.4-45.3	7-996.7	0.0063	3.22	0.92	2817
Kalaycı vd. (2007)	Orta Karadeniz	13.2-21-7	23.21-88.19	0.0130	2.86	0.92	143
Karachle ve Stergıou (2008)	Ege Denizi	13.1-18.5		0.002	3.44	0.99	6
Özdemir vd. (2009)	Orta Karadeniz	9.2-23.4	10.1-135.5	0.003	3.32	0.98	820
Özdemir vd. (2010)	Orta Karadeniz	9.7-23.1	9.8-126.9	0.0030	3.39	0.99	529
Ak vd. (2009)	Doğu Karadeniz	11.6-22.2	12.0-131.0	0.003	3.33	0.97	14
Bök vd. (2011)	Marmara Denizi	10.6-24.0	12.1-107.6	0.032	2.52	0.85	290
Kasapoğlu ve Düzgüneş (2013)	Karadeniz	12.5-20.2	16.0-75.19	0.009	3.00	0.86	25
Cengiz (2014)	Çanakkale Boğazı	76.5	4800				1
Samsun vd. (2017)	Orta Karadeniz	16.1-27.5	32.5-227.9	0.007	3.15	0.95	820
Samsun vd. (2017)	Orta Karadeniz	8.5-29.6	5.9-263.1	0.0046	3.25	0.95	790
Bu Çalışma	Marmara Denizi	12.3-47.3	18.9-794.1	0.010	2.95	0.97	1023

Tablo 3. Lüferin büyüme parametreleri ile ilgili farklı bölgelerde yapılmış çalışma sonuçları
Table 3. Study results on the growth parameters of bluefish in different regions

Araştırmacılar	Araştırma Alanı	N	L_∞	k	t_0	ϕ'
Lassiter (1962) (İlkbahar)	Kuzey Karolina	290	67.5	0.34	-0.25	3.19
Lassiter (1962) (Yaz)	Kuzey Karolina	154	128.5	0.10	-1.37	3.22
Richards (1976)	Güney İzlanda	64	79.5	0.32	-0.08	
Wilk (1977)	Florida	>25000	87.9	0.24	-0.11	3.27
Champagnat (1983)	Kuzey Batı Afrika	8771	104.4	0.228	-0.52	3.29
Barger (1990)	Atlantik Okyanusu	842	101.9	0.10	-2.49	3.29
Barger (1990)	Meksika Körfezi	1190	94.4	0.18	-1.03	3.21
Salerno vd. (2001)	Atlantik Okyanusu	3334	87.2	0.26	-0.93	3.30
Ceyhan (2005)	Kuzey Ege ve Marmara	2817	51.0	0.228	-1.26	2.77
Dhieb (2006)	Güney Doğu Tunus	577	48.3	0.195	-0.99	2.67
Bu Çalışma	Marmara Denizi	1023	48.7	0.247	-1.677	2.75

Yapılan araştırmada, ortalama gonadosomatik indeks değerleri 0,462-8,333 arasında değiştiği, üremenin deniz suyu sıcaklığının 25°C olduğu Temmuz ayında gerçekleştiği tespit edilmiştir.

Kuzeybatı Akdeniz'de yapılan bir araştırmada, yumurtlamanın, su sıcaklığının 25°C olduğu Temmuz ayında gerçekleştiği bildirilmiştir (Sabates ve Martin, 1993). Farklı bir araştırmada Karadeniz'de üremenin Ukrayna ve Bulgaristan kıyılarında 20-26°C su sıcaklığında olduğu rapor edilmiştir (Gordina ve Klimova, 1996). Agassiz ve Whitman (1885)' göre Güney İngiltere kıyıları boyunca deniz suyu sıcaklığının yılın en yüksek sıcaklık değerlerine ulaşmadığı sürece üreme gerçekleşmemektedir. 1960-1962 yıllarında Virginia açıklarında yapılan bir araştırmada benzer şekilde üremenin Temmuz Ağustos aylarında gerçekleştiği tespit edilmiştir (Norcross vd., 1974). Bu sonuçlar türün su sıcaklığına bağlı üreme döneminin tespit edildiği çalışma bulgularını desteklemektedir.

Güneydoğu Tunus kıyılarında yapılan bir başka araştırmada ise ortalama gonadosomatik indeks değerlerinin 1,54 ile 7,75 arasında değiştiği üremenin ise Ekim ayında gerçekleştiği belirtilmiş ancak lüferin üreme dönemi için gerekli olacak deniz suyu sıcaklığının (ortalama 25 ºC) Güney Doğu Tunus kıyılarında ancak bu dönemde yükseldiği belirtilerek üreme dönemi için esas koşulun su sıcaklığı olduğu vurgulanmıştır (Dhieb, 2006).

Marmara Denizi'nde yapılmış bu çalışma ile türün büyüme ve üreme özellikleri belirlenmiştir. Yaş kompozisyonu içerisinde 0 ve I yaşlı bireylerin ağırlıkta olduğu tespit edilmiştir. Söz konusu bu durumun daha önceki benzer çalışmaların sonuçlarında olduğu gibi kullanılan av aracı ve yoğun av baskısına bağlı olarak gerçekleştiği, lüferin yeterince büyüyemeden ve üreme fırsatı bulamadan avlandığı sonucunu açık bir şekilde göstermiştir. Bu nedenle, yoğun av baskısını ortadan kaldıracak tedbirlerin alınması elzemdir. Aksi takdirde mevcut olumsuz durumun devam etmesi halinde giderek azalan stoklar yakında yok olma tehlikesi ile karşı karşıya kalacak, korunması gereken önemli türler arasındaki yerini alacaktır.

Bu çalışma sonuçları araştırma sahası içerisindeki türün mevcut stoklarının takibi ve sürdürülebilir balıkçılık yönetimine katkı vereceği gibi yapılması planlanan sonraki çalışmalar için kaynak teşkil edecektir.

TEŞEKKÜR

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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

The fifth culture generation of Black Sea Trout (*Salmo trutta labrax*): Culture characteristics, meat yield and proximate composition

Beşinci nesil Karadeniz Alabalığı (*Salmo trutta labrax*): Kültür özellikleri, et verimi ve besin bileşimi

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Abstract: In this research, the culture characteristics of the fifth generation of Black Sea trout (*Salmo trutta labrax* PALLAS, 1814) were evaluated. First of all, trout were cultured in recirculating aquaculture system (RAS) and they kept in RAS until smoltification. After that, they were transported to marine cages till market size. Thus, the ratios of specific growth rate (SGR), feed conversion (FCR), mortality and condition factor (CF) were specified from hatching to 16th month and the results were evaluated as pre-smoltification and after-smoltification individually. Moreover, the meat yield and proximate composition of Black Sea trout's fifth generation was specified in market size. Samplings were carried out monthly between February 2014 and May 2015. Fish were started to feed in 0.105±0.007g until they reached to 335.50±44.39g in May 2015. According to results; SGR, CF, FCR and mortality were determined as between 0.98-2.70, 0.86-1.15, 1.02-1.30 and 7.67-7.78% until smoltification stage, respectively. However, they were detected between 0.68-2.36, 1.04-1.20, 0.98-1.35 and 0.01-5.82% after smoltification. Also, the meat yield, viserosomatic index (VSI) and hepatosomatic index (HSI) were found to be 60.30%, 9.28% and 1.65% in market-size respectively. According to chemical analyses, trout meat contains crude protein as 15.22%, fat as 7.21%, ash as 1.51% and water (moisture) as 75.17%. In the view of the results, culture characteristics, proximate composition and meat yield were found similar to other cultured trout species. With these features, the fifth generation can be recommended to aquaculture sector considering the economic value of the Black Sea trout in Turkey.

Keywords: *Black Sea Trout, feed conversion ratio, proximate composition, condition factor, Salmo labrax, endemic*

Öz: Bu çalışmada, Karadeniz alabalığı (*Salmo trutta labrax* PALLAS, 1814)'ın beşinci neslinin kültür karakteristikleri belirlenmiştir. Öncelikle alabalıklar kapalı devre yetiştiriclik ünitesi (RAS)'nde üretilmiş ve smolt boya gelene dek burada tutulmuşlardır. Sonrasında, alabalıklar deniz kafeslerine transfer edilmişler ve porsiyonluk boya gelene kadar orada tutulmuşlardır. Bu nedenle; spesifik büyüme oranı (SGR), yem dönüşüm oranı (FCR), ölüm oranı ve kondüsyon faktörü (CF) parametreleri yumurtadan çıkıştan 16. aya kadar belirlenerek sonuçlar smolt öncesi ve smolt sonrası olarak verilmiştir. Ayrıca, beşinci nesil Karadeniz alabalığının porsiyonluk boydaki et verimi de hesaplanmıştır. Örneklemeler, Şubat 2014 ile Mayıs 2015 arasında aylık olarak yapılmıştır. Balıklar 0,105±0,007g iken beslenmeye başlanmış ve Mayıs 2015'e kadar 335,50±44,39g'a ulaşmışlardır. Sonuçlara göre; smoltifikasyon öncesi SGR, CF, FCR ve ölüm oranı sırasıyla 0,98-2,70, 0,86-1,15, 1,02-1,30 ve %7,67-7,78 aralıklarında belirlenmiştir. Ancak bu parametreler smoltifikasyon sonrası 0,68-2,36, 1,04-1,20, 0,98-1,35 ve %0,01-5,82 olarak belirlenmiştir. Ayrıca; pazar boydaki et verimi, viserosomatik indeks (VSI) ve hepatosomatik indeks (HSI) değerleri sırasıyla %60,30, %9,28 ve %1,65 bulunmuştur. Kimyasal analizlere göre, alabalık eti %15,22 ham protein, %7,21 ham yağ, %1,51 ham kül ve %75,17 su (nem) içermektedir. Sonuçlar açısından, kültür özellikleri, besin bileşimi ve et verimi diğer kültüre alınan alabalık türlerine benzer bulunmuştur. Bu özellikleri ile, Karadeniz alabalığının eknomik değeri de göz önünde bulundurularak, beşinci nesil yetiştiricilik sektörüne önerilebilir.

Anahtar kelimeler: *Karadeniz alabalığı, yem dönüşüm oranı, besin bileşimi, kondüsyon faktörü, Salmo labrax, endemik*

INTRODUCTION

The aquaculture has increasing all over the World and culturing of new species are achieved day by day (FAO, 2017). Salmonidae species are integral part of the aquaculture sector (Emre and Kurum, 1998; Herrmann *et al.*, 1993; Katz, 2016) with their extensive economic value (Yeakley and Hughes, 2013) and they adapted to many countries having various environmental conditions since 1970 (Knapp *et al.*, 2007). In Europe, Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) which have great importance for aquaculture sector (Alexandre and Palstra, 2017; Janssen *et al.*, 2015; Liu *et al.*, 2016) are cultured extensively for a long time (Elliot, 1975; Taranger *et al.*, 2015) consisting almost 60% of total finfish production (European Commision, 2015). Economic profitability of aquaculture and the rising importance of product varity made Salmonids as significant (Bagliniere and Maisse, 1991). For this reason, there are lots of Salmonidae

species around the world which are cultured (Okumus, 2000).

Black Sea trout (*Salmo trutta labrax*) is also belongs to Salmonidae family and endemic species for eastern Black Sea (Geldiay and Balik, 1996; Innal and Erk'akan, 2006). Black Sea trout reproduce in up of the rivers where the same river they were hatched from the egg usually and they migrated to sea after smoltification for feeding parallel with growing (Geldiay and Balik, 1996; Slastenenko, 1956; Solomon, 2000; Svetovidov, 1984). This species has three ecotypes such as river, sea and lake and all of them found in Black Sea region of Turkey (Tabak *et al.*, 2001). However, Black Sea trout is listed within important and vulnerable species by Black Sea Biodiversity and Landscape Conservation Protocol (2003). Despite the IUCN Red list (2016) state that *Salmo trutta labrax* not yet been assessed for their database, this species endangered according to several domestic lists (GRID, 1999; Peev *et al.*, 2011) in Black Sea countries such as Bulgaria, Georgia and Russia. For this reason, the culture adaptation studies of this species were started by the Central Fisheries Research Institute (CFRI) from Turkey with the aim of conservation of Black Sea trout since 1998. After the success of the Black Sea trout culture, the culturing of this species has become prevalent especially in Eastern Black Sea region. Nowadays, nineteen fish farm which are registered to Republic of Turkey, Ministry of Food, Agriculture and Livestock are culture Black Sea trout legitimately and their culture reached 1440 ton per year in 2015 (TSI, 2016). Ultimately, the fifth culture line (F5) was achieved today with the works carried out such years. In this study; culture characteristics, meat yield and proximate composition of the latest culture line (fifth) of Black Sea trout were evaluated.

MATERIALS AND METHODS

Fish material

Broadstocks caught from their natural habitats which they are rivers of Firtina, Caglayan and Kapistre in northern Black Sea region in 1999 and they were adapted to culture conditions. In this study, fourth generation (F4) of Black Sea trout used as broadstocks and fifth generation (F5) which is latest culture line produced by Central Fisheries Research Institute in 2014-2015 breeding season were used in main study. The fertilised eggs of Black Sea trout are develop till 28th day, hatch in 41th day (Firidin *et al.*, 2012) and larvae are consumes their yolc sac completely until 30th day after the hatching (Cankiriligil *et al.* 2016). In January, obtained larvae were started to feed and growing was started to monitoring in February 2014. Approximately 4000 larvae were used in this study. All experiments were carried out in accordance with ethical conduct amendments of ARRIVE guidelines (Kilkenny *et al.*, 2010) and European Union Directive as 2010/63/EU (European Commission, 2010).

Tank material and rearing conditions

Main study was carried out in both recirculation aquaculture system (RAS) at around 10°C and marine cages within the range of 6.5 °C - 29 °C sea temperature and %0.17 salinity between February 2014 and May 2015. After that, the growing of larvae till smoltification were carried out in recirculating system having 1x1x05m fiber tanks with 6.9 lt/min flow rate and 10 % water exchance per day. Stock density was set as 10 kg/m³ for fish until smoltification (Cakmak *et al.*, 2010). After smoltification, fish were transported and stocked as 20 kg/m³ to marine cage unit having 4x4x3m net cages (operated in 40°57'35.07"N, 39°51'21.17"E) in December in order to complete their life-cycle. Water temperatures were measured three times a day with thermometer in both RAS and marine cage units and were shown in Figure 1.

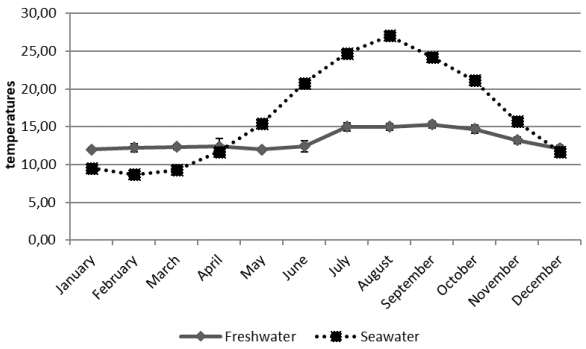

Figure 1. Yearly temperature records of freshwater re-circulating aquaculture system and marine cages. The lowest sea temperatures were recorded as 6.5°C in marine cages and 11.97°C in RAS unit. The highest tempretaures were recorded as 29°C in marine cages and 15.28°C in RAS unit.

Feeding

In the study, commercial rainbow trout feed which they are different size were used for feeding fish (Table 1). Firstly, fish were fed with daily equal to 3 percent of live fish weight and in time, this ratio was decreased to 1.5 percent parallel with fish growing. In feeding, 300-500µ granul feed was used as pre-growing feed and in time, different sized granul feed in range of 500-800µ and 6mm were used respectively. Feeding was carried out 5 times per day in starting and 3 times per day in growing.

Table 1. Commerical rainbow trout feed ratio

Composition	Pre-growing	Growing
Protein (min %)	50.0	49.0
Fat (min %)	15.0	15.0
Ash (max %)	12.0	12.0
Cellulose (max %)	2.0	3.0
Moisture (max %)	12.0	10.0
Phosphor (min %)	1.5	1.5
Metabolizable energy (kcal/kg)	4150.0	4000.0

Determination of growth characteristics

In this study, Fulton's condition factor (CF), weight gain (WG), specific growth rate (SGR), feed conserving ratio (FCR), survival rate (SR), meat yield, hepatosomatic index (HIS) and viserosomatic index (VSI) were determined in order to determinate growth characteristics of Black Sea trout' fifth generation. The mesaurements were carried out monthly. Fish lenght measured with Von-Bayer scale and the weight was determined by using digital balance with an accuracy of 0.01g (Holden and Reitt, 1974).

The equations given below were used in order to calculate these characteristics.

Fulton's condition factor (CF) (Ricker, 1975);

$CF = (W / L3)\ x\ 100$ W: Weight (g), L: Lenght (cm).

Weight gain (Ji *et al.*, 2011);

$GR\ \% = [(W2 - W1) / W1]\ x\ 100$ W_1: Starting weight (g), W_2: Final weight

The specific growth (Bagenal and Tesch, 1978; Houde and Scheckter, 1981);

$SGR\ \% = [(lnW2 - lnW1) / t]\ x\ 100$ W_1: Starting weight (g), W_2: final weight (g), t: duration.

Feed conversiton ratio (Ebrahimi and Ouraji, 2012);

$FCR = Fo / Wg$ F_o: Consumed feed amount (g), Wg: Weight gain.

Survival rate (Kritsanapuntu *et al.*, 2013);

$SR: 100\ x\ (n1/n0)$ n_1: Final living fish quantity, n_0: starting living fish quantity.

The meat yield was calculated with edible meat after the fish filleted and seperated all organs such as gonad, digestive tract, gill and others. An equation was used to estimation of meat yield given below (Öztan, 2005). Also, viserosomatic index and hepatosomatic index were calculated according to this equation.

$$Meat\ yield = [Meat\ weight\ (g) / Total\ weight\ (g)]\ x\ 100$$

$$VSI = [Viscera\ weight\ (g) / Total\ weight\ (g)]\ x\ 100$$

$$HSI = [Liver\ weight\ (g) / Total\ weight\ (g)]\ x\ 100$$

Proximate composition analysis

Total moisture, crude protein, fat and ash contents were determined to identify proximate composition. In the analyses, 30 market-sized fish was used. Trout fillettes were used as whole and sectioned from three different body parts. First of all proximate composition of whole fillets were determined. Subsequently, fillets were cut into two pieces throughout from anus to dorsal, vertically. The meat tissue from anus to caudal fin named as caudal section. Second part of the fillet were also divided two pieces throughout to linea laterallis and upper part was named as dorsal, lower part was named as abdomen sections. Ultimately, Moisture content was analysed by Horwitz (2000). Samples dehydrated in drying oven at 110ºC for 6 hours in each sample (Horwitz, 2000). Crude protein was determined by Kjeldahl (AOAC, 2000) method. In this method, the samples were digested with sulphuric acid and Kjeldahl catalyst containing selenium. Afterwards, the samples were distilled with sodium hydroxide. Further, the samples were titrated with HCl and obtained data were calculated by using 6.25 nitrogen conversion factor for fish and fishery products. The crude fat was specified by Folch *et al.* (1957). According to this method, fat content of fish meat was extracted from 5 gram of fish meat with 10 milliliter chloroform:methanol mixture (2:1) for 12 hours. The extracted samples were evaporated with a rotary evaporator at 55ºC until the mixture was concentrated. Afterwards, Total crude ash was determined by Horwitz (2000) method. According to the method, the samples were at 600ºC for 6 hours in burned by muffle. Ultimately, the obtained data of total fat and ash were estimated as percentages.

Statistical analyses

Differences between groups means were determined by one-way analysis of variance ANOVA using Tukey's multiple comparison tests. The level of significance was set as 0.05 (Zar, 1999). All statistics analyses were calculated using IBM SPSS Statistics package programme version 21.0.

RESULTS AND DISCUSSION

The results were evaluated as pre-smolt and after-smolt along with their culture environment. In the beginning, fish mean weight determined as 0.105±0.007g and they reached to smolt lenght with 12.67±0.69cm length and 19.84±3.16g weight in 10th month. Cakmak *et al.* (2007) stated that, smoltification of Black Sea trout occurs between 11.25–11.50 cm and after smoltification they can adapt to marine conditions quickly same as Atlantic salmon (*Salmo salar*) (Davidson and Good, 2016). After smoltification, trouts were transferred to marine cages and they reached to 335.50±44.39g in feeding trial ends (Table 2). The SGR were determined as highest in 4th month with 2.70 and in 12th month with 2.36, lowest in 2nd month with 1.18 and in 15th month with 0.68, in pre-smolt and fillet-size respectively. In smolt size, SGR was determined as 0.98. The condition factor was calculated lowest in pre-smolth with 0.86±0.09 and highest in after smolt with 1.20±0.10. In smolt size, CF was calculated as 0.97±0.08. The decrease of condition factor occurring in smolt size related to fish transporting to marine cages as well as stress caused by saltiness of Black Sea The mean of feed conversion ratio was determined as 1.10±0.12 in pre-smolt, 1.18±0.12 in after smolt respectively. The survival rate was determined as 93.89±3.75% in fresh water and 99.44±0.96% in marine cages. Finally, the mean weight of trout individuals calculated as 335.50gr as well as maximum as 347.85gr and minimum as 257.95gr. Growing parameters of Black Sea trout were shown in Table 2.

Table 2. Growing parameters of Black Sea trout alevin from hatching to 16th month beetween February 2014 and May 2015. CF: Condition factor, GR: Growth rate, SG: Spesific growth, SGR: Spesific growth rate, FI: Feed intake (biomass day %).

n:50	Lenght	Weight	CF	GR	SG	SGR	FI
Feb	2.30±0.10^{n}	0.11±0.01^{i}	0.86±0.09^{g}	-	-	-	-
Mar	2.60±0.14^{n}	0.15±0.02^{i}	0.88±0.06^{g}	32.38	0.11	1.18	%3
Apr	3.00±0.25^{n}	0.24±0.06^{i}	0.88±0.09^{g}	52.52	0.24	1.85	%3
May	3.80±0.34^{m}	0.50±0.13^{i}	0.88±0.06^{g}	124.53	0.88	2.70	%3
Jun	4.70±0.30^{l}	1.09±0.22^{i}	1.00±0.06^{f}	120.38	1.91	2.17	%2.5
July	6.50±0.59^{k}	3.16±0.79^{hi}	1.13±0.08^{ef}	274.64	9.60	2.21	%2.5
Aug	8.10±0.69^{j}	6,03±1.54^{hi}	1.11±0.07^{e}	28.24	3.70	2.16	%2
Sep	9.48±0.81^{i}	10.04±2.70^{ghi}	1.15±0.08^{d}	99.80	16.77	1.70	%2
Oct	10.80±0.75^{h}	14.78±3.22^{gh}	1.14±0.07^{cd}	33.76	11.33	1.29	%2
Nov	12.67±0.69^{g}	19.84±3.16^{fg}	0.97±0.08^{bcd}	28.66	12.87	0.98	%2
Dec*	14.10±1.13^{f}	32.1±6.228^{f}	1.04±0.09^{bc}	73.86	42.67	1.61	%1.5
Jan	17.72±1.17^{e}	65.33±11.05^{e}	1.17±0.07^{bc}	119.62	120.13	2.36	%1.5
Feb	21.91±1.23^{d}	124.19±23.72^{d}	1.17±0.08^{bc}	69.99	154.37	2.14	%1.5
Mar	25.49±1.12^{c}	196.63±24.71^{c}	1.18±0.06^{bc}	57.51	215.63	1.53	%1.5
Apr	27.20±1.34^{b}	241.15±31.20^{b}	1.20±0.09^{ab}	25.95	153.27	0.68	%1.5
May	30.30±1.63^{a}	335.50±44.39^{a}	1.20±0.10^{ab}	41.46	308.40	1.10	%1.5

* Values are expressed as mean ±SD (n = 3), mean values in column with different superscripts were significantly different (P <0.05).

The first generations of Black Sea trouts (F1) which they have 2.47±0.017 cm length and 0.093±0.0018g weight in starting were breeded for year in freshwater. According to results; trouts reached to 11.6±0.337 cm and 17.12±1.645 in one year. Afterwards they transported to marine cages and they showed quick growth rates in that environment as 20.1±0.589 cm and 101.77±8.957 g within three months. Their condition factor risen from 0.63± 0.016 to 1.04± 0.010 in end of the feeding trial. Moreover; their FCR were stated as2.52±1.41 and 2.83±0.70, survival rate were stated as 90.14±12.52% and 91.85±14.30% in pre-smolt and after-smolt era, respectively (Tabak *et al.*, 2001). Along with these, Black Sea trouts (F1) cultured in Abkhazia, Georgia reached to 20.9 cm length and 90.3 weight within 20 months (Solomon, 2000). In this study, the quick smoltification untill 10th month and reaching fillet-size in 15th month are achieved with selected breeding studies carried out since 1999 as well as decreases of mortality and feed conversion ratios in both pre-smolt and after smolt stages. According to results, condition factor was found higher to other studies carried out with first generations of Black Sea trout. The increase of condition factor in fifth generations also means to high meat yield and this condition were supported meat yield calculations. According to calculations, the meat yield of Black Sea trout's fifth genereation was calculated as 60.30±1.91% in fillet size. Atasaral Sahin et al. (2011) found meat yields raitos as 65.39% for *Salmo trutta labrax*, 67.28% for *Salvelinus fontinalis* and 69.83% for their hybrid. Also, Akhan et al. (2010) stated that meat yield of Rainbow trout that reared in Black Sea is vaired between 66.06±3.03% and 70.96±2.55%. After the trouts cleaned their bones, skin and whole viscera, they lose approximately %40 lose their total weight. Some cases, the meat yield can be observed lowly by reasons of gonadal growing caused by reproduction season as well as high VSI and HSI rates caused by over-feeding of some illnesses. Thus, viserosomatic index and hepatosomatic index were found as 9.27±1.12%, 1.65±0.86%, respectively. In the Black Sea trout's reproduction season, the size of gonads become larger until spawning and this situation meat yield are observe lowly (Cakmak *et al.*, 2007). The reproduction season starts in November and continue to mid-january, in culture conditions (Cakmak *et al.*, 2007). In our study, fillet-sized fish which they are not reached reproduction stage yet were used and this caused to low viserosomatic index rate as 9.27±1.12%.

Uysal and Alpbaz (2002) states that, wild Abant trout (*Salmo trutta abanticus)* and rainbow trout (*Oncorhynchus mykiss*) reached from 0.088±0.01g, 0.093±0.01g to 5.250±0.34g, 133.96±9.24g within 350days, respectively. Besides that, their condition factor as 0.90±0.01, 1.15±0.03 and mortality rate as 71%, 35% were determined. According to another research, brook trout (*Salvelinus fontinalis*) which they have 6.02±1.69 g weight in feeding trial was started is growth to 230.28±75.73g in saltwater, 318.50±99.39 g in freshwater. Also, feed conversion ratiso and mortality rate were determined as 1.71 and 58.5% in saltwater as well as 1.73 and 49.2% in freshwater (Okumus *et al.*, 1998). Also, Ustaoglu and Bircan (1998) stated that rainbow trout (*Oncorhynchus mykiss)* breaded in marine cages has 1.92±0.11 FCR, %17.92 mortality and 1.38±0.04 condition factor and they reached from 139.7g to 513.5±14.93g in the end of the 109 days of feeding trial. In our results, condition factor, survival rate and growth rate were found higher than the Abant trout (*Salmo trutta abanticus)* which is endemic species for Turkey and being cultured for the purpose of relasing to the rivers. Furthermore, while growth and mortality rates of rainbow trout cultured in freshwater which are one of the most cultured species in both fresh water and seas in Turkey (TSI, 2016) were found more than this study, condition factors were found statistically same. Our results also show that, Black Sea trout has lower growth rate and condition factor than rainbow trouts cultured in saltwater. When we compared to our results to data of other trout species cultured in Turkey, it is obvious fact that, the fifth generation of Black

Sea trout is promising species for aquaculture sector in terms of culture characteristics.

The lifelong alterations in the growth parameters of Atlantic salmon have been determined and listed below; mean smolt length as 14.8 cm (10.5–21.5 cm), mean smolt age as 2.91 years (1,04–5,85), mean survival rate from egg to smolt as %1.5 (%0.2–3.2), comeback length as 56.8 cm (48.5–70.0 cm), maturing in sea as 1.6 year(1.00–2.64) and rate of smolt to grilse as %7.4 (%1.3–17.5) (Hutchings and Jones, 1998). The mortality rate, specific growth rate and feed conversion rate belonging to Atlantic salmon which fed by nourishments included different levels of phospholipid, have been determined and listed as %3.57±0.90-%5.50±0.67; (SGR) 1.34±0.14-1.45±0.08; (FCR) 0.76±0.09-0.89±0.14, respectively (Taylor *et al.*, 2015). The individuals of Atlantic salmon have been weighted as 5,5 g on the average in the beginning of the experiment which nourished with products included different amounts of fish flour, wheat gluten flour and soya protein. At the end of an eighteen-week experimental period, final weight, total feed consumption and FCR values were detected and the values ranges between 19.23-27.29 g; 35.44-40.18 g; 1.85-2.63, respectively (Burr *et al.*, 2012). Other individuals of the species which were of 31.5 g on the average wight in the beginning have been observed for twelve-week period in the same study. Feeding products contained fish oil, chicken flour, corn and soya proteins were used during the experiment. At the end of the period; the final weight, total feed consumption, FCR and survival rate values were measured and the values range between; 101.7-109.9, 70.0-75.9g, 0.86-0.95 and 92.4-96.3, respectively. It is highly possible to accept the potential efficiency of the Black Sea trout in the aquaculture sector due to the approximate values of breeding performance of the Rainbow trout which cultured for more than a hundred year and of the brown trout cultured worldwide. It is recommended for the administrations to separate the broodfish from the broodstock after the age of 6 in which a decreasing performance in breeding is seen, in the applications of brood management. While rainbow trout adapted itself into sea water in the month of November which has the most proper sea water temperature, Black Sea trout until the 5th generation could be grown to the size that it can hardly be adaptated to sea water in the late period. To grow the F5 Black Sea trouts, which were produced in 2014 – 2015 producing period by CFRI, into smolt size will increase the profit by providing usage in advantages of sea water in producing.

According to proximate composition analysis; fifth generation of Black Sea trout meat has 75.17±1.21% moisture, 15.22±0.48% crude protein, 7.21±0.20% crude fat and 1.51±0.12% crude ash in fillet sized individuals. However, some chemical differences were observed by body parts. The meat obtained from dorsal section has highest crude protein as 16.71±0.44% and ash as 1.71±0.11%, the tail section has highest ratio of water as 76.20±1.02%. In abdomen, ratio of fat was determined as 10.38±0.51% and this amount is approximately two times higher than the meats sectioned from dorsal and tile sections. Proximate composition of Black Sea trout was shown in Table 3. The meat of Black Sea trout has high amount of protein, fat and ash. However, proximate composition of body parts shows differences. Abdomen section has highest fat ratio, lowest protein and moisture ratio. Contrary to this, dorsal section has highest protein and lowest fat ratios. Fish use dorsal muscles and tail for swimming and navigation. For this reason, these sections have more muscles and protein than the abdomen as might be expected (Videler, 1993; Wardle *et al.*, 1995). The abdominal part of the muscle tissues are major fat storage sites in Salmonids (Nanton *et al.*, 2007). Likewise, Black Sea trout is rich in terms of fatty acids (Sahin *et al.*, 2011) and moisture and fat are exist inversely correlated in food according to Dean (1990). Also, muscles need to carbohydrates which are mostly stored in muscles in the form of glycogen (Torgersen *et al.*, 2014) in order to compensate energy requariment for swimming (Palstra and Planas, 2011). For this reason, carbohydrate raitos were found more in dorsal and tail sections than the abdomen. Other studies that aim to evaluate proximate composition of Salmonid species in Turkey found similar results to ours. *Salmo trutta macrostigma* has 78.90±1.001%, 16.22±0.012%, 2.55±0.157%, 1.33±0.020% , *Salmo trutta abanticus* has 78.02±0.10, 18.91±0.18%, 1.44±0.03, 1.20±0.19 (Uysal et al., 2002), *Salmo trutta forma fario* has 78.30±0.36, 17.36±0.13, 2.71±0.21, 1.16±0.03 (Kaya et al., 2014), *Salvelinus fontinalis* has 23.46±0.15%, 69.51±0.37%, 9.92±0.07%, 8.05±0.18 (dry weight basis) (Sahin et al., 2011), *Oncorhynchus mykiss* has 77.78±1.10%, 15.47±0.21%, 4.11±0.55, 1.94±0.04% (Çankırılıgil & Berik, 2017) moisture, crude protein, fat and ash, respectively.

Table 3. Proximate composition of Black Sea trout's fifth generation

%	Dorsal	Abdomen	Caudal	Whole meat
Moisture	75.43±1.21^{b}	72.87±0.89^{c}	76.20±0.41^{a}	75.17±1.42
Protein	16.71±0.44^{a}	14.49±0.24^{c}	15.21±0.51^{b}	15.22±0.48
Fat	4.71±0.52^{c}	10.38±0.51^{a}	6.03±0.47^{b}	7.21±0.20
Ash	1.71±0.11^{a}	1.54±0.22^{b}	1.45±0.31^{c}	1.51±0.12
Carbohydrate	1.44±0.03^{a}	0.72±0.01^{c}	1.11±0.01^{b}	0.89±0.02

** Values are expressed as mean ±SD (n = 3), mean values in row with different superscripts were significantly different (P <0.05).*

Values of whole meat were not used in statistical analyses. It is fact that, best way of supplying fish source regularly and constantly to food sector is aquaculture in terms of sustainability (Anderson, 2007; Broitman *et al.*, 2017).

According to Teletchea and Fontaine (2014) aquaculture industry can focus on domestication of native fish species in future. Besides, 60% of European consumers like to try new fish products and species (European Commission, 2017). Thus, Black sea trout culture is becoming prevalent to aquaculture and seafood sector with all these developments. In sum, the growth performance and culture characteristics of individuals belongs to fifth culture line were evaluated in this study considering the profitable economic production models that use to culturing of Black Sea trout in Turkey. Moreover, the meat yield and proximate composition of F5 culture line were determined with the purpose of reveal that Black Sea trout as a valuable and nutricious fish species same as other prominent Salmonids. It is excpected that the study will submit further data to science community as well as becoming a source for Black Sea Trout culturing sector having a great importance for the food sector and the consumer.

CONCLUSION

Black Sea trout same as Rainbow trout are bred to a certain length in fresh water facilities and transplanted to cages in the Black Sea, when the temperature of seawater is convenient. In this manner, an aquaculture model has been used which took the advantages of salt water on the trout growth in this study. Besides, Black Sea trout has high potential for aquaculture sector. In this research, culture characteristics, meat yield and proximate composition of the Black Sea Trout's (*Salmo trutta labrax*) fifth generation (F5) were evaluated. In a conclusion, the fifth generation can be suggested to aquaculture sector as a new culture line with their similarities other cultured Salmonid species in terms of both culture conditions and consumer interests.

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