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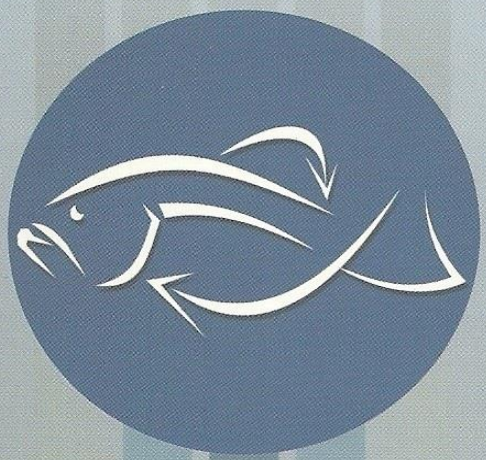

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Yazılar, dergiye yalnızca çevrimiçi gönderi sistemi ile elektronik versiyonda aşağıdaki talimatlara göre gönderilmelidir.

Yazı gönderi tipleri
Araştırma makaleler, derleme makaleler, kısa notlar ve raporlar, editöre mektup.

- Araştırma makaleler; Daha önce yayınlanmamış olan ve 7500 kelimeyi veya 25 sayfayı geçmemesi gerekir. Orijinal tam metin araştırma makaleleri (tablolar ve resimler dahil)
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  - o Materyal ve Yöntemler
  - o Bulgular
  - o Tartışma (Uygunsa Bulgular bölümü ile birleştirilebilir)
  - o Sonuçlar
  - o Etik Standartlara Uyum
    - a) Yazarların Katkıları
    - b) Çıkar Çatışması
    - c) Hayvanların Refahına İlişkin Beyan
    - d) İnsan Hakları Beyanı
  - o Kaynaklar
  - o Çizelge(ler) (metinde uygun konumda)
  - o Şekiller (metinde uygun konumda)
  - o Ekler (varsa)

Makale Formatı
Makale boyunca A4 boyutundaki kağıdın tüm kenarlarında çift aralıklı ve 25 mm kenar boşluklu referanslar, tablo başlıkları ve şekil başlıkları dahil olmak üzere 12 puntoluk bir yazı tipi kullanın (Times New Roman). Sayfanın bütün yönlerinde 25 mm'lik kenar boşlukları kullanın. Metin tek sütun formatında olmalıdır Yazarların şablon dosyalarını aşağıdaki bağlantılardan indirmeleri önerilir:

• Her sayfa Arap rakamları ile numaralandırılmalı ve yazının başından sonuna kadar satırlar sürekli olarak numaralandırılmalıdır.
• Vurgu için italik kullanın.
• Yalnızca SI (uluslararası sistem) birimlerini kullanın.
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Sorumlu yazar, kaynak listesinden önce ayrı bir bölümde makale metnine bir özet açıklama ekleyecektir. Aşağıdaki açıklama örneklerine bakın:

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Lütfen makale için yazarların katkılarını sağlayın. Ad ve soyadlarının ilk harflerini kullanın (örneğin; Yazar MO çalışmayı tasarladı, MF makalenin ilk taslağını yazdı, AF istatistiksel analizleri gerçekleştirdi ve yönetti. Tüm yazarlar son makaleyi okudu ve onayladı.).

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Mevcut herhangi bir çıkar çatışması burada verilmelidir. Çatışma yoksa, yazarlar şunları belirtmelidir:
Çıkar Çatışması: Yazarlar çıkar çatışması olmadığını beyan ederler.

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Çalışmada hayvan kullanılmışsa; Araştırma için kullanılan hayvanların refahına saygı gösterilmelidir. Hayvanlar üzerindeki deneyleri bildirirken, yazarlar aşağıdaki ifadeyi belirtmelidir:
Etik onay: Hayvanların bakımı ve kullanımı için geçerli tüm uluslararası, ulusal ve / veya kurumsal yönergelere uyulmuştur.
Veya geriye dönük çalışmalar için; makale metninde bir özet beyan aşağıdaki şekilde yer almalıdır:
Etik onay: Bu tür bir çalışma için resmi onay gerekli değildir.

d) İnsan Hakları Beyanı
İnsan katılımcıları içeren çalışmaları bildirirken, yazarlar aşağıdaki ifadeyi eklemelidir:
Etik onay: Çalışmalar, uygun kurumsal ve / veya ulusal araştırma etik komitesi tarafından onaylanmış ve 1964 Helsinki Bildirgesi ve daha sonra yapılan değişiklikler veya karşılaştırılabilir etik standartlarda belirtilen etik standartlara uygun olarak gerçekleştirilmiştir. Veya geriye dönük çalışmalar için; makale metninde aşağıdaki gibi bir özet beyan yer almalıdır:
Etik onay: Bu tür bir çalışma için resmi onay gerekli değildir.

KAYNAKLAR

Metinde Alıntı;
Lütfen metinde geçen her bir atıfın kaynaklar listesinde de sunulduğundan emin olun. Metindeki literatürü kronolojik olarak, ardından bu örnekler gibi alfabetik sırayla belirtin "(Elp vd., 2018; Biswas vd., 2016; Elp ve Osmanoğlu, 2019)". Atıfta bulunulan kaynak bir cümlenin konusuysa, parantez içinde yalnızca tarih verilmelidir. Bu örnek gibi biçimlendirilmiştir: “Durmaz (2007) .... etkinliğini araştırmıştır”.
• Tek yazar: yazarın soyadı ve yayın yılı (Elp, 2017)
• İki yazar: hem yazarların soyadları hem de yayın yılı (Adem ve Elp, 2017)

• Üç veya daha fazla yazar: birinci yazarın soyadı ve ardından "ve diğerleri". ve Elp et al., 2018 yayın yılı)

Kaynaklar Listesinde Alıntı;
Kaynaklar önce alfabetik olarak sıralanmalı ve daha sonra makalenin sonunda kronolojik olarak sıralanmalıdır. Aynı yazar (lar) dan aynı yıl içinde birden fazla kaynak yayın tarihinden (2016a) sonra yerleştirilen a, b, c vb. Harflerle belirtilmelidir. Çevrimiçi olarak yayınlanan makalelerin, kitapların, çok yazarlı kitapların ve makalelerin alıntıları aşağıdaki örneklere uygun olmalıdır:

Makale:
Adem, S. S., & Elp, M. (2017). Muscle spindle and comparison of fish muscle spindle with other vertebrates. Alinteri Journal of Agriculture Sciences, 32(2): 113-117

Durmaz, Y. (2007). Vitamin E (alpha-tocopherol) production by the marine microalgae Nannochloropsis oculata (Eustigmatophyceae) in nitrogen limitation. Aquaculture, 272(4): 717-722.

Elderwish, N., M., Taştan, Y. & Sönmez, A. Y., (2019). Türkiye'nin batı karadeniz kıyı sularındaki ağır metal birikimin mevsimsel olarak incelenmesi. Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi, 5(2): 1-8.

Elp, M., Osmanoğlu, M. İ., Kadak, A. E., & Turan, D., (2018). Characteristics of Capoeta oguzelii, a new species of cyprinid fish from the Ezine Stream, Black Sea basin, Turkey (Teleostei: Cyprinidae). Zoology in the Middle East. 64(2): 102–111. https://doi.org/10.1080/09397140.2018.1442295

Sönmez, A. Y., Kale, S., Özdemir, R. C. & Kadak, A. E. (2018). An adaptive neuro-fuzzy inference system (ANFIS) to predict of cadmium (Cd) concentration in the Filyos River, Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 18(12): 1333-1343. https://doi.org/10.4194/1303-2712-v18_12_01

Kitap:
Brown, C., Laland, K. & Krause, J. (Eds.) (2011). Fish Cognition and Behavior. 2nd ed. Oxford, UK: Wiley-Blackwell. 472p.

Kitap bölümü:
Langston, W. J. (1990). Toxic effects of metals and the incidence of marine ecosystems, pp. 102-122. In: Furness, R. W. (Ed.), Rainbow Heavy Metals in the Marine Environment. New York, USA: CRC Press. 256p.
Vassallo, A. I. & Mora, M. S. (2007). Interspecific scaling and ontogenetic growth patterns of the skull in living and fossil ctenomyid and octodontid rodents (Caviomorpha: Octodontoidea).pp. 945-968. In: Kelt, D. A., Lessa, E., Salazar-Bravo, J. A., Patton, J. L. (Eds.), The Quintessential Naturalist: Honoring the Life and Legacy of Oliver P. Pearson. 1st ed. Berkeley, CA, USA: University of California Press. 981p.

Tez:
Elp, M. (2002). Koçköprü baraj gölü'nde (Van) yaşayan siraz *(Capoeta capoeta*, Guldensteadt, 1772) ve inci kefali (*Chalcalburnus tarichi*, Pallas, 1811) populasyonları üzerine bir araştırma. Ph.D. Thesis. İstanbul University, İstanbul, Turkey.

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

Enstitü yayınları:
FAO. (2016). The State of World Fisheries and Aquaculture: Contributing to food security and nutrition for all. Rome. 200 pp.

Rapor:
FAO. (2018). Report of the ninth session of the Sub-Committee on Aquaculture. FAO Fisheries and Aquaculture Report No. 1188. Rome, Italy.

İnternet kaynakları:
Froese, R. & Pauly, D. (Eds.) (2018). FishBase. World Wide Web electronic publication. Retrieved on January 11, 2018 from http://www.fishbase.org.

TurkStat. (2019). Fishery Statistics. Retrieved on December 28, 2019 from http://www.turkstat.gov.tr/

Çizelge(ler)
Arapça olarak numaralandırılmış çizelgeler, üstte kısa bir açıklayıcı başlık ile ayrı sayfalarda yer almalıdır. Dipnotları çizelge gövdesinin altındaki tablolara yerleştirin ve bunları küçük harflerle (veya anlamlılık değerleri ve diğer istatistiksel veriler için yıldız işaretleriyle) belirtin. Dikey kurallardan kaçının. Çizelgelerde sunulan veriler, makalenin başka bir yerinde açıklanan sonuçları tekrar etmemelidir.

Şekil(ler)
Metinde tüm resimler 'Şekil' olarak etiketlenmeli ve ardışık Arapça rakamlarla, Şekil 1, Şekil 2 vb. İle numaralandırılmalıdır. Bir şeklin panelleri etiketlenmişse (a, b, vb.), Metinde bu panellere atıfta bulunurken aynı durumu kullanın. Şekillerin PNG, JPEG gibi elektronik formatlarda olması önerilir. TIFF (min. 300 dpi) de mevcut boyutlarda düzenlenmelidir. Tüm şekiller veya tablolar metin içinde sunulmalıdır. Yazı tipi boyutları 9 ila 11 punto arasında olmalıdır.

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This journal has no page charges.

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  a) Authors' Contributions
  b) Conflict of Interest
  c) Statement on the Welfare of Animals
  d) Statement of Human Rights
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Use a 12-point Times New Roman font, including the references, table headings and figure captions, double-spaced and with 25 mm margins on all sides of A4 size paper throughout the manuscript. The text should be in single-column format. The authors are encouraged to download the template files from the links below:

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REFERENCES

Citation in text;
Please ensure that each reference cited in the text is also presented in the reference list. Cite literature in the text in chronological, followed by alphabetical order like these examples "(Elp et al., 2018; Biswas et al., 2016; Elp and Osmanoğlu, 2019)". If the cited reference is the subject of a sentence, only the date should be given in parentheses. Formatted like this example: "Durmaz (2007) investigated the efficacy of…".

• Single author: the author's surname and the year of publication (Elp, 2017)
• Two authors: both authors' surnames and the year of publication (Adem and Elp, 2017)
• Three or more authors: first author's surname followed by "et al." and the year of publication Elp et al., 2018)

Citation in the reference list;
References should be listed first alphabetically and then further sorted chronologically at the end of the article. More than one reference from the same author(s) in the same year must be identified by the letters a, b, c, etc. placed after the year of publication (2016a). The citation of articles, books, multi-author books and articles published online should conform to the following examples:

Article:
Adem, S. S., & Elp, M. (2017). Muscle spindle and comparison of fish muscle spindle with other vertebrates. Alinteri Journal of Agriculture Sciences, 32(2): 113-117

Durmaz, Y. (2007). Vitamin E (alpha-tocopherol) production by the marine microalgae Nannochloropsis oculata (Eustigmatophyceae) in nitrogen limitation. Aquaculture, 272(4): 717-722.

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Chapter:
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Vassallo, A. I. & Mora, M. S. (2007). Interspecific scaling and ontogenetic growth patterns of the skull in living and fossil ctenomyid and octodontid rodents (Caviomorpha: Octodontoidea). pp. 945-968. In: Kelt, D. A., Lessa, E., Salazar-Bravo, J. A., Patton, J. L. (Eds.), The Quintessential Naturalist: Honoring the Life and Legacy of Oliver P. Pearson. 1st ed. Berkeley, CA, USA: University of California Press. 981p.

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

Institution Publication:
FAO. (2016). The State of World Fisheries and Aquaculture: Contributing to food security and nutrition for all. Rome. 200 pp.

Report:
FAO. (2018). Report of the ninth session of the Sub-Committee on Aquaculture. FAO Fisheries and Aquaculture Report No. 1188. Rome, Italy.

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TurkStat. (2019). Fishery Statistics. Retrieved on December 28, 2019 from http://www.turkstat.gov.tr/

Table(s)
Tables, numbered in Arabic, should be in separate pages with a short descriptive title at the top. Place footnotes to tables below the table body and indicate them with superscript lowercase letters (or asterisks for significance values and other statistical data). Avoid vertical rules. The data presented in tables should not duplicate results described elsewhere in the article.

Figure(s)
All illustrations should be labelled as 'Figure' and numbered in consecutive Arabic numbers, Figure 1, Figure 2 etc. in the text. If panels of a figure are labelled (a, b, etc.) use the same case when referring to these panels in the text. Figures are recommended to be in electronic formats such as PNG, JPEG. TIFF (min. 300 dpi) should be also arranged in available dimensions. All figures or tables should be presented in the body of the text. Font sizes size should be from 9 to 11 points.

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İÇİNDEKİLER / CONTENS

ARAŞTIRMA / RESEARCH

DERLEME / REVIEW

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 59-68 Araştırma Makalesi/Research Article

The Assessment of Diversity of Benthic Macroinvertebrates of a Stream from the Eastern Black Sea Basin, Turkey

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- Water quality parameters
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- Biotic index

Abstract

This research was aimed to assess the diversity of benthic macroinvertebrates and some physico-chemical water parameters of Fırtına Stream of East Blacksea Basın and carried out between November 2014 and August 2015. Benthic and water samples were taken for one year from selected six stations seasonally (November-February-May-August) from the upstream to the flowing to the sea. Water temperature, pH, dissolved oxygen and conductivity were measured *in situ*. The results were evaluated according to Turkish Surface Water Quality Regulation and Fırtına Stream had high water quality. The benthic macroinvertebrates consisted of *Ecydonorous* (Ephemeroptera, Heptaginiidae), *Sericostoma* (Trichoptera, Sericostomatidae), *Tipula*, *Tabanus* ve *Chironomus* (Diptera, Tipulidae, Tabanidae, Chironomidae) from Insecta class. Some of these organisms were seen in unpolluted and some of them in slightly polluted waters. The proportionally distribution of the organisms were as Sericostomatidae (83%), Tipulidae (14%), Heptaganiidae (2%) and Tabanidae (1%), respectively. Diversity index (H) value was found to be low between 0 and 0.68. Biotic index (BMWP) score was also low and in the Class IV category (polluted water).

Atıf bilgisi/Cite as: Cılız S., Kırkağaç M. (2022). The assessment of diversity of benthic macroinvertebrates of a stream from the eastern Black sea basin, Turkey. Menba Journal of Fisheries Faculty, 8(2), 59-68

INTRODUCTION

In aquatic systems, pollution cause physical, chemical and biological changes in the receiving environment. Benthic macroinvertebrates colonized on the stream substrate with their relatively long life cycles, are widely used in river quality studies, as they react rapidly by showing sensitivity under different stress conditions and are indicators in local regions because of their limited movements (Hawkes, 1979: Cummins, 1994; Richards et al., 1997; Midlen & Redding, 2000).

Fırtına Stream is one of the 26 main catchment watershed is located in the Eastern Black Sea Basin in Turkey as a tourism region has 68 km in length, It is formed by the merging of the streams on the slopes of the Kaçkar Mountains facing the Black Sea and it flows into the Black Sea. While the stream is fed by spring rainfalls and the glaciers in the Kaçkar Mountains during summer periods, the flow rate decreases significantly in the autumn and winter months. Black Sea trout (*Salmo trutta labrax*) and rainbow trout (*Onchoryncus mykiss*) are cultured a total of 775.5 tons / year in Rize Province and 690 tons of this amount is obtained from 19 fish farms on Fırtına Stream (Kurtoğlu, 2013). Besides this, local administrations in settlements on the Fırtına Stream leave their wastes to the stream where as the most important entrance of the Black Sea trout for spawning. So, Fırtına Stream is one of the most important rivers in the region to be protected against external factors that will affect the reproduction migration of Black Sea trout (Çelikkale et al., 1999; Aydın & Yandı, 2002; Tabak et al., 2002). There is only one study on benthic macroinvertebrates in Fırtına Stream, with sampling twice, in the summer period in July 2006 and 2008 (Kazancı et al.,2010).

In this research, it is aimed to assess the diversity of benthic macroinvertebrates and water quality of the Fırtına Stream with the samples taken seasonally for a year, to reveal the condition of the stream by comparing it with the previous studies.

MATERIAL AND METHODS

Fırtına Stream is located in Rize province, it is close to Ardeşen district, and in terms of geographical location; it is at the coordinates of latitude 41°11'17' 'N and longitude 40° 57'50 " E (Figure1). Fırtına Stream is the longest stream in the region with a length of 68 km and a drainage area of 798.7 km^2. Annual average rainfall in the valley is 1497.6 mm/m^2. Its average flow is 28.4 m^3/sec and it carries more water than most of the rivers in Turkey (Tabak et al. 2002).

Figure 1.The location of Fırtına Stream and the stations

This study was carried out between November 2013 and August 2014, with samples taken from a total of 6 stations (Figure 1). The first station was close to the source and as far away from environmental effects as possible (station 1), the others were close to the settlements and trout facilities (station 2 and station 3) and the last station (station 6) was on the point where the stream flows to the sea. The distances between the stations were about 10 km. Benthos and water samples were taken 4 times in a year as November-February-May-August, respectively. Water temperature (^{0}C), pH, electrical conductivity (µs/cm) and dissolved oxygen (mg/l) values were measured *in-situ* and evaluated according to Turkey Surface Water Quality Regulation (Anonymous 2004). Chlorophyll *a* was determined in the laboratory according to APHA (1998).

The benthic samples collected from the stations in triplicate by a hand-net was filtered through a series of sieves varying between 250 and 3000 µm mesh size, and the collected benthic macroinvertebrates were stored in 4% formaldehyde in sample containers. The benthic macroinvertebrates were identified at family and genus levels under binocular and stereo microscopes according to Edmondson (1959), Macan (1975), Grant (2001), Thorp & Rogers (2011) and counted. The results were given as abundance per unit area (individual/m^2).

Shannon-Weaver diversity index was used to evaluate the diversity of benthic macroinvertebrates. Therefore, the number of species (richness-S), the equibility of the abundance of families (E) and the total number of organisms (abundance-N) were determined (Zischke et al., 1992).

Shannon-Weaver Index (H) = $-\Sigma$ Ni / N $\log_2$Ni / N (1)

H = index value

N = total number of individuals of all species collected

Ni = i. indicates the total number of individuals belonging to the species.

Evenness index (E); E = H / ln S is calculated from the equation.

Here; H = Shannon-Weaver Index, S = Species richness

BMWP score of the stream was determined for assesing the biological quality of Fırtına Stream as giving scores to macroinvertebrate families depending on their sensitivity to physicochemical and environmental changes (Metcalfe-Smith, 1994; Anonymous, 2004). For this research, BMWP scores and water quality classes that were determined for benthic macroinvertebrates of Turkish running waters ecosystems were used (Kazancı et al., 2016) (Table 1 and Table 2).

Table 1. Table 1. TR-BMWP, family list (Kazancı et al. 2016)

Order	**Family**	**Score**
Trichoptera	Sericostomatidae	10
Ephemeroptera	Heptageniidae	8
Diptera	Tipulidae	5

Table 2. TR-BMWP scores and their corresponding quality classes

TR-BMWP Score	Category	Water Classes	Quality	Interpretation
>100	Very good	1		Unpolluted/Unimpacted
71-100	Good	2		Clean but slightly polluted/impacted
41-70	Moderate	3		Moderately impacted
11-40	Poor	4		Polluted/impacted
0-10	Very poor	5		Heavily polluted

Statistical analysis were carried out by using SPSS 11.5 Statistic Program.Variance analysis (One way-ANOVA), Duncan multiple range test were computed to evaluate the differences of in abundance values of benthic macroinvertebrates between stations and months (Kesici & Kocabaş 2007).

RESULTS AND DISCUSSION

Benthic macroinvertebrate of Fırtına Stream were identified as *Ecydonorous* (order-Ephemeroptera, family-Heptaginiidae), *Sericostoma* (order-Trichoptera, family Sericostomatidae), *Tipula*, *Tabanus* and *Chironomus* (order-Diptera, families Tipulidae, Tabanidae and Chironomidae respectively) (Table 3).

Table 3. Benthic macroinvertebrates of Fırtına Stream

Phylum-Arthropoda			
Class	**Order**	**Family**	**Genus**
Insecta	Ephemeroptera	Heptageniidae	*Ecdyonorous*
	Trichoptera	Sericostomatidae	*Sericostoma*
	Diptera	Tipulidae	*Tipula*
		Tabanidae	*Tabanus*
		Chironomidae	*Chironomus*

Benthic macroinvertebrates functional feeding groups consisted of shredders (Sericostomatidae), collectors (Chironomidae), scrapers (Heptaganiidae) and predators (Tipulidae, Tabanidae). During the study, the shredder group (Sericostomatidae) constituted the largest proportion as 75% in functional feeding groups which fed on particulate allochthonous organic material and faecal pellets on adults (Figure 2).

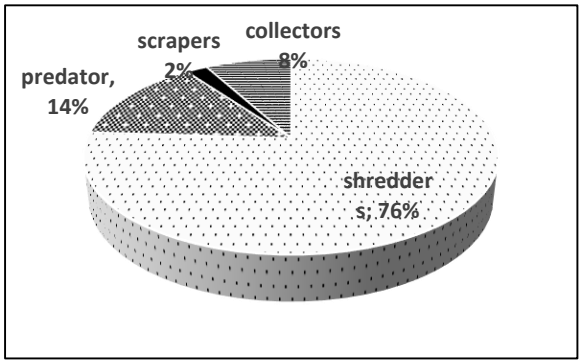

Figure 2. The proportions of functional feeding groups of Fırtına Stream (%)

The differences in the abundances of benthic macroinvertebrates of Fırtına Stream according to the stations and seasons were found to be statistically significant ($p < 0.05$) (Table 4). Sericostomatidae members are organisms that are sensitive to environmental effects, mostly found in upper part of the streams that is cold and includes high-dissolved oxygen, and their abundances were higher in the first station, especially in autumn samples than other stations. Members of the Tipulidae from Diptera show low tolerance to pollution. This makes them indicator organisms in waters with good water quality, while members of the Tabanidae family from the same order show moderate tolerance in the same conditions. In this study, members of Chironomidae and Tabanidae families with moderate pollution tolerance (Hawkes 1979) were found only in 1st station, but abundance values were low in autumn and winter. Ephemeroptera members, which are indicators of fast flowing and clean waters, were found to be low in abundance and were found only in autumn. Kırkağaç et al. (2004) investigated the effects of five trout farms on the macroinvertebrate communities on the Karasu Stream (Bozüyük), and found Tubificidae and Chironomidae members with high abundances as indicators of organic pollution, at all stations. In the 2nd and 3th stations which were the inlet and outlet of the trout farm on Fırtına Stream, no difference was found in macroinvertebrate diversity and abundances. However, the identified species in those stations were relatively intolerant to pollution. Although relatively tolerant species were found in

this study, their abundances are low. It is thought that heavy rainfall and floods may be the factor in the low abundance of those tolerant organisms.

A total of 36 families and 2080 individuals in samples taken from 10 stations, only in July of years 2006 and 2008 in Fırtına Stream were identified by Başören and Kazancı (2016). Among the families identified in benthic macroinvertebrates, the most common ones were Heptaganidae (30%), Baetidae (15%), Perlidae (11%), Blephariceridae (10%) and Hydropyschidae (9%), respectively. In this research, it was as Sericostomatidae (83%), Tipulidae (14%), Heptaganiidae (2%) and Tabanidae (1%) and the Heptaganiidae family was determined only in autumn. The results regarding the number of families, abundances and proportional distribution of benthic macroinvertebrates of this research are not similar to the results of Başören and Kazancı (2016). It is thought that temporal, seasonal and environmental factors caused the differences in the results.

Table 4. Average abundance values of benthic macroinvertebrates in Fırtına Stream, according to seasons and stations, individual/m^2 (n=3) and proportional changes of benthic macroinvertebrates groups in seasons according to stations (%)

Season	Organism Groups	Stations						
		1	**2**	**3**	**4**	**5**	**6**	**Total**
Autumn	***Trichoptera***	*83.96%*	*3.05%*	*0.76%*	-	*2.29%*		
	Sericostomatidae	110	4	1	-	3	-	118
	Diptera	*2.29%*	*0.75%*	*2.27%*	*1.52%*			
	Tipulidae	-	1	3	2	-	-	6
	Tabanidae	3	-	-	-	-	-	3
	Ephemeroptera	*1.52%*	-	-	*1.52%*	-		
	Heptageniidae	2	-	-	2	-	-	4
	Total abundance	115±5A*a**	5±1Bb	4±1Cc	4±1Bb	3±1Bb	-	131
Winter	***Trichoptera***	*12.50%*	*18.75%*	*6.25%*	*2.08%*	*8.33%*	*8.33%*	
	Sericostomatidae	6	9	3	1	4	4	27
	Diptera	*2.08%*	*8.33%*	*12.5%*	*12.5%*	*6.25%*	*2.08%*	
	Tipulidae	-	4	6	6	3	1	20
	Chironomidae	1	-	-	-	-	-	1
	Total abundance	7±1Bcb	13±2Aa	9±1Bb	7±2Abc	7±1Abc	5±1Bc	48
Spring	***Trichoptera***	-	*6.89%*	*10.34%*	*13.79%*	*3.44%*		
	Sericostomatidae	-	2	3	4	1	-	10
	Diptera	*6.89%*	*3.44%*	-	-	*3.44%*	-	
	Tipulidae	2	1	-	-	-	-	3
	Chironomidae	-	-	-	-	1	15	16
	Total abundance	2±0Cd	3±1Cc	3±1Cc	4±1Bb	2±0 Cd	15±1Aa	29
Summer	***Trichoptera***	*15%*	*5%*	*62.50%*	-	*2.5%*		
	Sericostomatidae	6	2	25	-	1	-	34
	Diptera	-	-	-	*10%*	*5%*		
	Tipulidae	-	-	-	2	1	-	3
	Chironomidae	-	-	-	2	1	-	3
	Total abundance	6±1Bb	2±1Ce	25±5Aa	4±1Bc	3±1Bd	-	40

** Mean values with different small letters in the same line is statistically significant ($p < 0.05$).
* Mean values with different capital letters in the same column is statistically significant ($p<0.05$).

Shannon Wiener index (H), species richness (S) and evenness index (E) values of Fırtına Stream were determined seasonally at the stations (Table 5). Species richness varied between 0 and 3 during the research. The H value, as the pollution level of the stream, ranged from 0 to 0.68. Stations were represented generally with one taxon except 2nd station in seasons. Therefore, the diversity was recorded only at 2nd station with 0.68. The lowest E value was detected in the 1st station in autumn. E values were generally found close to 1 at the stations during the research. This shows regular distributions of the abundances of the taxa in the stations.

Shannon Wiener index (H) value was generally higher at stations 4 and 5 compared to other stations. The distribution of taxa in winter was more homogeneous. The high Shannon Wiener index value is reported as an indicator of high water quality (Kazancı et al., 2010). However, it is stated that limited level of organic matter is an important factor in low macroinvertebrate diversity in high quality waters (Uyanık et al., 2005).

Table 5. Species richness (S) Shannon-Wiener Index (H) and equibility (E) values of benthic macroinvertebrates of Fırtına Stream

Season	Index	Stations					
		1	**2**	**3**	**4**	**5**	**6**
Autumn	S	3	2	2	2	1	
	H	0.20	0.5	0.56	0.6	0	
	E	0.18	0.72	0.81	1	0	
Winter	S	2	2	2	2	2	2
	H	0.41	0.61	0.68	0.41	0.68	0.50
	E	0.59	0.89	0.98	0.59	0.98	0.72
Spring	S	1	2	0	1	2	1
	H	0	0.63	-	0	0.66	0
	E	0	0.91	-	0	1	0
Summer	S	1	1	1	2	2	0
	H	0	0	0	0.6	0.6	-
	E	0	0	0	1	1	-

BMWP score values for macroinvertebrates of Fırtına Stream were evaluated according to Table 1. BMWP scores and taxon richness at the stations according to the seasons are given in Table 6. At the end of the research, the BMWP score varied between 17 and 29. The highest score was reached at 1st and 4th stations as 29 and 25, respectively. Taxon richness has been between 2 and 5. The highest taxon richness was determined in the 1st station. BMWP scores at stations according to seasons were not found to be generally high. The BMWP score range of Fırtına Stream (11-40) is considered as poor category according to Table 2.

Table 6. BMWP and N-taxa values of benthic macroinvertebrates at stations according to seasons in Fırtına Stream

Stations	Biotic Index	Seasons				Annually
		Autumn	**Winter**	**Spring**	**Summer**	
1	BMWP	22	12	5	10	29
	N-Taxa	3	2	1	1	5
2	BMWP	15	15	15	10	15
	N-Taxa	2	2	2	1	2
3	BMWP	15	15	10	10	17
	N-Taxa	2	2	1	1	2
4	BMWP	15	15	10	7	25
	N-Taxa	2	2	2	2	3
5	BMWP	10	15	12	17	17
	N-Taxa	1	2	1	2	3
6	BMWP	-	15	2	-	17
	N-Taxa	-	2	1	-	3

In the research, BMWP values varied between 15-29 and the water quality was determined as Class IV. According to BMWP scores (48-109) of Başören & Kazancı (2016), BMWP scores were found to be low due to the low species richness and their low abundances in this research. However, low macroinvertebrate diversity can also be seen in waters where there is little destruction and where competitive superior species dominate the resources (Ward & Tockner, 2001).

The composition of functional feeding groups in Fırtına Stream consisted of those fed with grinder (Sericostomatidae), collector (Chironomidae), scraper (Heptaganiidae) and predator (Tipulidae, Tabanidae). Among the benthic macroinvertebrates, no filterers have been found. Scrappers that use terrestrially coarse particulated organic materials as a food source and convert them into fine particulated and dissolved organic matter (Meyer & O'Hop, 1983). Sericostomatidae were encountered at 1st station in all seasons except spring and disappeared towards the downstream in Fırtına Stream. Savic et al. (2013) reported that grinders are found at a rate of 50% in the upstream and decrease in the downstream in the Nisava River of Eastern Serbia. Bonada

et al. (2004) reported that Sericostomatidae members tolerate slight increases in ammonium, orthophosphate and suspended solids in water.

Chironomidae, one of the collectors fed with fine particulate organic matter which was transported to the downstreams is seen in the last two stations in spring and summer but their abundances were relatively low. Tomanova et al. (2006) reported that the mobility of scraper, predators and shredders were high due to searching for food actively or by exposing to flow there was a risk of drift in floating substrates, it is not very suitable for macroinvertebrates to use their feeding strategies in ecosystems where pollution is seen suddenly. On the contrary, these organism groups can adapted themselves and act as collectors just to eliminate the effect of the current. However, it has been declared that the amount of internal and external organic matter in running waters will determine the distribution and abundance of functional nutrition groups of benthic macroinvertebrates (Vannote et al., 1980). In this research, the flow rate of Fırtına Stream is high, and the distribution of organisms belonging to the feeding groups was found to be irregular with low abundances. However, it is thought that using functional feeding groups with sediment quality analyses and long term investigation should be done for ecological evaluation of Fırtına Stream.

The differences between the average water temperature, dissolved oxygen, electrical conductivity and pH values according to the seasons and stations were found to be statistically significant ($p<0.05$) (Figure 3). The differences between chlorophyll *a* concentrations at the stations according to seasons were found to be statistically significant ($p <0.05$) (Figure 4).

During the research in Fırtına Stream, the temperature values measured in this research are in the range of the values reported by Alemdağ (1993) and Alkan et al. (2013). However, the lowest value for the winter that has been reported was higher than the value measured in this research. It is reported that the very low water temperature in Fırtına Stream is due to the high altitude and the long stay of snow in this region (Akın, 2016). Since the average temperature during the research is below 25°C, Fırtına Stream is evaluated as "High Quality Water" class, which has the potential to be used as drinking water and trout can be grown according to the Surface Water Quality Regulation (Anonymous, 2004).

During the research in Fırtına Stream, the lowest dissolved oxygen values were measured in summer and the highest values were measured in winter. The values obtained from this research are similar to the dissolved oxygen values reported by Akın (2016). In this research, no decrease tendency in the average dissolved oxygen values from the first to the last station in general. It was reported by Başören and Kazancı (2016) that the dissolved oxygen concentrations varied between 7.6-10.8 mg/l at 10 stations in July 2006 and 2008 in Fırtına Stream and due to the dissolved oxygen concentration below 8 mg/l at some stations, the stations were classified as Class I and II according to the Surface Water Regulation. Gedik et al. (2010) reported that the average dissolved oxygen value was about 10.40 mg/l at the station where Fırtına Stream flows to the sea whereas the value was about 10.60 mg /l in this research. It is thought that the high flow rate of Fırtına Stream caused higher dissolved oxygen concentrations even in downstreams. However, dissolved oxygen values tended to decrease with increasing temperature values at the stations. Since the average dissolved oxygen value at the stations is above 8 mg/l, Fırtına Stream is in the “High Quality Water” class, according to the Surface Water Quality Regulation (Anonymous, 2004).

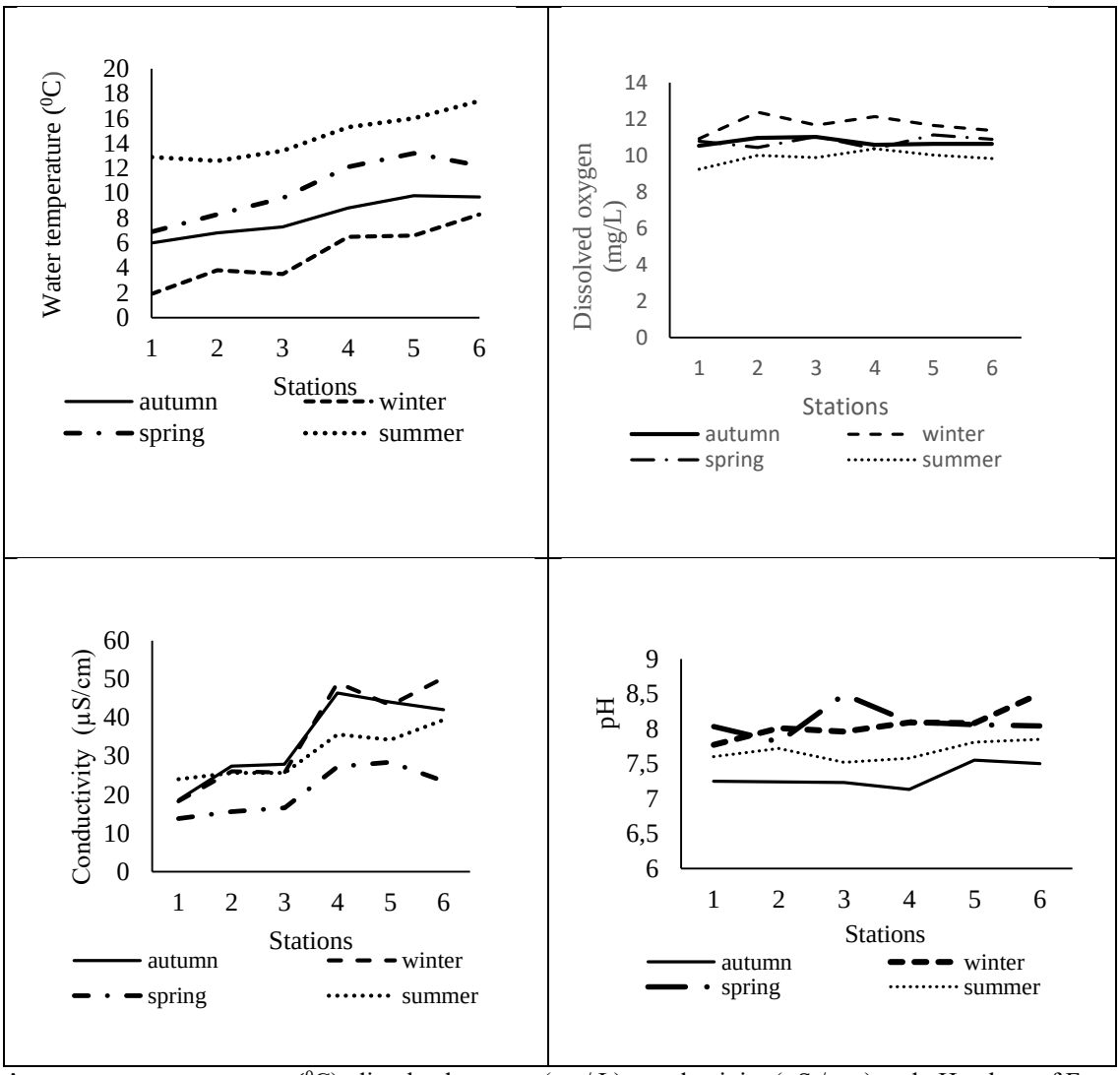

Figure 3.Average water temperature (^{0}C), dissolved oxygen (mg/ L), conductivity (µS / cm) and pH values of Fırtına Stream during the research

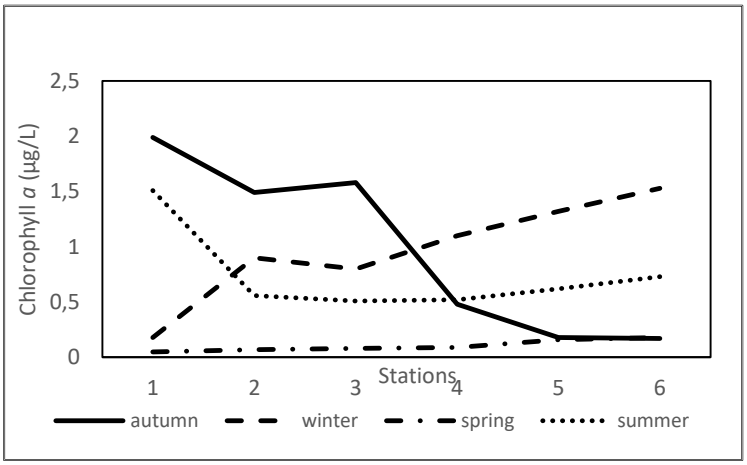

Figure 4. Average chlorophyll *a* (µg/L) concentrations of Fırtına Stream according to seasons at stations.

During the research, the highest pH values were measured in winter and summer. However, it has been observed that pH values at the last stations are generally higher than the first stations. It was reported from a previous study from Fırtına Stream that the pH values were high in the spring and summer months, which may be caused by the mixing of snow and rain water to the stream in autumn and winter months (Gedik et al., 2010). In this research, the pH values were higher than the previous investigations in Fırtına Stream (Alemdağ, 1993; Başören & Kazancı, 2010; Alkan et al., 2013). According to the Surface Water Quality Regulation (Anonymous, 2004), Fırtına Stream is a high quality water in terms of pH values.

During the research, the highest average conductivity values 50.30±1.00 µS/cm were measured at the last stations and the conductivity values of the stations increased in parallel with the increase in temperature. However, it has been reported that

low ion concentration in running waters limits the flora and fauna in terms of species diversity and abundance (Allan, 1995). As similar to the highest value of conductivity in as declared (54.77 ± 1.04 µS/cm) by Gedik et al (2010) for Fırtına Stream that the stream is not rich in ions. However, it was reported that conductivity measurements are the best one in order to give the results regarding the level of pollution in water compared to other physical and chemical measurements, and in running waters which is under minimal pollution effects, the conductivity value is measured below 50 µS/cm (Wenner et al.2003). Since the average conductivity value of Fırtına Stream is below 50 µS / cm, it is in the high quality water class according to the Surface Water Quality Regulation (Anonymous, 2004).

During the research, the average chlorophyll *a* concentration varied between 0.05±0.02 and 1.99 ± 0.09 µg/l in Fırtına Stream. Chlorophyll *a* concentrations was generally tend to increase by the stations except autumn. Alkan et al. (2013) reported that the average chlorophyll *a* concentration in Fırtına Stream was below 1 µg/l. Phytoplankton biomass in the streams are low and downstreams are convenient for phytoplankton production because of high nutrient loading and low flows (Allan, 1995).

CONCLUSION

In this research, Fırtına Stream evaluated as 'High Quality Water' in the category Class I water quality according to Turkey Surface Water Quality Regulation. However, when evaluated in terms of benthic macroinvertebrates, Shannon Weiner index value found to be low. Likewise, the biotic index-BMWP score was also found to be low and it was evaluated in Class 4 water quality in the polluted water class. The water flow of Fırtına Stream is about 30 m^3/sec with the highest flow in the region among the streams and its slope is high. Because of this, chlorophyll *a* concentration is low and aquatic plants growing is poor. As indicated above, low macroinvertebrate diversity can also be seen in clean waters where competitive superior species dominate the resources. However, no filterers feeding group were found in the stream. Therefore, it is thought that the amount of organic matter in the environment may be a factor limiting species diversity and abundance.

The Fırtına Stream in the East Black Sea region is considered as one of the 200 ecological regions that have priority in protection in the world as biodiversity and ecological reservoir. The water quality of Fırtına Stream should be preserved for fish populations surviving. However, the applied diversity and biotic indices of benthic macroinvertebrate of the stream were found to be quite low according to Başören & Kazancı (2010). It is thought that this situation may arise from the sampling period, hydrology of water and terrestrial inputs. In recent years, the stream is under threat due to the increase in tourism facilities and road construction works in the region, Fırtına Stream should be monitored in long-term research in the case of benthic macroinvertebrates as indicators of water quality.

COMPLIANCE WITH ETHICAL STANDARDS

a)Authors' Contributions:

This article was derived from the PhD thesis of the first author. Second author supervisor of the doctorate thesis; statistical analyses and preparation of the article for publishing.

b) Conflict of Interest:

The author(s) declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper

c) Statement on the Welfare of Animals:

Not applicable

d) Statement of Human Rights:

Not applicable

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 69-74 Araştırma Makalesi/Research Article

A Preliminary Study on the Effects of Inorganic Nutrient Enrichment on the Growth and Survival Rates of Green seaweed *Caulerpa racemosa*

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Abstract

Caulerpa racemosa is one of the edible green seaweeds abundant in the Philippine waters. This seaweed is commonly collected from the wild and sold fresh in the local marketplace throughout the country. Due to harvesting pressures and increasing demand, the expansion of its culture techniques needs to be further explored. In this study, the effects of inorganic nutrient enrichment on the growth and survival rates of green seaweed *C. racemosa* were determined under laboratory conditions for 21 days. Three different concentrations of inorganic fertilizer (ammonium phosphate): 10 ppm (T1), 20 ppm (T2), 30 ppm (T3), and Control (T4, seawater only) were used in the study with 3 replicates. Sampling was done every week. Results revealed that the specific growth rates (SGR) of nutrient-enriched *C. racemosa* in T1, T2, T3, and T4 groups were calculated as 1.41±1.09 % day^{-1}, 0.76±0.76 % day^{-1}, 1.64±2.01 % day^{-1}, and -0.44±0.48 % day^{-1}, respectively. Although no significant difference (p>0.05) was observed among the treatments, 30 ppm (T3) concentration obtained the highest SGR and mean weight throughout the study period. All treatments survived (100%) after 21 days. Our preliminary results indicated that inorganic nutrient enrichment might have positive effects on the growth of green seaweed *C. racemosa*. However, further studies are needed on the effects of inorganic fertilizers as nutrient enrichment for *C. racemosa* to come up with a robust conclusion.

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INTRODUCTION

Seaweeds or macroalgae are one of the top commodities in the world aquaculture (Azis et al., 2019). Among the important seaweeds is the genus of *Caulerpa*, which is commonly known as sea grape because of its grape-like or circular shapes of ramuli containing a high nutritional value that is usually consumed directly or made of various kinds of processed products (Azis et al., 2019; Fakhrulddin et al., 2021). *Caulerpa* species belongs to green seaweed, which gradually increasing its demand in certain places owing to its rich bioactive compounds and secondary metabolites (De Souza et al., 2009; Yangthong et al., 2009; Matanjun et al., 2009; Lin et al., 2012; Santos et al., 2015; Pangestuti and Kim, 2015; Santos et al., 2015; Rabia, 2016). Various species of *Caulerpa* ranges its crude protein level from 3.6 to 7.5 % dry weight (Paul and de Nys, 2008). *C. lentillifera* contained a comparatively high in polyunsaturated fatty acid (PUFA) at more than 5 % of dry weight basis and it has also omega-3 fatty acids like for example linolenic acid (Matanjun et al., 2009; Kumari et al., 2010; Saito et al., 2010). Other pigments and PUFAs in *Caulerpa* play an important role in antioxidant activity (Murata et al., 1999; Bocanegra et al., 2009). Moreover, minerals are the major component of *Caulerpa* species (Paul and de Nys, 2008), including micronutrients like iron and zinc and also the essential trace elements (e.g., chromium, molybdenum, nickel, cobalt, selenium, and vanadium) (Peña-Rodriguez et al., 2011). Therefore, seaweed like *Caulerpa* could be a good source of minerals and trace elements as suggested for daily intake for human (Indergaard and Minsaas, 1991; Ortega-Calvo et al., 1993; Rupérez, 2002; Dawczynski et al., 2007; Paul et al., 2014).

The Tawi-Tawi's local market in the southern Philippines and in other regions as well vastly obtained their sold seaweeds, such as *Caulerpa* species, from the natural environment (Tahiluddin et al., 2022a), and its market demand is continuously increasing. Farming of *Caulerpa* is another measure to lessen its pressure in the wild stock (Gennaro & Piazzi, 2014; Asmida et al., 2017; Susilowati, 2019). Farming of *Caulerpa* species is popular in the Indo-Pacific region (de Gaillande et al., 2017). The cultivation of *Caulerpa* species (*C. racemosa* and *C. lentillifera*) in the Philippines. was started early 1990s and is still widely practiced nationwide (Estrada et al., 2021). *C. racemosa*, in particular, is commonly cultured in man-made ponds in the intertidal mangrove zone (Horstmann, 1983). With the aim of improving the production of *Caulerpa* from aquaculture, there is a need to explore other aspects, such as the incorporation of inorganic nutrient enrichment.

Inorganic nutrient enrichment with different nutrients or fertilizers to boost the seaweeds in terms of production and farmer profits have been reported by various researchers (Luhan et al., 2015; Tahiluddin, 2018; Sahir et a., 2019; Illud et al., 2020; Robles, 2020; Tahiluddin & Terzi, 2021; Tahiluddin et al., 2021b; Tahiluddin et al., 2022b; Sarri et al., 2022). The seaweed farmers in Tawi-Tawi, Philippines, are growing red seaweed *Kappaphycus* species nutrient-enriched with inorganic fertilizers (Tahiluddin et al., 2022b; Tahiluddin et al., 2021a, 2021b and 2021c). Among the utilized inorganic fertilizers is ammonium phosphate [$(NH_4)_3PO_4$], which showed a significant increase in growth and nitrogen assimilation in the cultured seaweed *Kappaphycus* species (Tahiluddin et al., 2021b, 2022b). There are few studies that applied nutrient enrichment to grow *Caulerpa* species, either by using organic fertilizers like cow dung (Rabia, 2016) and vermicompost (Susilowati, 2019) or inorganic fertilizer like Conway's and Von Stotch (Fakhrulddin et al., 2021). The influence of ammonium phosphate on *Caulerpa* species has not yet been studied. Thus, this study aimed to evaluate the effects of nutrient enrichment using ammonium phosphate on the growth and survival rates of green seaweed *C. racemosa*.

MATERIALS AND METHODS

Study site and duration

The experiment was conducted in the Phycology Laboratory of Mindanao State University Tawi-Tawi College of Technology and Oceanography (MSU-TCTO), Multi-species Hatchery, College of Fisheries, Sanga-Sanga, Bongao, Tawi-Tawi, Philippines for 21 days from April to May of 2019.

Source and acclimatization of *Caulerpa racemosa*

The naturally growing *C. racemosa* at the MSU-TCTO floating cage, Bongao Channel, Tawi-Tawi, Philippines (Figure 1) was collected manually, including its roots, ramuli, and rhizoid. The seaweed was cleaned by removing the adhering materials such as other seaweeds, debris, and sand, then it was rinsed with sterilized seawater. Clean seaweed was acclimatized for one week in a tank and cultured in a plastic bottle container with sand and sterilized seawater, then covered with PE transparent cellophane. A fluorescent lamp (Firefly, T8) was used as a light (75 µmol photon m^{-2} s^{-1}), and 12:12 hours of light and dark were applied. The temperature and salinity of the water for the whole culture duration were 26.5-27 ºC and 34-35 ppt, respectively.

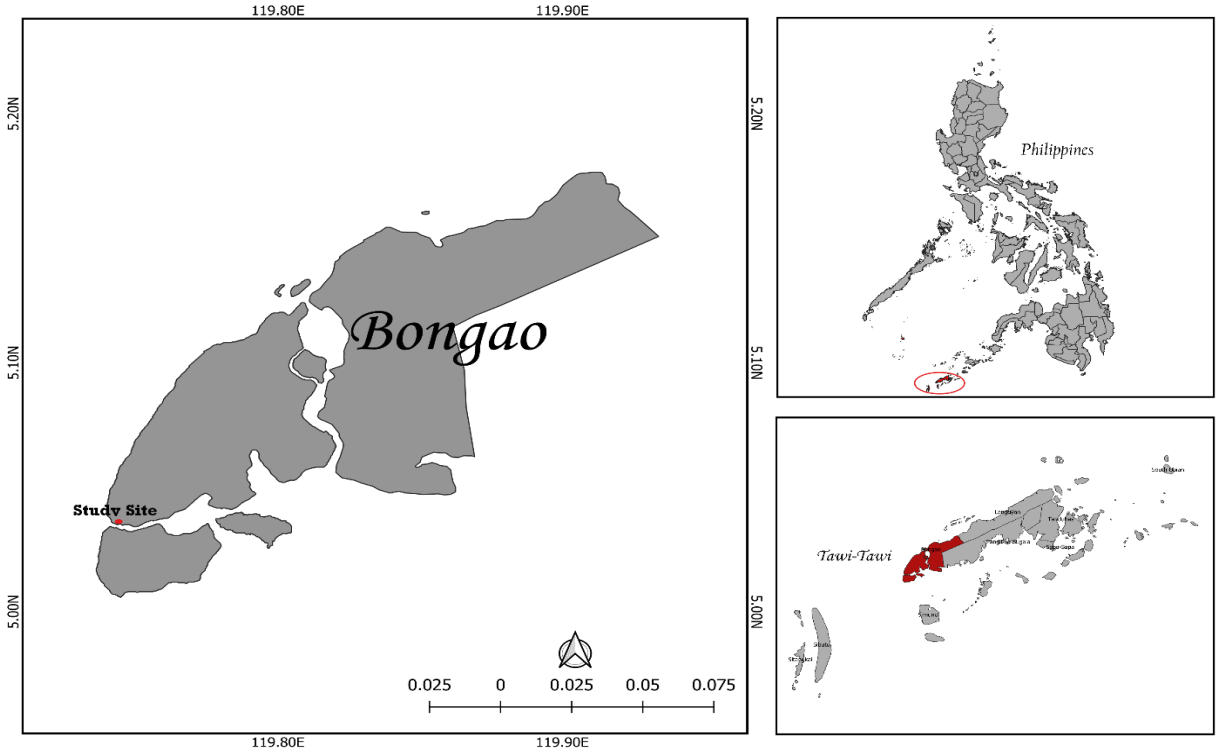

Figure 1. Collection site of *Caulerpa racemosa*

Culture of *Caulerpa racemosa*

Ammonium phosphate fertilizer (16-20-0) which contains nitrogen, phosphorus, and potassium or NPK, was used in culture media. Fertilizer was pounded until the size was fine enough to be dissolved in the seawater. The solutions were prepared according to the added nutrients in the sterilized seawater of the culture media, which served as the treatments of the study, namely: Treatment 1 (T1) – 10 ppm, Treatment 2 (T2) – 20 ppm, and Treatment 3 (T3) – 30 ppm, and Control – only sterilized seawater (T4). Each treatment was in triplicate, and a total of 12 containers were used. Clean sand was provided in each 1200 mL bottle. The seaweed was planted in the sand by submerging the seaweed's root to the bottom. The light was provided, and the temperature and salinity were maintained as mentioned earlier. The water in the containers was changed 100% weekly with fresh, sterilized seawater mixed with the respective concentrations of nutrient.

Growth sampling

The sampling of seaweed was done every 7 days of the culture period. Seaweed was patted with tissue paper to remove the excess water. All seaweed in the culture containers was weighed using a top loading weighing scale. The growth (μ) expressed as a specific growth rate (SGR) was calculated following the formula of Luhan et al. (2015).

$$\mu = \frac{\ln(Wf) - \ln(Wi)}{DOC} x\ 100$$

Where:

ln = Natural log
Wf = Final weight
Wi = Initial weight
DOC = Days of culture

Data analysis

The data on the growth and survival rates were analyzed in IBM SPSS software version 25. Determination of the significant differences of the treatments were computed using One-way Analysis of Variance (ANOVA) and Post-hoc (Duncan) was used to rank the means. To compare each treatment across culture periods, t-test was used. The data were expressed as mean ± SE (standard error). The used level of significance was $p<0.05$.

RESULTS

The specific growth rate (SGR) of *Caulerpa racemosa* in laboratory-cultured enriched with different concentrations of ammonium phosphate for 21 days is shown in Figure 2. One-way ANOVA revealed that nutrient enrichment with ammonium phosphate on the *C. racemosa* did not significantly influence its SGR.

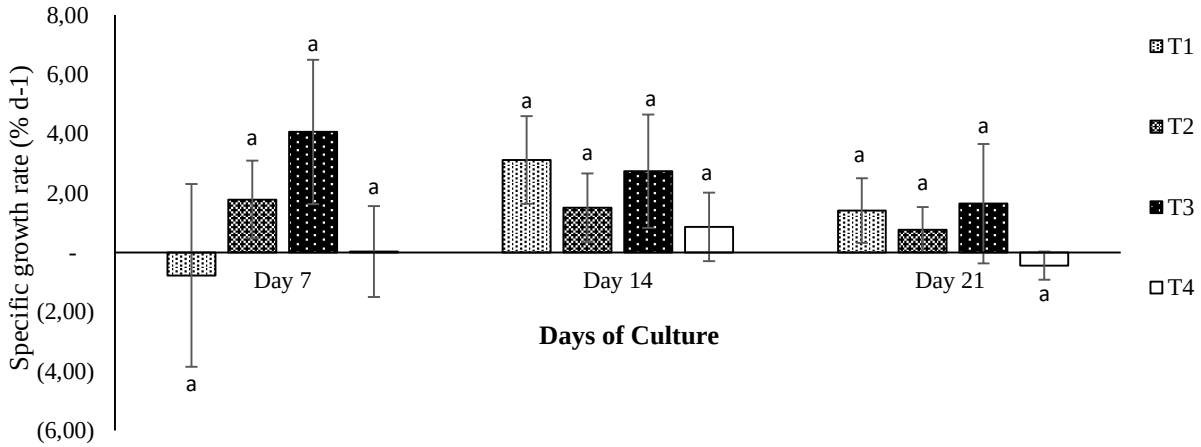

Figure 2. Mean specific growth rate of *C. racemosa* in every sampling. T1=10 ppm, T2=20 ppm, T3=30 ppm, and T4= Control-SSW only. Bar with the same letters are not significantly different ($p>0.05$). Error bars in SEM (standard error mean), n=12.

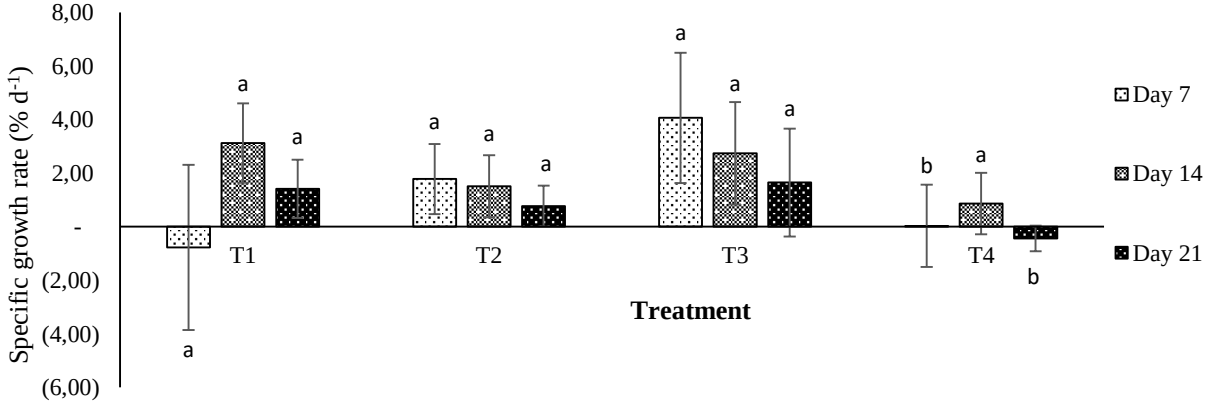

Figure 3. Change of mean specific growth rate of *C. racemosa* in every sampling. T1=10 ppm, T2=20 ppm, T3=30 ppm, and T4= Control- SSW only. Bar with different letters are significantly different ($p<0.05$). Error bars in SEM (standard error mean), n=12.

During the 7 days of the experiment, T3 (4.06±2.43 % day^{-1}) obtained the highest SGR, followed by T2 (1.78±1.31 % day^{-1}), then Control (0.03±1.54 % day^{-1}) and the lowest was T1 (-0.78±3.08 % day^{-1}). On day 14, T1 (3.12±1.48 % day^{-1}) had the highest SGR succeeded with T3 (2.74±1.91 % day^{-1}) followed by T2 (1.50±1.16 % day^{-1}), and the least was Control (0.86±1.15 % day^{-1}). On day 21, T3 (1.64±2.01 % day^{-1}) received the highest SGR, while T1, T2, and Control had SGRs of 1.41±1.09 % day^{-1}, 0.76±0.76 % day^{-1}, and-0.44±0.48 % day^{-1}. Although there were no significant differences among treatments from day 7 to 21, it can be seen in Figure 2 that the T3 (30 ppm) consistently gained the highest SGR. In terms of change in SGR during samplings, T1, T2, and T3 did not show a significant change in SGR from day 7 to 21. However, in a Control group, its SGR significantly increased (p<0.05) from day 7 to 14 but significantly dropped (p<0.05) from day 14 to 21. All the seaweed in all treatments survived (100%) throughout the culture period, although there was a whitening of some parts of seaweed's roots, ramuli, and rhizoids.

DISCUSSION

Although there was no significant difference, higher growth of laboratory-cultured *C. racemosa* was observed when enriched with 30 ppm of ammonium phosphate fertilizer, and without fertilizer, the growth declined after 21 days. The availability of nutrients accessible to the seaweeds enhanced its nitrogen content, a nutrient crucial for seaweed growth, and a previous study indicated that with a higher concentration of nutrients, stored nitrogen was also higher (Tahiluddin et al., 2021b), resulting in better growth performance (Tahiluddin et al., 2022b). This indicates that as a higher concentration of ammonium phosphate is made readily available to *C. racemosa*, the seaweed takes advantage of this nutrient to fuel its physiological needs; hence, the growth was higher in higher concentrations. Rabia (2016) reported that *C. lentillifera* farmed using the sowing method in fishpond performed better growth rate as the nutrient content in substrates was high in concentrations, improving the seaweed productivity and growth compared to the tray method unattached on the substrate of the pond. It is related to the nutrient availability in the culture area or container, which is very significant as fertilizer applied will enhance the plant growth and biomass produced (Fakhrulddin et al., 2021). A positive result is congruent to the study of Zuldin et al. (2019) on *C. macrodisca* with a positive growth rate of 5.13±0.06 % g day^{-1} cultured in a tank. In addition, Paul et al. (2014) obtained results on the mean weight of 0.1 kg $week^{-1}$ *C. racemosa* and 1.5 kg $week^{-1}$ for *C. lentillifera* cultivated using the tray culture method in a 6-week culture period. An almost similar study with used of nitrate nutrient (1mM NO_3-N) to improve the specific growth rate with 0.97 % day^{-1} of the red seaweed *Kappaphycus alvarezii* cultured in the laboratory (Sahoo & Ohno, 2003). According to the result of Luhan et al. (2015), the *K. alvarezii* enriched using 10 ppm of sodium nitrate improved the growth with an SGR of 2.34 % day^{-1} similar result to the findings of Sarri et al. (2022), where nutrient enrichment with 8.82 g L^{-1} urea fertilizer in *K. striatus* obtained good growth with 3.90 % day^{-1} SGR after 45 days of cultured in the farm.

The *C. racemosa* laboratory-cultured with different concentrations of ammonium phosphate in the present study has no effect on its survival rate. The concentrations of fertilizer are still under the tolerable level of *C. racemosa*. The application of fertilizer or nutrients in the culture water is very important in order to achieve target production (Luhan et al., 2015). The benefits can provide by the nutrients depending on the type of fertilizers and the concentrations (Sarri et al., 2022).

CONCLUSION

Our preliminary results on the effects of inorganic nutrient enrichment on *C. racemosa* cultured under laboratory conditions showed that 30 ppm of ammonium phosphate fertilizer obtained better growth performance after 21 days, albeit no significant difference. This suggests that nutrient enrichment can enhance the production of *Caulerpa* species. Further studies need to be conducted in terms of different concentrations, longer culture periods, different culture environments, and effects on the quality of *Caulerpa* on inorganic nutrient enrichment.

COMPLIANCE WITH ETHICAL STANDARDS

a) Authors' Contributions

A. B. T.: Designed the study.

R.J.F. R. & A. B. T.: Performed the experiment work.

R.J.F.R & A.B.T.: Drafted the paper.

b) Conflict of Interest

The authors declare that there is no conflict of interest.

c) Statement on the Welfare of Animals

Ethical approval: For this type of study, formal consent is not required.

d) Statement of Human Rights

This study does not involve human participants.

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 75-82 Araştırma Makalesi/Research Article

Nutritional Composition and Some Biological Characteristics of the Tub Gurnard (*Chelidonichthys lucerna*) Captured in the Western Black Sea Coasts of Türkiye

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Abstract

The study was carried out between 01 September 2021 and 15 April 2022 in the Western Black Sea coasts. Tub gurnard (*Chelidonichthys lucerna* L., 1758) were examined in the commercial fishery. A total of 28.885 kg tub gurnard was caught during the study period. Total length and weight of 54 tub gurnard individuals were measured. Minimum, maximum and average total lengths were calculated as 15.2 cm, 55.5 cm and 25.6±0.95 cm, respectively. Length-weight relationship (LWR) of tub gurnard were determined as $W=0.0123L^{2.9757}$ for all individuals in the study. The value of the parameter 'b' was found negative allometric growth for tub gurnard. The food components of male and female tub gurnard were determined to 75.540±0.303, 75.801±0.69 for moisture 20.130±0.024, 19.151±0.023 for protein, 2.764±0.042, 3.704±0.059 for lipid, 1.550±0.042, 1.530±0.059 for ash, 0.434±0.121, 0.281±0.041 for carbohydrate and 141.677±0.062, 144.432±0.057 energy (kcal), respectively. In the study, it was determined that the biological fetures and nutrition composition values of tub gurnard vary as gender.

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INTRODUCTION

Pelagic species are mostly caught in Türkiye seas. While most of the production is supplied from the Black Sea region, it attracts attention especially in anchovy and other small pelagic fishes such as horse mackerel, bluefish, shad and sprat (TurkStat, 2021). However, although the production amount of demersal fish is low, their economic value is high.

Besides pelagic species, demersal fish such as whiting, red mullet and turbot are caught in the Black Sea. These species are captured by demersal trawls, gillnets and trammel nets. With these fishing gears, some non-target species can be captured except for target species. One of these species is the tub gurnard (*Chelidonichthys lucerna*), which has economic value (ICES, 2010; Kasapoğlu and Düzgüneş, 2017; Özdemir et al., 2019; Rodriuges et al., 2019). Tub gurnard is one of the three species of Triglidae family living in the Black Sea. (Bilecenoğlu et al., 2014; Yankova et al., 2014).

There are many studies on some population and biological features of tub gurnard in the Marmara Sea, Aegean Sea, Mediterranean and Atlantic coasts, (Papaconstantinou, 1984; Colloca et al., 1994; Abdallah, 2002; Santos et al., 2002; Borges et al., 2003; Mendes et al., 2004; İşmen et al., 2004; Eryılmaz and Meriç, 2005; İlhan and Toğulga, 2007; Deval et al., 2007; Boudaya et al., 2008; Çiçek et al., 2008; Vallisneri et al., 2011; Stagioni et al., 2012; Demirel and Dalkara, 2012; Akyol, 2013) but studies in the southern Black Sea coats are very few (Haşimoğlu et al., 2016; Özdemir et al., 2019).

There are many studies on the processing technologies and quality of economical fish used for both the aquaculture industry and human consumption in the Black Sea region (Duyar et al., 2012; Duyar et al., 2013; Çağlak et al., 2016; Tokur & Aksun, 2018; Bayraklı & Duyar, 2019a; Bayraklı & Duyar, 2019b). However, in recent years, studies on fish that have passed from discarded and by-catch to target species and are likely to pass are at a very low level. Notable among these species are scorpionfish, sole fishes and goby fishes (Duyar et al., 2020).

In this study, it was aimed to determine some biological characteristics in terms of fishing technology and the nutrient composition of human consumption and processing technology of tub gurnard captured as by-catch by the demersal trawl in the Black Sea coats.

MATERIAL AND METHOD

The study was carried out in the Southern Black Sea coasts of Türkiye at monthly by using a commercial demersal trawl (01 September 2021 – 15 April 2022). The sampling areas were western Black Sea (Sinop-İnceburun coasts), this area is an important transit and aggregation location pelagic and demersal fish shoals in the Black Sea coasts of Türkiye (Figure 1). Samples were collected with demersal trawl at depths ranging from 60 m to 105 m.

Figure 1. Map of the area where the fish samples were caught.

Fishes were captured by using a typical otter demersal trawl with 40 mm codend mesh size; tow duration was to 45-90 minutes.

A total of 36 hauls were conducted during the study period. Fish were measured to the nearest 1 mm (total length) and weighted to the nearest 0.01 g (Figure 2). The gender and maturity stages were determined by the macroscopic and microscopic examination of the gonads (Follesa and Carbonara, 2019).

Figure 2. Length measurement of tub gurnard captured by demersal trawl

Length-weight relationships were estimated by fitting an exponential curve ($W=aL^b$) to the data (Ricker, 1975; Pauly, 1984).

Parameters a and b of the exponential curve were estimated by linear regression analysis over log-transformed data: logW=loga+blogL

Where

L is the total length (cm),

W is the total weight (g),

a is the intercept and b is the slope, using the least-squares method.

The association-degree between variables of W and L was calculated by the determination coefficient (R). Additionally, 95% confidence limits of the parameter b were estimated. The Student's t test was used for comparison of the slopes (Zar, 1996).

From nutrient composition analysis, total crude protein was performed using Kjeldahl (AOAC, 1990), crude oil analysis (Bling & Dyer, 1959), crude ash analysis (AOAC, 1984), and moisture analysis (Ludorf & Meyer, 1973). Carbohydrate and energy amounts were calculated according to Merril & Watt (1973).

Carbohydrate (g/100g) = 100 – (W + F + P + A),

Energy (Kcal/100g) = (Fat * 9.50) + (Protein * 5.65) + (Carbohydrate * 3.90)

Analysis of the nutrient composition of fresh tub gurnard was carried out in two replications and in three parallels.

RESULTS

A total of 28.885 kg tub gurnard were caught with demersal trawl during the study. Female fish were captured more and larger size than male fish. The captured fishes occurs of 65% (35) female fishes and 35% (19) male fishes. A total of 54 specimens ranging sizes were between 15.2 and 55.5 cm. The average total length and weight of the fishes was determined as 25.6±0.95 cm and 312.50±78.55 g (Table 1).

Table 1. Length and weight parameters of the tub gurnard (*Chelidonichthys lucerna*)

Parameters		**Female**	**Male**	**Combined**
Length (cm)	Maximum	55.5	41.4	55.5
	Minimum	15.2	16.3	15.2
	Average	30.43±1.44	22.15±1.57	25.62±0.95
Weight (g)	Maximum	1541.5	622.4	1541.5
	Minimum	55.2	56.6	55.2
	Average	362.17±85.86	227.75±88.32	312.50±78.55

The length-weight relationships (LWRs) of tub gurnard were calculated as $W=0.0123L^{2.9757}$ (R=0.98, N=54), negative allometric growth (Pauly's t-test, $P < 0.05$) were obtained for all individuals. Descriptive statistics on the length and sample size (n), regression parameters a and b of the length-weight relationship (LWR), 95% confidence intervals of a and b, the coefficient of determination (R) of analyzed species are shown in Table 2.

Table 2. Length-weight relationship (LWR) parameters for tub gurnard

Parameters of LWR	
N	54
a	0.01232
95 % Confident of a	0.00987-0.01398
b	2.9757
b (SE)	0.0471
95 % Confident of b	2.9286-3.0228
R	0.9811
Growth	− Allometric
P (t-test)	0.05<

N is number of specimens; a is intercept of the relationship; b is slope of the relationship; R is coefficient of determination; b (SE) is the standard error of b.

Nutrient composition analyses were made in the meat of fresh tub gurnard (*Chelidonichthys lucerna*) in males and females, energy amounts were calculated and the results are given in Table 3.

Table 3. Nutrient composition energy value of fresh tub gurnard (*Chelidonichthys lucerna*)

	Male (♂)	**Female (♀)**
Moisture (%)	75.540±0,303	75.801±0.69
Crude protein (%)	20.130±0,024	19.151±0.023
Crude oil (%)	2.764±0,042	3.704±0.059
Crude ash (%)	1.550±0,042	1.530±0.059
Carbohydrate (%)	0.434±0,121	0.281±0.041
Energy (kcal7100g)	141.677±0,062	144.432±0.057

DISCUSSION

The tub gurnard has an important economic value in the Türkiye fish market. Many scientists have stated that tub gurnard are caught by trammel nets, gillnets, and demersal trawl nets (Özdemir et al., 2003; Çiçek et al., 2006; Ceylan et al., 2014; Kasapoğlu and Düzgüneş, 2017; McCartey and Marriott, 2018; Özdemir et al., 2019).

The present study were founded as 25.6±0.95 cm average length of fishes. The maximum, minimum total length measured for fishes were 55.5 cm, 15.2 cm respectively. Minimum and maximum total lengths were reported as 2.2 cm (Eastern Mediterranean Sea) and 88.2 cm (Eastern Black Sea) in Türkiye seas (Çiçek et al., 2006; Haşimoğlu et al., 2016).

Length-weight relationship was determined as $W=0.01124L^{2.943}$ (R=0.989) for tub gurnard (negative allometric growth, b<3) in the study. b values, which indicated positive allometric growth (Papacostantinou, 1984; İlhan and Toğulga, 2007; İlkyaz et al., 2008; Bilge et al., 2014; El-Serafy et al., 2015; McCarty and Marriott, 2018) and isometric growth (Borges et al., 2003; İşmen et al., 2004; Eryılmaz & Meriç, 2005; Keskin & Gaygusuz, 2010; Bök et al., 2011; Vallisneri et al., 2011; Demirel & Dalkıran, 2012; Özdemir et al., 2019) for tub gurnard.

The present study showed that the b-values have generally been in agreement similar with results (negative allometric growth) in the previously most studies (Papacostantinou et al. 1994; Serene et al. 1998; Abdallah, 2002; Santos et al. 2002; Çiçek et al. 2006; Olim & Borges, 2006; İşmen et al. 2007; Sangun et al. 2007; Boudaya et al. 2008; Çiçek et al. 2008; İşmen et al. 2018).

The variations in b-values may be attributed to one or more factors: the seasons and effects of different region, differences in salinity, temperature and pollution of aquatic environment, sex, food quality and availability, differences in the number of fish examined, as well as in the observed size ranges of the sampled species (Gonçalves et al., 1997; Froese et al., 2011; Özdemir et al., 2018).

First reproduction size of male and female are 17-18 cm and 19-20 cm for tub gurnard in the Türkiye seas (İşmen et al., 2004; Eryılmaz & Meriç, 2005; Ilhan & Toğulga, 2007). The lengths are range 25 cm and 40 cm in some studies of other Mediterranean countries (Papacostantinou, 1984; Baron, 1985; McCarty & Marriott, 2018). The minimum landing size (MLS) is 18 cm for tub gurnard in Türkiye seas (Anonymous 2020). But it is not sufficient for once breeding of fish. The size is absolutely raised for the sustainable and continuity of tub gurnard fish stocks in Türkiye seas.

As a result of the nutrient composition analyses made in the meat of male tub gurnard caught in Sinop, crude protein, crude oil, crude ash, moisture, and carbohydrate ratios were respectively; It was determined as 23.12%, 2.64%, 1.55%, 75.54%, 0.43%. As a result of the nutrient composition analyses made in the meat of female individuals of the same fish, crude protein, crude oil, raw ash, moisture, and carbohydrate ratios were respectively; 19.15%, 3.70%, 1.53%, 75.80%, 2.28%. While the energy value of male tub gurnard was calculated as 141.68kcal/100g, the energy value of female individuals was calculated as 144.43 kcal/100g.

As a result of the study, the protein value (20.13%) of the male tub gurnard was found to be higher than the protein value of the female (19.15%). The lipid value (2,76%) of male tub gurnard was found to be lower than that of female fish (3,70%), and the difference between the sexes was significant ($p<0.05$).

The spawning period of tub gurnard is between June and September. While female fish store their lipid in their muscles before the breeding period, the amount of lipid in the muscles decreases during the breeding period, the lipid rate in the ovaries increases and they spend their fat for egg development. Çaklı (2007) grouped fish samples into three categories according to their lipid content. Fish samples with lipid content of 0-5% are classified as lean fish, those containing 5-10% lipids as oily fish, and those containing more than 10% lipid as very fatty. The tub gurnards are evaluated in the lean fish group.

The raw ash value of male tub gurnard was found to be 1.55%, while it was 1.53% in female fish. It was determined that the difference in raw ash value between the gender was insignificant ($p>0.05$).

There was no significant difference between the moisture values of male and female tub gurnard ($p>0.05$) and the results were generally consistent with the moisture content of the fish (75,54-75.80). Close analysis results on tub gurnard fillets are generally similar to other studies on tub gurnard (Ersoy, 2006; Küçükgülmez et al. 2010; Roncarati et al. 2014; Dağtekin, 2021).

The energy value of male tub gurnard was lower than that of female tub gurnard. Since female tub gurnard have a higher amount of lipid than males, the energy amount of females is calculated to be higher.

CONCLUSION

Consequently, changes in the Black Sea ecosystem in recent years also affect fish stocks and population characteristics (Bat et al., 2007). For this reason, studies on stock, biology and population characteristics of all fish living in the Black Sea should be kept up to date and continued.

Although tub gurnard is captured as by-catch in the demersal trawl fisheries, the fish is a valuable fish for the fishermen, in Türkiye (Özdemir, et al., 2019). Tub gurnard have to not capture by the fishermen before reaching the first reproductive length (20 cm) and minimum landing size for tub gurnard should be reviewed by the fisheries management. The minimum landing size should not be less than 25 cm in order to renew itself and ensure the sustainability of the tub gurnard stocks.

People need an average of 50-55g of animal protein per day for a healthy diet (Bayraklı, 2021; Duyar, 2016). The tub gurnard has a high nutritional value and is a type of fish that is loved and consumed by the people of the region.

Fish species caught by bottom trawl and discarded have a very little probability of survival if released to the sea again. Consequently, it will be useful to bring discarded species into the economy. It is understood that the studies intended at reducing the discard rate have not reached a sufficient level universal.

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 83-93 Araştırma Makalesi/Research Article

The Relationships Between Fish Size and Otolith Dimensions Between Sexes in the Grey Wrasse, *Symphodus cinereus* (Bonnaterre, 1788)

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Abstract

In this study, the morphology of the sagittal otoliths of *Symphodus cinereus*, which exhibits an alternative reproductive tactic, was compared between the sexes. Fish specimens were collected using trammel net during the period June 2015 and May 2016 from waters around Rize City at the Black Sea coasts. The otolith weights (OWe), eyed and blind side otolith lengths (OL) and otolith width (OW) of each specimen were measured at the scale of nearest 0.0001g and 0.001 mm, respectively. A total of 119 sample fish (48 males and 71 females) were collected to examine. It was recorded that total length and weight ranged from 10.2 to 14.4 cm and 18.51 to 68.23 g for females and 10 to 16.4 cm and 17.14 to 70.29 g for males. It was found that the coefficients of determination between otolith weight and total length is $R^2 = 0.725$ whereas otolith weight and the total length for sexes combined is $R^2 = 0.715$. It was also demonstrated a strong positive relationship between the total length- otolith dimensions (OL/TL, OW/TL, Owe/TL). We determined the differences in otolith length, width and weight between male and female sagittal otoliths. According to these results, female sagittal otoliths tend to be larger than males ($p<0.05$). The results of this study are important as they reveal the otolith differences of *Symphodus cinereus* between the sexes.

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INTRODUCTION

Teleost fish have three semicircular canals arranged perpendicular to each other. These channels open into nested chambers or otic sacs (Wright et al., 2002). Teleost fish have three couplesotoliths, three on each side; sagitta, asteriskus, lapillus (Ekingen 1983). Otoliths are consisting of calcium carbonate and are found in the inner ears of bony fish and also function in hearing and balance (Campana, 2004). When the sagittal otolith varies less within the species, it is a very important otolith because it shows significant morphological differences between species (Campana, 2004). Therefore, trait of the sagittal otolith such as shape and size are used to distinguish fish species and higher order taxonomic groups (Paxton, 2000; Tuset et al., 2003, 2015). Otolith morphology in many different fields of fish biology; anatomy of fish species, taxonomic revisions of fish taxa, determination of phylogenetic relationships, ecomorphology studies, determination of the relationships among fish growth and otolith growth and, determination of similarities between fish that are fossil and the growth of fish living today (Bostancı et al. 2012). It is significantly important to know relationship between fish length and sagittal otolith length to have a considerable information on determining fish length from otoliths in stomach of predators and understand prey predator relationships (Granadeiro & Silva 2000, Battaglia et al. 2010, Kasapoglu & Duzgunes 2013). The morphological variant of the sagittal otolith may be affected by age, environmental and genetic factors (Cardinale et al., 2004; Vignon & Morat, 2010), however, it may vary according to its somatic growth ratio, habitat and is also related to the individual's nutrition (Lombarte & Lleonart, 1993; Strelcheck et al., 2003; Gagliano & McCormick, 2004). A 20 species of Labridae (Wrasse), which has 504 species in the world (Parenti & Randall 2011), live on the coasts of Turkey (Bilecenoğlu et al. 2014) and 8 in the Black Sea (Keskin 2010). As a territorial marine fish, Labridae are described as small and inhabit in rocky and algal inshore areas (Costello 1991). Grey wrasse (*Symphodus cinereus* (Bonnaterre, 1788) is a species belonging to the genus *Symphodus.* It shows distribution in Mediterranean Sea and from Gibraltar to Arcachon basin in Eastern Atlantic. It lives in eel grass beds in coastal areas and sometimes in soft bottoms between 1-20 m. This species is usually found in lagoons and estuaries with plenty of cover. It feed on shrimps, amphipods, isopods, gastropods and bivalves (Quignard & Pras 1986). There are different types of otolith research in the literature. However, knowledge on some aspects of otolith morphology is still limited.

The studies of intra-sex and between-sex variations in otolith morphology in species with alternative reproductive tactics are limited in the literature. Alternative reproductive tactics (ART) occur in case of the individuals of any sex species, refers at

least two different reproductive morphs, as well as each morph try to achieve reproduction by alternative means. (Gross, 1996; Taborsky et al., 2008; Neff & Svensson, 2013). In most species with ARTs, males do not show a continuity for distribution of phenotypic traits, which brings about two or more reproductive morphs together within a population that are behaviorally, physiologically and morphologically distinct from one another. It is known that otolith morphology differs in species, adopting alternative reproduction (Bose et al. 2017). Accordingly, ARTs could be a critical source of intraspecific variation in otolith morphology that could provide further investigation. *S. cinereus* is one of these different alternative reproductive species. Males of *S. cinereus* was reported to nest with algae on sandy-muddy base on the coast of France (Thau lagoon) (Quignard, 1962). Subsequently, males were reported to guard and ventilate the nest (Lejeune, 1985). *S. cinereus* of males have three different phenotypes regarding their reproductive behavior: territorial male, satellite males and sneakers (Lejeune and Voss, 1980; Michel and Voss, 1982; Lejeune, 1985). So, there is the possibility of an ART for males (Lejeune, 1985). Bose et al (2017) suggested that examining the otoliths of fish species exhibiting different reproductive tactics may provide two benefits. First, it provides an opportunity to use study systems that identify differences in physiology, behavior, and life history that cause phenotypic changes in sagittal otolith morphology, which is a species-specific and limited feature Second, it tests the importance of considering alternative reproduction tactics when examining the population structure of species with economic value (Bose et al., 2017). In this study, the relationships between fish length and otolith length, width and weight of *S. cinereus* species were investigated between sagittal otoliths for female, male and all individuals. Considering the different reproductive tactics in *S. cinereus* males, it was hypothesized that the sagitta morphology might be different.

MATERIAL AND METHODS

Fish specimens (N=119) were collected by using trammel net during the period of June 2015 and May 2016 from waters around Rize City at the Black Sea coasts (41° 3'58.23"N 40°38'20.93"E) (Figure 1). All sampled grey wrasse was taken to the laboratory for other analysis. For each fish, the weight (W) (±0.0001 g) and total length (TL) (±0.1 mm) were determined. After that, sagittal otolith pairs were carefully removed and then properly cleaned. Otolith pairs were stored dry for further examination. After all otoliths were measured without distinguishing right and left otoliths. It was determined the sex was through macroscopic examination of the gonads (71♀, 48♂). The width and length of the otoliths were measured with the Nikon SMZ1000 stereomicroscope, with Nikon SMZ1000 digital camera was connected (magnification from x0.8 to x8.0) imaging system (Figure 2). The description of otolith length was the longest axis between posterior and anterior otolith edge. The width of otolith was described as the distance from dorsal to ventral edge taken perpendicular to the length through the otolith focus. The weights of the otoliths were weighed in Shimadzu ATX-224 brand precision scales with 0.0001 mg sensitivity. Relationships between otolith dimensions and fish length and weight were calculated according to the equation y=ax + b (Le Cren, 1951, Froese, 2006; (a=point of the y-axis of the line, b=slope of the line). The deviations from the expected 1:1 sex ratio were determined using chi-square (χ^2) test. Total lengths of male and female fish were compared with the t-test. In addition, statistical test (ANOVA) was applied to determine whether the regression was statistically significant. The ratio of otolith length to total length was calculated for each fish. Thus, the effect of different length frequencies of male and female otoliths was eliminated. Using these data, the Mann-Whitney U test was performed to test the statistical difference in otolith lengths between the sexes.

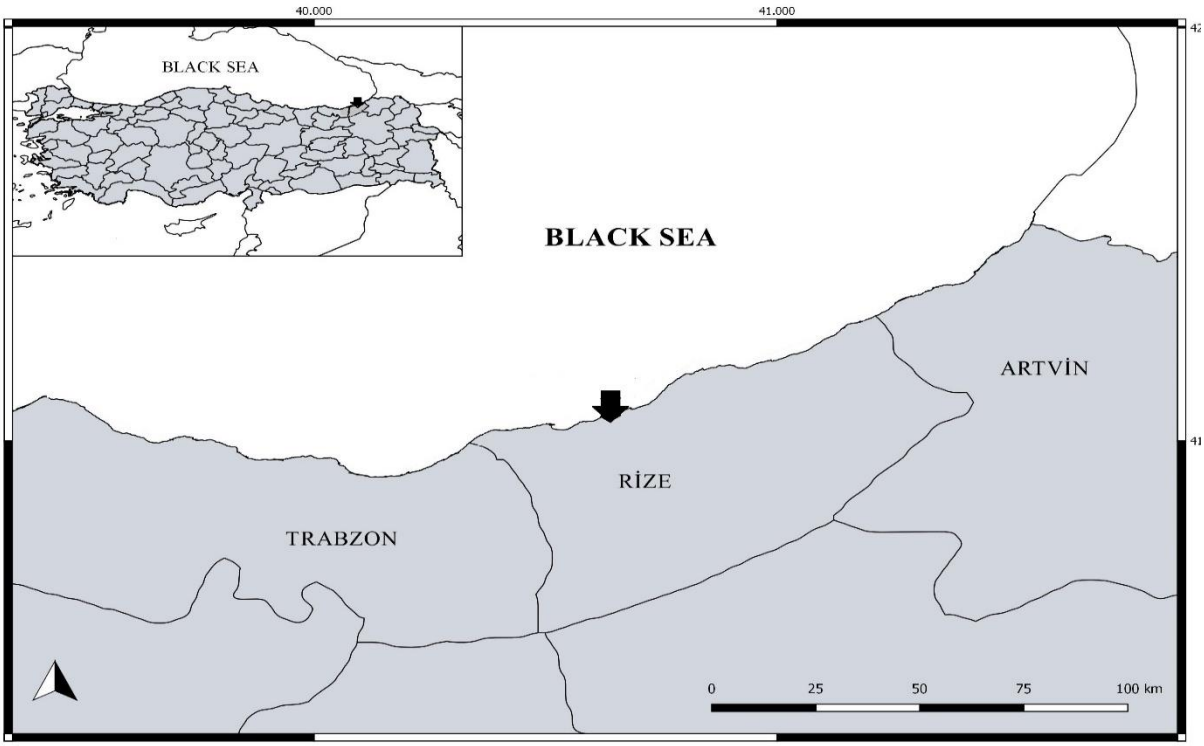

Figure 1. Study area in the Black Sea.

Figure 2. Typical images of *Symphodus cinereus* otoliths and the position of fix-points used to measure length and width under the microscope (OL was the longest axis between posterior and anterior otolith edge. OW was described as the distance from dorsal to ventral edge).

RESULTS

A total of 119 (71♀, 48♂) fish otoliths were examined throughout the study. The morphological data on weight and length for females, males, and both sexes combined are given in Table 1. The ratio of females and males of the entire sample was 1/1.47. This ratio was statistically differing significantly form the expected 1:1 ratio between sexes ($\chi 2$=8.036; $p < 0.05$). The difference in the values of the total length of female and male is statistically significant. ($t_{d.f.}$:118 =2,79, $p < 0.05$). The mean OL/TL value of female individuals (2.58±0.215) is greater than the OL/TL value of male individuals (2.47±0.266). The difference in the OL/TL values between the sex groups is greater than would be expected by chance, thus there is a statistically significant difference (T=5219.5, p<0.001). Regression relationship parameters and coefficients between fish length and weight with otolith dimensions and statistical test results by sex are given in Table 2. In the linear regression model, the coefficients of (R^2) were determined between 0.587 and 0.831. The regressions between total length and otolith width in both sex and total weight and otolith weight in males were not statistically significant (Table 2). The determined coefficient was $R^2 = 0.72$ between total length and otolith length and for total length and otolith weight, it was found as $R^2 = 0.72$ for female (Figure 3). The determined coefficient was $R^2 = 0.731$ between total length and otolith length, whereas it was $R^2 = 0.747$ between total length and otolith weight for male (Figure 4). The correlation between total length and otolith width was weak for both sexes (Figure 3, 4). The results obtained from this study indicated that otolith dimensions increase when the total length increase and it can be made correlation between otolith growth and growth of *S. cinereus*. The determined coefficient between fish weight and otolith weight was found $R^2 = 0.664$ whereas, the coefficient between total length and otolith weight was $R^2 = 0.715$ for overall (Figure 5). It was seen a moderate relationship between otolith weight and fish weight, and also between total length and otolith weight. When the male and female sagittal otoliths of *S. cinereus* were compared, the difference between the length, width and weights of the otoliths was found to be significant according to the Mann-Whitney U test results (Table 3).

Table 1. Morphometric measurements of otoliths by sex.

	OL (mm)	OW (mm)	Owe (g)	TL (cm)	W (g)
		♀			
Min	2.428	1.413	0.0007	10.2	18.51
Max	4.461	2.526	0.004	15.4	68.23
Mean	3.342	1.895	0.002	12.8-	37.92
SD	0.498	0.237	0.001	0.14	1.39
		♂			
Min	1.966	1.347	0.0007	10.0	17.40
Max	4.554	2.318	0.0033	16.4	70.29
Mean	3.122	1.746	0.002	12.5-	35.71
SD	0.595	0.231	0.001	0.15	1.51
		♀+♂			
Min	1.966	1.347	0.0007	10.0	17.14
Max	4.554	2.526	0.004	16.4	70.29
Mean	3.254	1.836	0.002	12.7	37.03
SD	0.548	0.245	0.001	0.12	1.15

OL: otolith length, OW: otolith width, Owe: otolith weight, TL: total length, W: total weight

Table 2. Regression relationship parameters and coefficients between fish length and weight with otolith dimensions and statistical test results by sex.

		Coefficient				Linear regression		
Sex	Variable	*a*	P(0.001)	*b*	P<0.001	R^2	F	P(0.001)
Female	TL&OL	-0.873	<	0.327	<	0.720	270.4	<
	TL&OW	-0.0003	>	0.147	<	0.645	190.8	<
	TL&OWe	-0.0037	<	0.000444	<	0.722	273.1	<
	TW&OWe	0.00042	<	0.00004	<	0.646	191.2	<
	OL&OWe	-0.00204	<	0.00123	<	0.819	475.1	<
Male	TL&OL	-1.276	<	0.350	<	0.731	187.8	<
	TL&OW	0.0626	>	0.134	<	0.711	170.1	<
	TL&OWe	-0.00308	<	0.000379	<	0.747	203.7	<
	TW&OWe	0.0002	>	0.000041	<	0.739	195.5	<
	OL&OWe	-0.00137	<	0.000975	<	0.831	339.2	<
Overall	TL&OL	-1.111	<	0.342	<	0.726	464.8	<
	TL&OW	-0.0644	>	0.149	<	0.587	249.9	<
	TL&OWe	-0.0035	<	0.000425	<	0.715	442.6	<
	TW&We	0.000297	<	0.000043	<	0.664	348.1	<
	OL&OWe	-0.00177	<	0.00113	<	0.817	785.7	<

OL: otolith length, OW: otolith width, Owe: otolith weight, TL: total length, W: total weight, TW: total weight

Table 3. Mann-Whitney U test results of otolith length relationships between sexes

Sex	♀		♂		Statistical test
	Mean	SD	Mean	SD	
TL/OL	3.892061	0.317712	4.089408	0.439954	*U*=2681.5 p<0.001
TL/W	6.768921	0.842388	7.228125	0.534509	*U*=2163.5 p<0.001
TL/Owe	6846.02	2033.619	8259.489	2254.166	*U*=2296.5 p<0.001

Table 4. *a*,*b* and R^2 values of Grey wrasse individuals compared with other studies.

S. cinereus	Location	N	Fish total length (cm)	Fish length			
				Otolith measurements	*a*	*b*	R^2
Škeljo and Ferri, 2011	Adriatic Sea	127	6.0-10.3	Length	1.83	0.66	57.3%
				Width	1.97	0.61	32.4%
				Weight	2.68	0.26	52.4%
This study	Black Sea	119	10-16.4	Length	0.34	1.11	0.72
				Width	0.14	0.06	0.58
				Weight	0.00	0.00	0.71

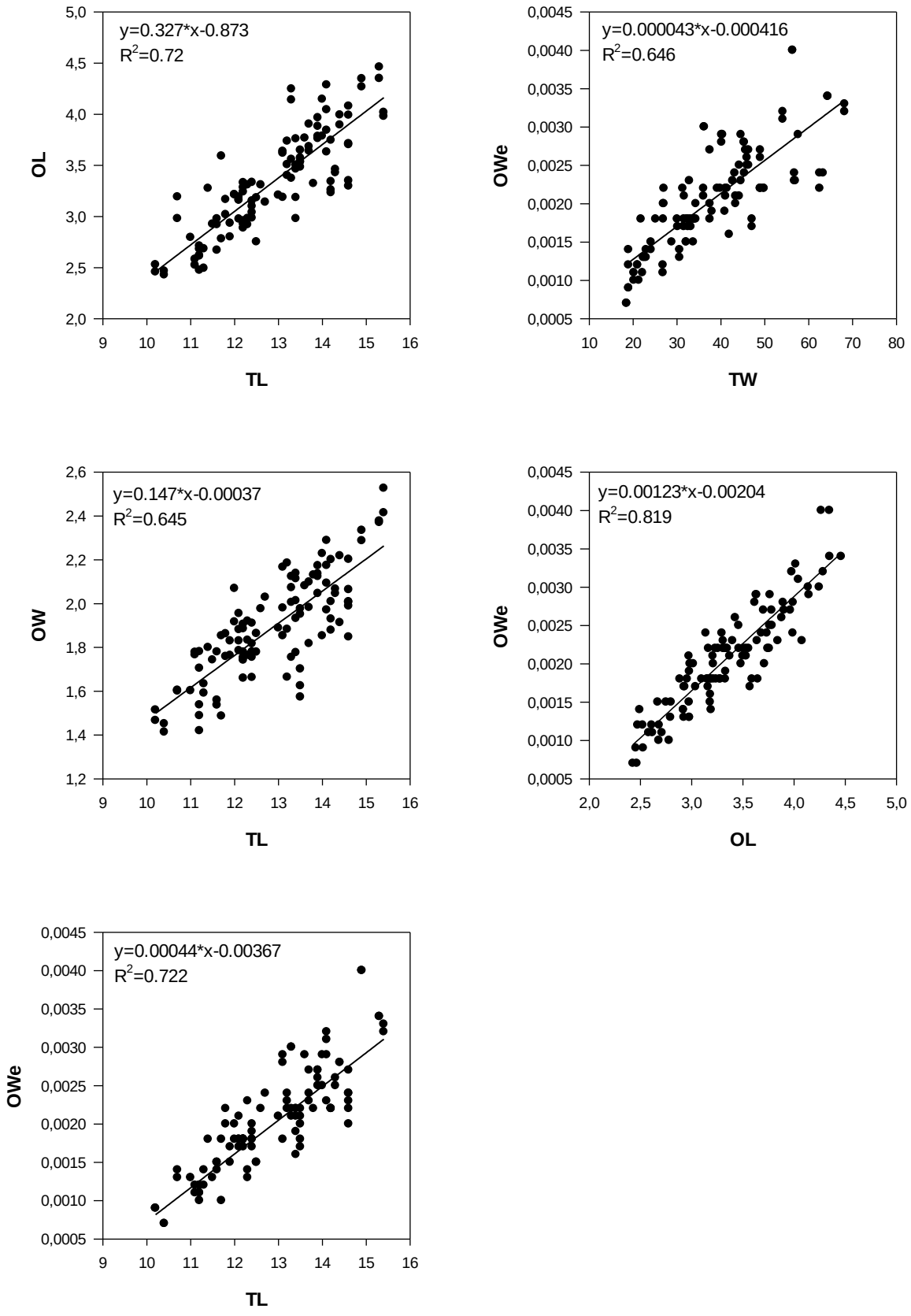

Figure 3. Relationships of otolith dimensions and weight with total length and body weight of female fish.

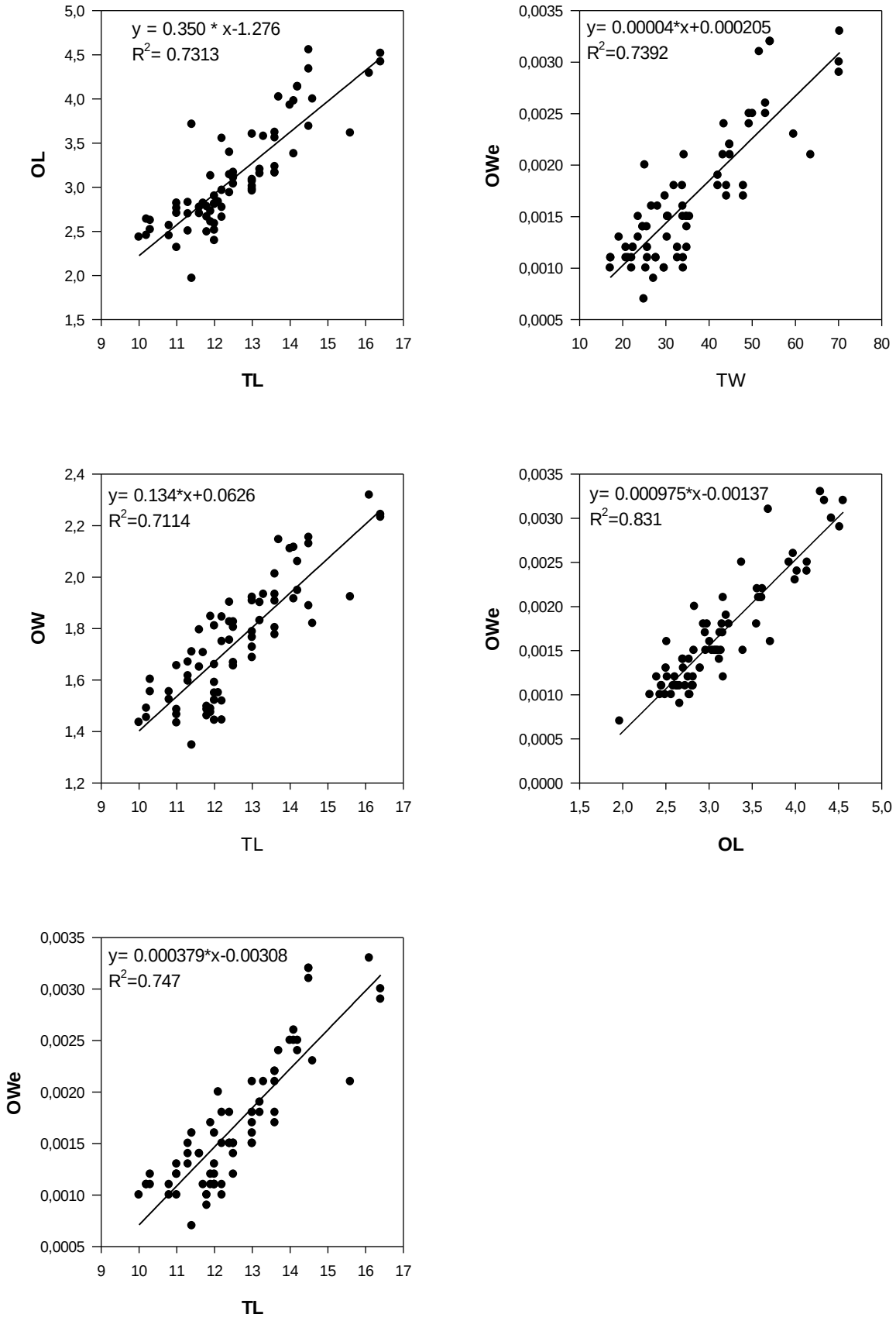

Figure 4. Relationships of otolith dimensions and weight with total length and body weight of male fish.

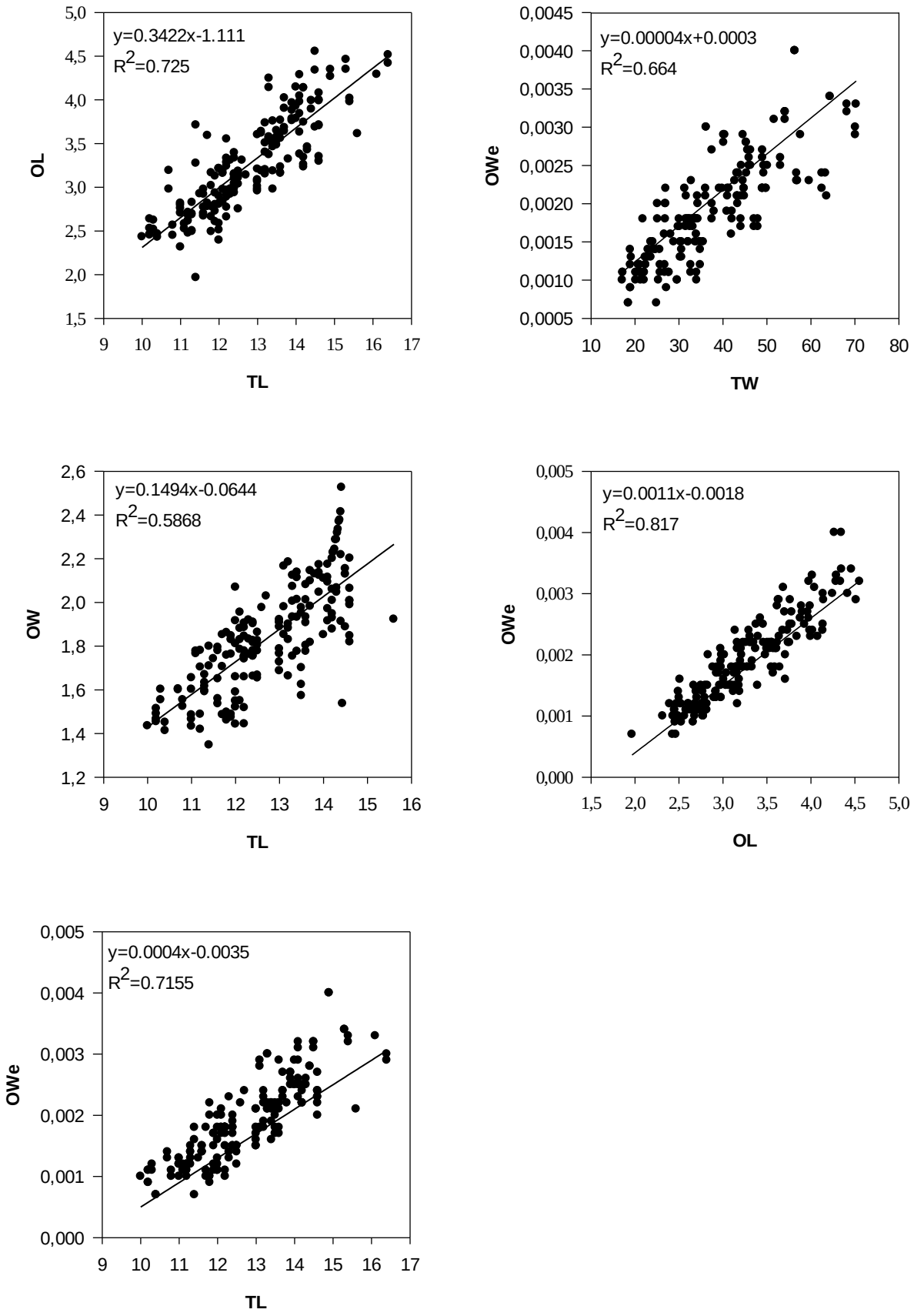

Figure 5. Relationships of otolith dimensions and weight with total length and body weight of overall individuals.

DISCUSSION

It is little known about the biology and otolith morphology of *S. cinereus* living in Black Sea waters. The cause of difficulty in collecting data on this species is absence of a fishery targeted this fish because of the limited commercial value. That is why, the information is available only through bycatch from fishery and from scientific expeditions (Bal 2014). Škeljo & Ferri (2012) investigated the otolith morphology of *S. cinereus* and five wrasse species in their study. According to their results in *S. cinereus* species, a strong correlation was found between fish length and fish weight and otolith length and otolith weight, while a weak correlation was found with otolith width. Although, different fish size ranges were examined in our study with this mentioned study, similar results were obtained (Table 4). Škeljo & Ferri (2012) found that otolith length and otolith width values which were as a result of morphometric measurements in their study in the Eastern Adriatic, were lower than the otolith length and otolith width values obtained in this study. The environmental factors, especially temperature, are effective in otolith growth, so low temperatures slow down the otolith growth and affect the physiological process of material deposition on otoliths (Morales-Nin 1987). In this study, the length, weight and width of female and male otoliths were compared and it was determined that female otoliths tended to be larger than male otoliths. Bose et al. (2020) determined that the sagittal otoliths of female and male individuals in African cichlids are different and that the otoliths of females are longer than the otoliths of males. In the literature, there are studies examining the shape and size of the sagittal otolith between two stocks. For example, Bose et al. (2017) found no difference in shape between the sagittal otoliths of two different geographic populations of *Porichthys notatus*, while Campana and Casselman (1993) found differences in sagittal shape among *Gadus morhua* stocks and reported that this may be related to the growth rates between populations. The otolith variability shown is in accordance with genetic (population and stocks) and environmental (temperature) effects on otolith growth observed by Lombarte & Lleonart (1993) and Torres et al. (1999). In this study, TL/OL, TL/W, TL/OWe between the two sexes was significant. In the study revealing the difference of otoliths of *Porichthys notatus* species that show alternative reproductive tactics. Bose et al. (2017), reported that sagitta shape also differed between females and males of the conventional guarder tactic. Differences in the otolith shape between the sexes was reported in some studies in the literature (Campana & Casselman, 1993; Carvalho et al. 2020; Başusta and Khan, 2021). Differences in otolith shape between the sexes may be related to the physiology, somatic growth rate and physiology of the sexes. (Campana & Casselman, 1993; Cardinale et al., 2004). Additionally, some factors such as sex-specific hormone levels, unequal growth rates, and distinct habitat usage for male and female fish are also effective to facilitate regulation of consequent otolith shape which can be a result in significant measure of sexual dimorphism. (Tuset et al. 2015, Tuset et al. 2016, Parmentier et al. 2018, Vaux et al. 2019).

As a result, this study revealed the relationship between fish size and otolith size of *S. cinereus* and determined the difference in size of female and male otoliths. In this study, the length, width and weight relationships of sagittal otoliths are discussed. It is recommended to carry out studies comparing the sagittal otoliths of male phenotype forms of *S. cinereus*, which show alternative reproductive tactics in the future. Otolith shape and size provide an important tool to contribute to fisheries population studies and fish stock management (Bose et al., 2018). We believe that this study will make important contributions to future studies that examine the factors affecting otolith shape and size in more detail.

AUTHORS' CONTRIBUTIONS

HO designed the release and performed the Lab work. YC interpreted the data. Both authors prepared the article.

CONFLICT OF INTEREST

The author confirms that no conflicts of interest exist and the funders had no role in study design, data collection, analysis, and decisions.

ETHICAL APPROVAL

For this type of study, formal consent is not required.

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 94-104 Araştırma Makalesi/Research Article

Yetiştiriciliği yapılan ve doğadan avlanan gökkuşağı alabalığının (*Oncorhynchus mykiss*, Walbaum 1792) karaciğer dokusu besin düzeylerinin karşılaştırılması

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- Vitaminler
- Karaciğer

Öz

Bu araştırmada, Keban Baraj Gölü Pertek Bölgesi'nde yetiştiriciliği yapılan ve bu bölgede avlanan gökkuşağı alabalıklarının (*Oncorhynchus mykiss*) karaciğer dokusu yağ asitleri, yağda çözünen vitaminler (A, D, E ve K vitaminleri) ve kolesterol düzeyleri karşılaştırılmıştır. Analizlerde tek çift bağlı doymamış yağ asidi (MUFA) olarak oleik asit bulunmuştur. Oleik asidin doğa ile kafes değerlerindeki farklılıkların Mayıs ve Haziran aylarında önemli ($P<0.05$) olduğu tespit edilmiştir. Çok çift bağlı doymamış yağ asidi (PUFA) olarak dokosaheksaenoik (DHA) asit tespit edilmiştir. Dokosaheksaenoik asidin doğa ile kafes değerlerindeki farklılıkların Mayıs ayında önemli ($P<0.05$) olduğu belirlenmiştir. Yağda çözünen vitaminler açısından en yüksek değer, E vitamininde tespit edilmiştir. E vitamininin doğa ile kafes değerlerindeki farklılıkların Nisan ayında önemli ($P<0.05$) olduğu belirlenmiştir. Kolesterolün ise, doğa ile kafes değerlerindeki farklılıkların Nisan ve Mayıs aylarında önemli ($P<0.05$) olduğu tespit edilmiştir. Sonuç olarak, doğadaki alabalıkların karaciğerinde ΣMUFA, eikosapentaenoik asit (EPA), D vitamini ve kolesterol içeriğinin daha yüksek; ΣPUFA, DHA ve E vitamini içeriğinin ise daha düşük düzeyde olduğu tespit edilmiştir.

Comparison of nutrient levels in liver tissue of farmed and wild rainbow trout (*Oncorhynchus mykiss*, Walbaum 1792)

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Abstract

In this research, fatty acids, fat soluble vitamins (A, D, E and K vitamins) and cholesterol levels in liver tissue of rainbow trout (*Oncorhynchus mykiss*) farmed and caught in Keban Dam Lake Pertek Region were compared. In the analysis, oleic acid was found as a single double bonded unsaturated fatty acid (MUFA). The differences between wild and cage values of oleic acid were found to be significant ($P<0.05$) in May and June. Docosahexaenoic (DHA) acid was detected as a polyunsaturated fatty acid (PUFA) with double bonds. The differences between wild and cage values of docosahexaenoic acid were determined to be significant ($P<0.05$) in May. In terms of fat soluble vitamins, the highest value was determined in vitamin E. The differences between wild and cage values of vitamin E were determined to be significant ($P<0.05$) in April. On the other hand, the differences between wild and cage values of cholesterol were found to be significant ($P<0.05$) in April and May. As a result, it was found that ΣMUFA, eicosapentaenoic acid (EPA), vitamin D and cholesterol contents were higher in the liver of wild trout; ΣPUFA, DHA and vitamin E contents were lower.

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GİRİŞ

Su ürünleri; yüksek oranda protein, doymamış yağ asidi ve esansiyel aminoasit içeriği, düşük karbonhidrat ve yağ oranı, zengin vitamin ve mineral madde içeriğine sahip olduğu için oldukça önemli bir besin kaynağıdır (Köprücü, 2012).

Lipitler, hayvansal organizmaların en önemli enerji kaynaklarından biri olmasıyla birlikte; yapılarında bulunan yağ asitleri hücre zarının yapı taşlarını oluşturmaktadır. Ayrıca depolanabilme, taşınabilme, koruyucu özelliği, yağda çözünen vitaminlerin kaynağı ve hormon aktivitesine sahip olan prostaglandinlerin hammaddesi olarak vücutta önemli görevleri bulunmaktadır (Çetinkaya, 1989).

Balıklar özellikle n-3 serisi yağ asitleri bakımından zengin olan çoklu doymamış yağ asidi (Poly Unsaturated Fatty Acids: PUFA) kaynağıdır. Özellikle eikosapentaenoik asit (EPA, C20:5 n-3) ve dokosaheksaenoik asit (DHA, C22:6 n-3) insan sağlığı için oldukça önemlidir. Örneğin; yağ asitleri beyin gelişimi ile fonksiyonlarında aktif rol oynamakta, koroner kalp hastalıklarının önlenmesi, bağışıklık sisteminin güçlenmesi, üreme sistemi ve sinir sistemi fonksiyonlarında da etkilidir (Cahu vd., 2004; Kebir vd., 2007).

Kolesterol, ökaryotik membranların yapısında olup, membranın akışkanlığını düzenleyen bir bileşiktir. Bununla birlikte; D vitamini, steroid hormonları ve safra asitlerinin türetildikleri başlangıç maddesidir. Kolesterol, hayvansal dokularda yüksek oranda bulunmaktadır (Keha ve Küfrevioğlu, 2015).

Vitaminler, balıklar için esansiyel yapıda olan organik bileşiklerdir. Genel olarak vitaminler, hücre metabolizmasında önemli bir yere sahiptir. Katalitik fonksiyonları gerçekleştirirler. Temel besin maddelerinin oluşum ve parçalanmalarına katılarak metabolizmayı yönetirler. A vitamini görme, epitelizasyon, büyüme, üreme ve kemiklerin gelişiminde etkilidir (Kalaycıoğlu vd., 1998). D vitamini kalsiyum, fosfor metabolizması ve bağışıklık sistemini etkilemektedir (Yılmaz vd., 2005). E vitamini, oksidasyona karşı hassas olan vitaminlerin ve doymamış yağ asitlerinin oksidasyona karşı korunmasında, balık türlerinin yumurtlama performansının ve yumurta kalitesinin artışında görev almaktadır (Halver, 1972, 1989; Bromage ve Roberts, 1995). K vitamini, kan pıhtılaşması ile kemik metabolizmasında önemli roller üstlenmektedir (Bingöl, 1976).

Karaciğer, lipit metabolizması açısından önemli bir organdır. Bununla birlikte, yağ asidi alımı, oksidasyonu, doymamış yağ asitlerinin diğer dokulara sağlanması gibi önemli işlevleri vardır (Rincon-Sanchez vd., 1992). Balığın karaciğerini incelemek, diyette bulunan besin maddelerinin büyüme ve gelişmeyi nasıl etkilediğini görmemizi ve balığın sağlıklı bir şekilde beslenip beslenmediğini anlamamızı sağlamaktadır (Caballero vd., 1999).

Doğada bulunan balıkların tükettikleri besinlerin özellikleri ve miktarı ile kültür ortamında verilen yemlerin içerikleri ve miktarı mutlak olarak farklılıklar arz etmektedir. Bu noktadan yola çıkarak, doğadaki balıklar ile kültür ortamında yetiştirilen balıkların besin kaliteleri arasındaki farklılıkları ortaya koymak için bazı türlerde denemeler yapılmıştır. Bu amaçla, tasarlanan çalışmamızda da bir dizi incelemeler yapılması hedeflenmiştir. Bu çalışmada; Keban Baraj Gölü Pertek Bölgesi'nde yetiştiriciliği yapılan ve bu bölgede avlanan gökkuşağı alabalığının (*O. mykiss)* karaciğerindeki yağ asitleri, yağda çözünen vitaminler (A, D, E ve K vitaminleri) ve kolesterol düzeyleri araştırılmıştır.

MATERYAL VE YÖNTEM

Materyal

Çalışmada balık materyali olarak, ortalama ağırlığı 356.01 g ve ortalama total boyu 30.88 cm olan gökkuşağı alabalıkları kullanılmıştır. Gökkuşağı alabalıkları; Nisan (20 adet), Mayıs (20 adet) ve Haziran (20 adet) ayları süresince doğadan (toplam 60 adet) ve işletmelerden (toplam 60 adet) temin edilmiştir. Yakalanan balıklar buz içerisinde taşınarak laboratuvara nakledilmiştir. Ardından kimyasal analizler için karaciğerden doku örnekleri alınmıştır.

Yöntem

Yağ Asitleri Analizi

Lipitlerin ekstraksiyonu için; 1 g örnek 3:2 (v/v) oranında 10 ml hekzan-izopropanol karışımında homojenize edilmiştir. Homojenat, 10 dk 8000 rpm'de santrifüjlenerek yağ asitleri analizinde kullanılmıştır (Hara ve Radin, 1978).

Metil esteri hazırlanması için; hekzan/izopropanol fazındaki lipit ekstraktı, deney tüplerine alınmıştır. %2'lik methanolik sülfürik asitten 5 ml ilave edilip, vorteksle karıştırılmıştır. Bu karışım, 15 saat 55ºC'lik etüvde inkübasyonda bırakılmıştır. %5'lik sodyum klorürden 5 ml ilave edilerek karıştırılmıştır. Tüplerdeki yağ asidi metil esterleri, 5 ml hekzanla ekstrakte edilerek, 5 ml %2'lik $KHCO_3$ ilave edilip faz ayrımı için beklenmiştir. Azot akımında çözücüsü uçtuktan sonra, 1 ml heptanla çözülerek viallere alınarak SHIMADZU 2010 plus gaz kromatografisi ile analizleri yapılmıştır. Analiz sırasında kolon sıcaklığı 120-220°C, enjektör sıcaklığı 240°C ve dedektör sıcaklığı 280°C'de sabitlenmiştir. Azot gazı, taşıyıcı gaz olarak kullanılmıştır. Analiz esnasında, standart yağ asidi metil esterleri karışımları enjekte edilerek yağ asitlerinin alıkonma süreleri tespit edilmiştir. Daha sonra programlamanın yapılması ile örneklerin yağ asidi metil esterlerinin analizi gerçekleştirilmiştir (Christie, 1992).

Kolesterol ve Yağda Çözünen Vitaminlerin Analizi

Kolesterol ile yağda çözünen vitaminlerin düzeylerini belirlemek için, SHIMADZU Marka full sistem VP serisi "yüksek performanslı sıvı kromatografi cihazı (HPLC)" kullanılmıştır. Kolesterol analizi için, 1'er gram karaciğer örneklerinin

esterleştirilmesiyle, kolesterol ekstrakte edilmiştir. Ekstraktlar, 5 dk 5000 rpm'de santrifüj edilmiştir. Sonra, üst fazdaki numuneden cihaza her defasında 5 µl enjeksiyon yapılmıştır. Kolesterol ve yağda çözünen vitaminlerin standartlarına ait kromatogram L'opez-Cervantes vd. (2006)'nın ifade ettiği şekilde elde edilmiştir.

İstatistiki Analiz

Doğadan avlanan ve kültür ortamından alınan gökkuşağı alabalıklarından elde edilen verilerin karşılaştırılmasında "Tek Yönlü Anova Testi" ile "Bağımsız İki Örnek T-Testi" kullanılmıştır. Gruplar arası farklılıklar, 0.05 önem derecesinde değerlendirilmiştir. Hangi gruplar arasında farklılıkların olduğunu belirlemek için "Duncan" çoklu karşılaştırma testi kullanılmıştır. İstatistiksel analizler, SPSS 18.0 paket programı (SPSS Inc. Chicago, Illinois, USA) ile yapılmıştır.

BULGULAR

Yağ Asidi Kompozisyonu

Doğadan avlanan gökkuşağı alabalığının karaciğer dokusundaki SFA içinde en yüksek oranlar, palmitik asitte (C16:0) (Nisan ayında %12.58, Mayıs ayında %15.85, Haziran ayında %15.49) görülmüştür ($P<0.05$). MUFA içinde baskın olarak bulunan yağ asidi, oleik asit (C18:1n-9) olarak belirlenmiş ve oleik asit oranının ise %16.84 ile %22.96 arasında değiştiği saptanmıştır ($P>0.05$). PUFA içinde baskın olarak bulunan yağ asidi ise DHA (C22:6 n-3)'dır. DHA'nın toplam yağ asitlerindeki oranları Nisan ayında %24.39, Mayıs ayında %24.09, Haziran ayında %20.49 olarak bulunmuştur ($P>0.05$) (Tablo 1).

Yetiştiriciliği yapılan gökkuşağı alabalığının karaciğer dokusundaki SFA içinde en yüksek oranlar, palmitik asitte (C16:0) (Nisan ayında %16.62, Mayıs ayında %14.18, Haziran ayında %18.44) görülmüştür ($P<0.05$). MUFA içinde baskın olarak bulunan yağ asidi, oleik asit (C18:1n-9) olarak belirlenmiş ve oleik asit oranının ise %14.62 ile %16.64 arasında değiştiği belirlenmiştir ($P>0.05$). PUFA içinde baskın olarak bulunan yağ asidi, DHA (C22:6 n-3)'dır. DHA oranları Nisan ayında %27.58, Mayıs ayında %30.26, Haziran ayında %17.44 olarak belirlenmiştir ($P<0.05$) (Tablo 1).

Tablo 1. Doğadan avlanan ve yetiştiriciliği yapılan gökkuşağı alabalığının karaciğer dokusu yağ asidi kompozisyonunun aylara göre değişimi

Yağ asitleri	Doğa			Kafes		
	Nisan	Mayıs	Haziran	Nisan	Mayıs	Haziran
SFA (Saturated fatty acid)						
C14:0 (Miristik asit)	0.67±0.03 [a]	0.85±0.06 [a]	2.09±0.21 [b]	0.83±0.02 [b]	0.38±0.01 [a]	2.14±0.17 [c]
C16:0 (Palmitik asit)	12.58±0.12 [a]	15.85±0.71 [b]	15.49±0.72 [b]	16.62±0.39 [b]	14.18±0.32 [a]	18.44±0.53 [c]
C18:0 (Stearik asit)	9.32±0.52 [b]	7.05±0.85 [a]	8.67±0.53 [ab]	8.99±0.26 [c]	6.71±0.31 [a]	7.82±0.52 [b]
ΣSFA	22.57	23.75	26.25	26.44	21.27	28.40
MUFA (Monounsaturated fatty acid)						
C16:1 n-9 (Palmitoleik asit)	2.81±0.51 [a]	4.92±0.68 [b]	4.39±0.48 [ab]	2.37±0.41 [b]	1.08±0.17 [a]	1.15±0.10 [a]
C18:1 n-9 (Oleik asit)	16.84±1.90 [a]	21.49±2.41 [a]	22.96±1.49 [a]	15.01±1.76 [a]	14.62±0.61 [a]	16.64±1.33 [a]
C20:1 n-9 (Eikosanoik asit)	1.43±0.12 [a]	1.47±0.17 [a]	2.04±0.17 [b]	1.32±0.08 [b]	0.20±0.04 [a]	0.22±0.03 [a]
C24:1n-9 (Nervonik asit)	2.29±0.07 [b]	1.21±0.15 [a]	2.48±0.20 [b]	0.78±0.04 [a]	0.80±0.06 [a]	0.75±0.04 [a]
ΣMUFA	23.37	29.09	31.87	19.48	16.70	18.76
PUFA (Polyunsaturated fatty acid)						
C18:2 n-6 (Linoleik asit)	3.66±0.78 [a]	4.29±0.59 [a]	2.53±0.70 [a]	11.36±1.03 [a]	13.03±0.56 [a]	14.01±1.25 [a]
C18:3 n-6 (γ-Linolenik asit)	0.00±0.00 [a]	0.00±0.00 [a]	0.00±0.00 [a]	0.35±0.05 [b]	0.75±0.09 [c]	0.05±0.01 [a]
C18:3 n-3 (α-Linolenik asit)	0.68±0.05 [a]	0.60±0.06 [a]	0.68±0.13 [a]	0.05±0.01 [a]	0.34±0.03 [b]	0.49±0.09 [b]
C20:2 n-6 (Eikosadienoik asit)	1.01±0.24 [c]	0.45±0.10 [b]	0.06±0.01 [a]	1.86±0.12 [b]	0.00±0.00 [a]	0.03±0.01 [a]
C20:3 n-3 (Eikosatrienoik asit)	0.62±0.09 [c]	0.33±0.06 [b]	0.09±0.02 [a]	2.49±0.18 [b]	2.28±0.11 [b]	0.77±0.12 [a]
C20:4 n-6 (Araşidonik asit)	6.93±0.59 [b]	5.64±0.65 [ab]	5.15±0.38 [a]	5.46±0.25 [a]	7.90±0.35 [b]	5.91±0.43 [a]
C20:5 n-3 (Eikosapentanoik asit)	5.28±0.42 [a]	4.92±0.23 [a]	5.05±0.35 [a]	2.15±0.08 [b]	1.67±0.06 [a]	3.05±0.25 [c]
C22:5 n-3 (Dokosapentaenoik asit)	2.55±0.19 [a]	3.07±0.27 [a]	4.69±0.36 [b]	0.48±0.03 [a]	1.85±0.30 [b]	4.44±0.42 [c]
C22:6 n-3 (Dokosaheksaenoik asit)	24.39±2.20 [a]	24.09±2.29 [a]	20.49±1.13 [a]	27.58±0.93 [b]	30.26±0.99 [b]	17.44±2.06 [a]
ΣPUFA	45.12	43.39	38.74	51.78	58.08	46.19
Σn-3	33.52	33.01	31.00	32.75	36.40	26.19
Σn-6	11.60	10.38	7.74	19.03	21.68	20.00
Σn-3/Σn-6	2.89	3.18	4.00	1.72	1.68	1.31
DHA/EPA	4.62	4.90	4.06	12.83	18.12	5.72

Aynı satırdaki farklı harflerle belirlenen veriler arasındaki farklar önemlidir (P<0.05).

Farklı aylarda gökkuşağı alabalığının karaciğer dokusundaki SFA içinde en yüksek oranlar, palmitik asitte (C16:0) (sırasıyla doğa ve kafeste olmak üzere Nisan ayında %12.58, %16.62, Mayıs ayında %15.85, %14.18, Haziran ayında ise %15.49, %18.44) görülmüştür (Tablo 2).

MUFA içinde baskın olarak bulunan yağ asidi, oleik asit (C18:1n-9) olarak belirlenmiş ve oleik asit oranının ise %14.62 ile %22.96 arasında değiştiği belirlenmiştir (Tablo 2).

PUFA içinde en baskın olarak bulunan yağ asidi, DHA (C22:6 n-3)'dır. DHA oranları, sırasıyla doğa ve kafeste olmak üzere Nisan ayında %24.39, %27.58, Mayıs ayında %24.09, %30.26, Haziran ayında ise %20.49, %17.44 olarak bulunmuştur (Tablo 2).

Tablo 2. Farklı aylarda gökkuşağı alabalığının karaciğer dokusu yağ asidi kompozisyonunun doğa ile kafese göre değişimi

Yağ asitleri	Nisan		Mayıs		Haziran	
	Doğa	Kafes	Doğa	Kafes	Doğa	Kafes
SFA (Saturated fatty acid)						
C14:0 (Miristik asit)	0.67±0.03	0.83±0.02**	0.85±0.06**	0.38±0.01	2.09±0.21	2.14±0.17
C16:0 (Palmitik asit)	12.58±0.12	16.62±0.39**	15.85±0.71	14.18±0.32	15.49±0.72	18.44±0.53**
C18:0 (Stearik asit)	9.32±0.52	8.99±0.26	7.05±0.85	6.71±0.31	8.67±0.53	7.82±0.52
ΣSFA	22.57	26.44	23.75	21.27	26.25	28.40
MUFA (Monounsaturated fatty acid)						
C16:1 n-9 (Palmitoleik asit)	2.81±0.51	2.37±0.41	4.92±0.68**	1.08±0.17	4.39±0.48**	1.15±0.10
C18:1 n-9 (Oleik asit)	16.84±1.90	15.01±1.76	21.49±2.41*	14.62±0.61	22.96±1.49**	16.64±1.33
C20:1 n-9 (Eikosanoik asit)	1.43±0.12	1.32±0.08	1.47±0.17**	0.20±0.04	2.04±0.17**	0.22±0.03
C24:1n-9 (Nervonik asit)	2.29±0.07**	0.78±0.04	1.21±0.15	0.80±0.06	2.48±0.20**	0.75±0.04
ΣMUFA	23.37	19.48	29.09	16.70	31.87	18.76
PUFA (Polyunsaturated fatty acid)						
C18:2 n-6 (Linoleik asit)	3.66±0.78	11.36±1.03**	4.29±0.59	13.03±0.56**	2.53±0.70	14.01±1.25**
C18:3 n-6 (γ-Linolenik asit)	0.00±0.00	0.35±0.05*	0.00±0.00	0.75±0.09**	0.00±0.00	0.05±0.01*
C18:3 n-3 (α-Linolenik asit)	0.68±0.05**	0.05±0.01	0.60±0.06**	0.34±0.03	0.68±0.13	0.49±0.09
C20:2 n-6 (Eikosadienoik asit)	1.01±0.24	1.86±0.12**	0.45±0.10**	0.00±0.00	0.06±0.01*	0.03±0.01
C20:3 n-3 (Eikosatrienoik asit)	0.62±0.09	2.49±0.18**	0.33±0.06	2.28±0.11**	0.09±0.02	0.77±0.12**
C20:4 n-6 (Araşidonik asit)	6.93±0.59	5.46±0.25	5.64±0.65	7.90±0.35**	5.15±0.38	5.91±0.43
C20:5 n-3 (Eikosapentanoik asit)	5.28±0.42**	2.15±0.08	4.92±0.23**	1.67±0.06	5.05±0.35**	3.05±0.25
C22:5 n-3 (Dokosapentaenoik asit)	2.55±0.19**	0.48±0.03	3.07±0.27**	1.85±0.30	4.69±0.36	4.44±0.42
C22:6 n-3 (Dokosaheksaenoik asit)	24.39±2.20	27.58±0.93	24.09±2.29	30.26±0.99*	20.49±1.13	17.44±2.06
ΣPUFA	45.12	51.78	43.39	58.08	38.74	46.19
Σn-3	33.52	32.75	33.01	36.40	31.00	26.19
Σn-6	11.60	19.03	10.38	21.68	7.74	20.00
Σn-3/Σn-6	2.89	1.72	3.18	1.68	4.00	1.31
DHA/EPA	4.62	12.83	4.90	18.12	4.06	5.72

**P<0.01, *P<0.05

Kolesterol ve Yağda Çözünen Vitamin Düzeyleri

Doğadan avlanan gökkuşağı alabalığının karaciğer dokusundaki en yüksek miktarda bulunan D_3 vitaminidir. Vitamin D_3, Nisan ayında 11.72 mg/100 g, Mayıs ayında 10.84 mg/100 g, Haziran ayında ise 0.42 mg/100 g olarak bulunmuştur ($P<0.05$). Kolesterol miktarları ise, Nisan ayında 849.02 mg/100 g, Mayıs ayında 943.02 mg/100 g, Haziran ayında ise 181.90 mg/100 g olarak belirlenmiştir ($P<0.05$) (Tablo 3).

Yetiştiriciliği yapılan gökkuşağı alabalığının karaciğer dokusunda E vitamini, en fazla düzeyde bulunan vitamindir. Vitamin E miktarları, Nisan ayında 10.16 mg/100 g, Mayıs ayında 6.06 mg/100 g, Haziran ayında ise 1.78 mg/100 g olarak bulunmuştur ($P<0.05$). Kolesterol miktarları ise, Nisan ayında 536.11 mg/100 g, Mayıs ayında 761.99 mg/100 g, Haziran ayında ise 175.83 mg/100 g olarak bulunmuştur ($P<0.05$) (Tablo 3).

Tablo 3. Doğadan avlanan ve yetiştiriciliği yapılan gökkuşağı alabalığının karaciğer dokusu yağda çözünen vitamin ve kolesterol düzeylerinin aylara göre değişimi

Vitamin ve kolesterol	Doğa			Kafes		
	Nisan	Mayıs	Haziran	Nisan	Mayıs	Haziran
A	4.97±1.14 ^{c}	1.87±0.39 ^{b}	0.35±0.06 ^{a}	0.11±0.01 ^{c}	0.07±0.01 ^{b}	0.03±0.00 ^{a}
D_2	0.09±0.02 ^{b}	0.00±0.00 ^{a}	0.01±0.00 ^{a}	0.12±0.03 ^{a}	0.36±0.06 ^{b}	0.05±0.01 ^{a}
D_3	11.72±1.93 ^{b}	10.84±2.73 ^{b}	0.42±0.10 ^{a}	0.32±0.03 ^{b}	1.75±0.07 ^{c}	0.02±0.00 ^{a}
E	6.72±1.08 ^{b}	7.00±0.52 ^{b}	1.83±0.31 ^{a}	10.16±1.79 ^{c}	6.06±1.51 ^{b}	1.78±0.14 ^{a}
K_1	1.76±0.46 ^{b}	0.23±0.05 ^{a}	0.12±0.03 ^{a}	0.10±0.03 ^{a}	1.19±0.28 ^{b}	0.08±0.01 ^{a}
K_2	0.86±0.23 ^{ab}	1.58±0.42 ^{b}	0.25±0.06 ^{a}	0.19±0.04 ^{a}	0.54±0.10 ^{b}	0.40±0.08 ^{b}
Kolesterol	849.02±88.63 ^{b}	943.02±75.75 ^{b}	181.90±23.04 ^{a}	536.11±20.89 ^{b}	761.99±26.75 ^{c}	175.83±12.49 ^{a}

Aynı satırdaki farklı harflerle belirlenen veriler arasındaki farklar önemlidir ($P<0.05$).

Farklı aylarda gökkuşağı alabalığının karaciğer dokusunda en yüksek düzeyde bulunan vitaminler, D_3 ile E vitaminidir. Vitamin D_3 miktarları sırasıyla doğa ve kafeste olmak üzere; Nisan ayında 11.72, 0.32 mg/100 g, Mayıs ayında 10.84, 1.75 mg/100 g, Haziran ayında ise 0.42, 0.02 mg/100 g olarak bulunmuştur. Vitamin E miktarları sırasıyla doğa ve kafeste olmak üzere; Nisan ayında 6.72, 10.16 mg/100 g, Mayıs ayında 7.00, 6.06 mg/100 g, Haziran ayında ise 1.83, 1.78 mg/100 g olarak elde edilmiştir (Tablo 4).

Kolesterol miktarları ise sırasıyla doğa ve kafeste olmak üzere; Nisan ayında 849.02, 536.11 mg/100 g, Mayıs ayında 943.02, 761.99 mg/100 g, Haziran ayında ise 181.90, 175.83 mg/100 g olarak belirlenmiştir (Tablo 4).

Tablo 4. Farklı aylarda gökkuşağı alabalığının karaciğer dokusu yağda çözünen vitamin ve kolesterol düzeylerinin doğa ile kafese göre değişimi

Vitamin ve kolesterol	Nisan		Mayıs		Haziran	
	Doğa	Kafes	Doğa	Kafes	Doğa	Kafes
A	4.97±1.14**	0.11±0.01	1.87±0.39**	0.07±0.01	0.35±0.06**	0.03±0.00
D_2	0.09±0.02	0.12±0.03	0.00±0.00	0.36±0.06**	0.01±0.00	0.05±0.01**
D_3	11.72±1.93**	0.32±0.03	10.84±2.73**	1.75±0.07	0.42±0.10*	0.02±0.00
E	6.72±1.08	10.16±1.79*	7.00±0.52	6.06±1.51	1.83±0.31	1.78±0.14
K_1	1.76±0.46*	0.10±0.03	0.23±0.05	1.19±0.28**	0.12±0.03	0.08±0.01
K_2	0.86±0.23*	0.19±0.04	1.58±0.42*	0.54±0.10	0.25±0.06	0.40±0.08
Kolesterol	849.02±88.63*	536.11±20.89	943.02±75.75*	761.99±26.75	181.90±23.04	175.83±12.49

**P<0.01, *P<0.05

Keban Baraj Gölü Pertek Bölgesine Ait Suyun Sıcaklık, pH ve Çözünmüş Oksijen Düzeyleri

Keban Baraj Gölü Pertek Bölgesine ait suyun sıcaklık, çözünmüş oksijen ve pH değerleri Tablo 5'de gösterilmiştir.

Tablo 5. Keban Baraj Gölü Pertek Bölgesine ait suyun sıcaklık, çözünmüş oksijen ve pH değerleri

Parametreler	**Aylar**		
	Nisan	**Mayıs**	**Haziran**
Sıcaklık (˚C)	11.80±0.02 [a]	20.00±0.04 [b]	26.30±0.06 [c]
pH	8.72±0.02 [a]	8.80±0.02 [b]	8.96±0.03 [c]
Çözünmüş oksijen (mg/L)	11.30±0.01 [a]	9.80±0.03 [b]	8.76±0.02 [c]

Aynı satırdaki farklı harflerle belirlenen veriler arasındaki farklar önemlidir (P<0.05).

TARTIŞMA

Yağ Asidi Kompozisyonu

Çalışmamızdaki balıklardan elde edilen karaciğer dokularındaki palmitik asit (C16:0) oranı %12.58-18.44 olarak belirlenmiştir**.** Haliloğlu vd. (2004) *O. mykiss*'in karaciğer dokusundaki palmitik asit miktarını %16.4-19.7 olarak bildirmişlerdir. Harlıoğlu (2012) *O. mykiss*'in karaciğer dokusunda palmitik asit miktarını %17.37 olarak belirtmiştir. Öz (2017) *O. mykiss*'in karaciğer dokusunda palmitik asit miktarını %12,03-13,18 olarak bildirmiştir. Çalışmamızdaki bulgular ile Haliloğlu vd. (2004), Harlıoğlu (2012) ve Öz (2017)'ün palmitik asit bulguları uygunluk göstermektedir. Akpınar vd. (2009) palmitik asit miktarını *Salmo trutta macrostigma*'nın karaciğerinde %19,0-19,1 arasında olduğunu ifade etmişlerdir. Jankowska vd. (2010) doğa ve kafesteki *Perca fluviatilis*'in yağ asitleri profili çalışmasında; karaciğerde palmitik asit miktarını %21,34-21,96 olarak belirtmişlerdir. Kaçar ve Başhan (2022) palmitik asit miktarını *Cyprinus carpio*'nun karaciğerinde %18,94-31,7 arasında olduğunu ifade etmişlerdir. Çalışmamızdaki bulgular, Akpınar vd. (2009), Jankowska vd. (2010) ve Kaçar ve Başhan (2022)'a göre düşüktür.

Oleik asit (C18:1 n-9) oranı %14.62-22.96 olarak bulunmuştur. Haliloğlu vd. (2004) *O. mykiss*'in karaciğer dokusundaki oleik asit miktarını %15.2-22.3 olarak bildirmişlerdir. Harlıoğlu (2012) *O. mykiss*'in karaciğer dokusunda oleik asit miktarını %16.10 olarak belirtmiştir. Akpınar vd. (2009) oleik asit miktarını *Salmo trutta macrostigma*'nın karaciğerinde %15,6-17,6 aralığında bulmuşlardır. Öz (2017) *O. mykiss*'in karaciğer dokusunda oleik asit miktarını %17,24-21,71 olarak bildirmiştir. Çalışmamızdaki bulgular ile Haliloğlu vd. (2004), Harlıoğlu (2012), Akpınar vd. (2009) ve Öz (2017)'ün oleik asit bulguları uygunluk göstermektedir. Jankowska vd. (2010) doğa ve kafesteki *Perca fluviatilis*'in yağ asitleri profili çalışmasında; karaciğerde oleik asit miktarını %10,59-14,10 olarak ifade etmişlerdir. Çalışmamızdaki bulgular, Jankowska vd. (2010)'ne göre yüksektir. Kaçar ve Başhan (2022) oleik asit miktarını *Cyprinus carpio*'nun karaciğerinde %14,69-27,62 arasında olduğunu ifade etmişlerdir. Çalışmamızdaki bulgular, Kaçar ve Başhan (2022)'a göre düşüktür.

n-3 serisi yağ asitlerinden DHA (C22:6 n-3) oranı %17.44-30.26 olarak tespit edilmiştir. Haliloğlu vd. (2004) *O. mykiss* ile ilgili çalışmasında, karaciğer dokusuna ait DHA (C22:6 n-3) oranını %24.9-25.9 olarak bildirmişlerdir. Harlıoğlu (2012) *O. mykiss*'in karaciğer dokusunda DHA (C22:6 n-3) oranını %30.49 olarak belirtmiştir. Öz (2017) *O. mykiss*'in karaciğer dokusunda

DHA oranını %25,83-30,96 olarak bildirmiştir. Mevcut çalışmadaki bulgular ile Haliloğlu vd. (2004), Harlıoğlu (2012) ve Öz (2017)'ün DHA yağ asitleri bulguları uygunluk göstermektedir. Akpınar vd. (2009) *Salmo trutta macrostigma*'nın karaciğerinde DHA oranının %12,7-15,6 arasında bulunduğunu ifade etmişlerdir. Akpınar vd. (2009)'ne göre çalışmamızdaki DHA oranı yüksektir. Jankowska vd. (2010) doğa ve kafesteki *Perca fluviatilis*'in yağ asitleri profili çalışmasında; karaciğerde DHA oranını %16,40-21,28 olarak ifade etmişlerdir. Jankowska vd. (2010)'ne göre çalışmamızdaki DHA oranı yüksektir. Kaçar ve Başhan (2022) DHA oranını *Cyprinus carpio*'nun karaciğerinde %7,27-17,51 arasında olduğunu ifade etmişlerdir. Çalışmamızdaki bulgular, Kaçar ve Başhan (2022)'a göre yüksektir.

Toplam n-3 (Σn-3) serisi yağ asitleri oranları %26.19-36.40 ve toplam n-6 (Σn-6) serisi yağ asitleri oranları %7.74-21.68 arasında bulunmuştur. Bu karaciğer dokularına ait toplam n-3 serisi yağ asitlerinin, toplam n-6 serisi yağ asitlerine oranının (Σn-3/Σn-6) 1.31-4.00 arasında olduğu belirlenmiştir. Haliloğlu vd. (2004) *O. mykiss*'in karaciğer dokusuna ait Σn-3 serisi yağ asitlerini %28.1-34.0, Σn-6 serisi yağ asitlerini %12.3-14.9 ve ∑n-3/∑n-6 oranını ise 1.94-2.71 arasında bulmuşlardır. Bu çalışmadaki bulgular ile Haliloğlu vd. (2004)'nın Σn-3, Σn-6 ve Σn-3/Σn-6 yağ asitleri bulguları uygunluk göstermektedir. Harlıoğlu (2012) *O. mykiss*'in karaciğer dokusunda Σn-3 serisi yağ asitlerini %40.38, Σn-6 serisi yağ asitlerini %8.81 ve ∑n-3/∑n-6 oranını ise 4.58 olarak belirtmiştir. Çalışmamızdaki Σn-3 ve Σn-3/Σn-6 serisi yağ asitleri bulguları; Harlıoğlu (2012)'na göre düşük, Σn-6 serisi yağ asitleri bulguları ise uygunluk göstermektedir. Akpınar vd. (2009) *Salmo trutta macrostigma*'nın karaciğerinde ∑n-3 serisi yağ asitlerinin %24,5-31,1, ∑n-6 serisi yağ asitlerinin %10,9-12,4 ve ∑n-3/∑n-6 oranının ise 1,97-2,89 arasında bulunduğunu ifade etmişlerdir. Akpınar vd. (2009)'ne göre çalışmamızdaki Σn-3 serisi yağ asidi bulguları yüksek, Σn-3/Σn-6 oranı ile Σn-6 serisi yağ asidi bulguları ise uygunluk göstermektedir. Jankowska vd. (2010) doğa ve kafesteki *Perca fluviatilis*'in yağ asitleri profili çalışmasında; karaciğerde Σn-3 serisi yağ asitlerini %22,64-28,49, Σn-6 serisi yağ asitlerini %6,69-11,85 ve ∑n-3/∑n-6 oranını ise 2,40-3,38 olarak bildirmişlerdir. Jankowska vd. (2010)'ne göre çalışmamızdaki Σn-3 ve Σn-6 serisi yağ asidi bulguları yüksek, Σn-3/Σn-6 oranıyla uygunluk göstermektedir. Kaçar ve Başhan (2022) *Cyprinus carpio*'nun karaciğerinde ∑n-3 serisi yağ asitlerinin %15,07-25,84, ∑n-6 serisi yağ asitlerinin %6,09-15,77 ve ∑n-3/∑n-6 oranının ise 1,33-2,55 arasında bulunduğunu ifade etmişlerdir. Kaçar ve Başhan (2022)'a göre çalışmamızdaki Σn-3 ve Σn-6 serisi yağ asidi bulguları yüksek, Σn-3/Σn-6 oranı yağ asidi bulguları ise uygunluk göstermektedir.

Bu çalışmada, *O. mykiss*'in karaciğer dokusunda belirlenen yağ asidi miktarları ile diğer araştırmacıların tespit ettiği değerler arasındaki farklılıkların nedeni; balıkların türü, yaşı, cinsiyeti, büyüklüğü, farklı doku ve organlarda bulunması, mevsimsel değişimler, su sıcaklığındaki farklılıklar, beslenme ve yaşadığı ortam koşulları olabilir.

Kolesterol ve Yağda Çözünen Vitamin Düzeyleri

Çalışmamızda, vitamin A (retinol) 0.03-4.97 mg/100 g, vitamin D (D_2+D_3) 0.07-11.81 mg/100 g, vitamin E (α-Tokoferol) 1.78-10.16 mg/100 g, vitamin K (K_1+K_2) 0.29-2.62 mg/100 g olarak belirlenmiştir.

Harlıoğlu (2014), *Barbus grypus* türünün karaciğerinde 1.08 mg/100 g vitamin A, 0.34 mg/100 g vitamin D, 2.85 mg/100 g vitamin E ve 0.79 mg/100 g vitamin K olduğunu ifade etmişlerdir. Çalışmamızdaki vitamin miktarları, Harlıoğlu (2014)'nun bildirdiği değerlerle uygunluk göstermektedir.

Kandemir (2010), *Esox lucius*'un vitaminlerle ilgili çalışmasında, karaciğerde 1.81 mg/100 g vitamin K, 3.94 mg/100 g vitamin D ve 13.06 mg/100 g vitamin E olduğunu ifade etmiştir. Kandemir (2010)'in vitamin E miktarı, mevcut bulgulara göre yüksektir.

Yaptığımız çalışmada, karaciğer dokusundaki kolesterol içeriği 175.83-943.02 mg/100 g olarak bulunmuştur. Kandemir (2010) *Esox lucius*'un karaciğerindeki kolesterol miktarını 32.0 mg/100 g olarak belirlemiştir. Harlıoğlu (2014), *Barbus grypus* türünün karaciğerinde 185.6 mg/100 g kolesterol bulunduğunu bildirmiştir. Çalışmamızdaki kolesterol miktarı, Harlıoğlu (2014)'nun bulgularıyla uygunluk göstermekte; Kandemir (2010)'in bulgularından ise yüksek olduğu görülmektedir.

Bu çalışmada, *O. mykiss*'in karaciğer dokusunda belirlenen A, D, E ve K vitamini ve kolesterol miktarları ile diğer çalışmalardaki bulgular arasındaki farklılıkların nedeni; tür, yaşama ortamı, beslenme koşulları, büyüklük, yağlılık durumu, su şartlarının farklılığı, biyolojik ve mevsimsel farklılıklar olabilir.

SONUÇ

Doğadaki alabalıkların karaciğerinde ΣMUFA, eikosapentaenoik asit (EPA), D vitamini ve kolesterol içeriğinin daha yüksek; ΣPUFA, DHA ve E vitamini içeriğinin ise daha düşük düzeyde olduğu tespit edilmiştir. Çalışmamız, Pertek bölgesinde doğa ve kafeslerdeki gökkuşağı alabalıklarında besin madde içerik ve düzeylerini belirlemeye yönelik yapılan ilk çalışma özelliği taşımakta olup özgün değere sahiptir.

ETİK STANDARTLARA UYUM

Yazar katkıları

Bütün araştırıcılar projede görev almış olup çalışmaya katkı sunmuşlardır.

Çıkar çatışması

Yazarlar çıkar çatışması olmadığını beyan ederler.

Çalışmaya İlişkin Beyan

Etik onay: Hayvanların bakımı ve kullanımı için geçerli tüm uluslararası, ulusal ve / veya kurumsal yönergelere uyulmuştur.

İnsan Hakları Beyanı

Etik onay: Bu tür bir çalışma için resmi onay gerekli değildir.

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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2022; 8(2): 105-113 Araştırma Makalesi/Research Article

Comparison of Meat Yield and Proximate Composition of Rainbow Trout (*Oncorhynchus mykiss*) Grown in Concrete Ponds and Cages of Two Farms in Two Different Provinces of Turkey

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Abstract

In this study, it was aimed to compare meat yields and nutrient contents of male and female rainbow trout individuals obtained from pond and cage units of two fish farms located in two provinces, Kayseri and Kahramanmaraş, Turkey. The results showed that the highest meat yield was in female individuals reared in the pond unit of the farm in Kahramanmaraş with 55.70% and the lowest meat yield was in male individuals reared in the pond unit of the farm in Kayseri with 47.17%. When all males and females were compared, it was determined that female individuals had higher meat yield and no significant differences were found between pond and cage groups. The highest condition factor (1.55) was found in the Kahramanmaraş cage male group, while there was no significant difference in other groups. HSI values were higher in male individuals and VSI values were higher in the cage groups. Protein values were found to be higher in females. The highest protein contents were determined in the Kahramanmaraş cage female (20.16%), Kahramanmaraş pond female (20.11%), and Kayseri cage female (19.89%) groups. Moreover, the highest lipid values were found in the Kahramanmaraş cage male (7.36%) and Kahramanmaraş pond male (7.16%) groups. The highest moisture was observed in the Kayseri pond male group with 75.84%. The ash content did not differ between groups.

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INTRODUCTION

Fish meat contains favorable amino acids for nutritional physiology, has a low carbohydrate and fat ratio, and has a high polyunsaturated fatty acid ratio. The combination of these factors along with its easy digestibility and richness in vitamins and minerals make fish meat a high-valued food product (Varlık et al., 2007). Fish meat is among recommended and easy-to-digest food sources since it does not contain cellulose and fibers like plants and cartilage and nerves like other meats (Gorga, 1998).

Salmonids are one of the most produced and economically important fishes in the World after carp and tilapia. According to the statistics of 2020 in Turkey, rainbow trout accounts for approximately one-third of the total amount of annual aquaculture with 144.182 tons of production (TUİK, 2021).

Rainbow trout culture in Turkey is mainly carried out in concrete ponds, cage systems installed in dam lakes, and cage enterprises located in the Black Sea. In addition to spring waters; streams and well waters are also used as a water source for fish farming in ponds.

The importance of trout, which is currently a significant agricultural product preferred in the global market as fresh, frozen, or processed, increases day by day. Meat quality in trout production is particularly an uncompromisable matter. Demonstrating the extent to which rearing conditions can affect meat and nutritional quality is of great importance in terms of the standardization of products and the need for studies on this topic is gradually increasing. Therefore, the present study aimed to demonstrate the effects of two different rearing environments and sex differences on rainbow trout's meat yield, nutrient content, and parameters such as VSI (viscerosomatic index), HSI (hepatosomatic index), and K (condition factor).

MATERIALS AND METHODS

Sample Preparation

The rainbow trout (*Oncorhynchus mykiss*) individuals used in the study were obtained from concrete ponds and net cages in Kahramanmaraş and Kayseri provinces of Turkey, where trout farming is a common practice. A total number of 80 fish, which were of similar length and weight and fed with similar diets, were used as the study materials. The proximate analyse results of feed sample are given in Table 1. Forty fish from each province were obtained (for each province: 10 individuals of both sexes from cages and 10 individuals of both sexes from ponds; i.e., a total of 20 males and 20 females) in April. These rainbow trout individuals obtained from different regions for the study were brought to the laboratory at Çukurova University, Fisheries Faculty, Aquaculture Department in cold chain and analyzed. Sex determination was carried out by macroscopic examination of the dissected fish's gonads (Lagler, 1956).

Table 1. Proximate analysis of the diets (%)

Ingredient	Result (%)
Protein	44.16±0.13
Lipid	19.10±0.32
Crude ash	9.50±0.06
Dry matter	91.65±0.06

Meat Yield

The net weight of fish [of which head, internal organs, and spine (including intermuscular bones) were removed] was calculated using the formula below:

Skinned and Skinless (net) weight (yield) = Weight of edible parts/Total body weight x100

Proximate Analysis

The fish fillets were obtained after removing viscera, bones, skin, and head. The fillets were then thoroughly cleaned by washing and homogenized. The AOAC (1990) procedures were employed to determine the moisture and ash contents of the fish. The nitrogen content, which was determined as per Kjeldahl's method (AOAC, 1990), was converted to estimate the crude protein content. Bligh & Dyer (1959)'s method was used to analyze the lipid content. All analyzes were carried out in triplicate.

Estimation of Performance Parameters

The following equations described by Korkut et al. (2007) were used in the calculations for condition factor (K), hepatosomatic index (HIS), and viscerosomatic index (VSI):

$K = W \text{ (body weight)} / L^3 \text{ (fish length)} \times 100$

HSI = Liver weight / fish weight x 100

VSI = Weight of all internal organs / fish weight x 100

Statistical Analysis

Data were compared with one-way variance analysis (ANOVA). Duncan's multiple range test was employed to determine significant differences at the confidence level of 5%. Statistical analyses were performed using the SPSS software (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Meat Yield

The weight values of rainbow trout individuals, obtained from the concrete pond and lake cage units of two commercial fish farms in Kahramanmaraş and Kayseri, are given in Table 2. The mean weights of female and male individuals obtained from the pond units of the farm in Kahramanmaraş were determined to be 261.07 and 236.47, respectively, while the mean weights of female and male individuals obtained from the same farm's cage units were 252.63 and 283.93, respectively.

On the other hand, the mean weights of female and male individuals obtained from the pond unit of the farm in Kayseri were measured to be 285.23 and 223.80, respectively. The mean weights of female and male individuals of the same farm's cage units were 272.90 and 275.10, respectively.

Statistical differences were observed when the weights of fillets as well as inedible parts were examined ($p<0.05$).

Table 2. Mean whole body, fillet, inedible part weights, and meat yield of rainbow trout individuals.

Farm and unit where fish samples were obtained from	Whole body weight (g)	Fillet weight (g)	Inedible part weight (g)	Meat yield (%)
(G1) Kahramanmaraş Pond Female	261.07±13.42^{ab}	145.40±8.22^{a}	105.17±7.60^{c}	55.70±2.42^{a}
(G2) Kahramanmaraş Pond Male	236.47±12.32^{bc}	119.17±8.11^{bc}	107.07±5.92^{c}	50.35±2.55^{c}
(G3) Kahramanmaraş Cage Female	252.63±17.04^{abc}	127.20±6.75^{abc}	112.25±8.26^{bc}	50.44±1.20^{c}
(G4) Kahramanmaraş Cage Male	283.93±9.53^{a}	141.73±8.95^{ab}	142.70±9.87^{a}	49.81±2.61^{cd}
(G5) Kayseri Pond Female	285.23±5.51^{a}	137.13±2.88^{ab}	138.47±1.55^{a}	48.07±2.60^{cd}
(G6) Kayseri Pond Male	223.80±11.28^{c}	105.40±9.74^{c}	113.43±11.64^{bc}	47.17±2.60^{d}
(G7) Kayseri Cage Female	272.90±2.72^{a}	145.20±6.86^{a}	120.03±11,.64^{abc}	53.18±3.67^{b}
(G8) Kayseri Cage Male	275.10±6.47^{a}	134.90±4.12^{ab}	134.90±3.78^{ab}	49.04±1.61^{cd}

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$). Sample groups of each environment are numbered from one (G1) to eight (G8) and are displayed in the table.

The lowest fillet weight was observed in the G6 group, which also displayed the lowest whole-body weight. However, the meat yield was relatively low in the G4, G5, and G8, the groups which had the highest whole body weight. Moreover, although the G1, G2, G3, and G7 showed lower whole-body weights than these groups, they displayed higher meat yield values.

The highest whole-body weights and fillet weights of rainbow trout were found in the G1, G4, G5, and G7 groups. Regarding the inedible part weights, it was observed that the values in the G4 and G5 were higher than in the G1 and G7 groups. The main reason for this difference in the G1 and G7 could be attributed to that inedible parts consist of different components (head, internal organs, bones) and the weight and size of these components depend on various factors. Therefore, the weights of visceral fats and liver were also determined in the study.

Various evaluations have been made regarding meat yield in studies on rainbow trout. Bugeon et al. (2010) found the meat yield of all female individuals having a mean weight of 3.6 kg as 61%. In another study, de Souza et al. (2015) determined the mean meat yield of rainbow trout, which they divided into two different weight groups (i.e., 330-370 g and 371-440 g) as 45.29% and 47.61%, respectively. In the former study, the meat yield is higher than that of this study, while the values obtained in the latter are lower. Similar results to the present study were reported by Duman et al. (2011). In their study on *Salmo trutta macrostigma*, they used 4 different sizes of fish and reported meat yield values between 58.04% and 61.07%.

In the present study, statistical analyzes were carried out also to reveal whether the sex and environment in which the rearing was performed (pond or cage unit) have effects or whether these factors influence meat yield (Table 3).

Table 3. Weight changes and meat yields (%) of samples, regardless of unit or farm

Sex	Whole body weight (g)	Fillet weight (g)	Inedible part weight (g)	Meat yield (%)
Female	267.96±14.25^{a}	138.73±12.24^{a}	118.98±16.03^{b}	51.85±3.97^{a}
Male	254.83±22.32^{b}	125.30±16.32^{b}	124.53±18.92^{a}	49.09±3.71^{b}

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$).

As a result of the statistical analysis, without considering any other factor than sex, it was observed that the fillet weight and meat yield of female individuals, which also had higher whole body weight, were higher than that of male individuals. This could be attributed to the fact that female individuals grow faster and more than male individuals. Okumuş (2000) stated that

since cultured individuals grow faster than wild ones, the inedible parts grow more and cause a decrease in meat yield. However, in another study conducted on *Salmo gairdneri*, it was reported that the edible part ratio increases with the increase in fish weight (Kim, 1998). The high mean weight of females, of which mean meat yield was high, supports this study.

These results are in line with the study of Çelik and Kızak (2018) on the meat yield of rainbow trout reared in ponds and cages. They determined the groups' mean meat yields as 61.37% and 62.81% and found no statistical difference.

Furthermore, in several other studies, it has been reported that the meat yield may be the data related to the nutrition of trout (Arıman and Aras, 2003), and feed quality and type may be influential on meat yield (Alexis et al., 1986; Beyter, 2008). It has also been stated that the rearing environment (Kiriş and Dikel, 2002) and genotypic characteristics can affect meat yield (Bosworth et al., 2004; Şahin et al., 2011).

Performance Parameters

Condition factor, hepatosomatic index, and viscerosomatic index data of rainbow trout obtained from different environments were also computed and the results are presented in Table 4.

Table 4. Condition factor (K), hepatosomatic index (HSI), and viscerosomatic index (VSI) values of different rainbow trout individuals

Farm and unit where fish samples were obtained from	K	HSI	VSI
(G1) Kahramanmaraş Pond Female	1.31 ± 0.01^{bc}	1.13 ± 0.07^{b}	$5.14\pm.22^{d}$
(G2) Kahramanmaraş Pond Male	1.39 ± 0.01^{abc}	1.89 ± 0.12^{a}	8.55 ± 0.93^{abcd}
(G3) Kahramanmaraş Cage Female	1.52 ± 0.09^{ab}	1.30 ± 0.09^{b}	11.08 ± 0.72^{ab}
(G4) Kahramanmaraş Cage Male	1.55 ± 0.08^{a}	1.51 ± 0.06^{ab}	9.05 ± 1.29^{abc}
(G5) Kayseri Pond Female	1.45 ± 0.09^{abc}	1.44 ± 0.22^{b}	11.94 ± 0.82^{a}
(G6) Kayseri Pond Male	1.26 ± 0.10^{c}	1.14 ± 0.04^{b}	7.58 ± 2.04^{bcd}
(G7) Kayseri Cage Female	1.36 ± 0.09^{abc}	1.17 ± 0.21^{b}	7.45 ± 0.85^{de}
(G8) Kayseri Cage Male	1.50 ± 0.09^{ab}	1.49 ± 0.12^{ab}	8.92 ± 0.67^{abc}

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$). Sample groups of each environment are numbered from one (G1) to eight (G8) and are displayed in the table.

Various statistical differences were observed in all three parameters. The condition factor was the highest (1.55) in male individuals obtained from the cage unit of Kahramanmaraş farm, whereas the lowest value was determined to be 1.26 in male individuals obtained from the pond unit of Kayseri farm.

The condition factor is one of the important parameters that can give an idea regarding the nutrition and development of fish and accordingly their morphology (Korkut et al., 2007). The K value has been determined in wild and farmed fish of many fish species. Yiğit and Aral (1999) stated that this value should be between 1.14 and 1.53 (optimum 1.37) for trout. When these values and the data obtained from this study are compared, it can be stated that the samples of all groups in the present study displayed very high condition factor values.

Çelik and Kızak (2018) compared market-size trout samples cultured in cages and ponds and found the condition factors as 1.03 and 1.05. Yıldırım et al. (2002), on the other hand, found the K values as 1.5 and 1.6 in the study they performed on albino and normal-pigmented rainbow trout (315 g and 366 g). Consequently, it was determined the values obtained from this study are acceptable and similar to the optimum values stated by Yiğit and Aral (1999). Thus, it was determined that there were no significant drawbacks in the nutrition, caring, and rearing conditions as well as the general health status of the fish.

The highest HSI value was determined to be in the male individuals obtained from the pond unit of Kahramanmaraş farm (G2) and there was homogeneity in the majority of the samples, except for a few values. The difference between the HSI values of the G1, G3, G5, G6, and G7 was insignificant. Moreover, the G4 and G8 displayed higher HSI values than the G2 but lower values than the other groups.

Fishes store the excess energy in the liver except during the breeding season. Typically, a high HSI value indicates liver enlargement due to the fat accumulation caused by low quality or high quantity of dietary fat (Korkut et al., 2007). In addition, HSI is also considered an index of growth (Halver and Hardy, 2002).

It has also been employed to understand energy and fat metabolism in trout in many studies, especially where different nutrients and feed additives are tested. The HSI values were reported between 0.98 and 1.24 after zeolite application (Danabaş, 2009), between 0.97 and 1.15 after prebiotic supplementation (Azari et al., 2014), between 1.10 and 1.48 after fig and rosemary extract utilization (Yılmaz and Er, 2019), and between 1.3 and 1.9 after Vitamin E supplementation at different rates (Yıldız, 2005). As a result, it was inferred that the differences detected in the current study were not caused by the diet because both fish

farms use the same feed. Since the data regarding the genetic source of fish, water temperature, nurturing performance of employees, or stocking density of fish were not recorded in the study, it does not seem possible to build an explanation on solid ground for the differences observed in the HSI values. However, the lower HSI observed in females could be attributed to females' faster growth and higher energy expenditure in comparison with males. It can also be stated that the efficiency of cage and pond environments is not at the level to reveal the differentiation of both environments in terms of the HSI values.

Considering the VSI values, it was observed that there were great variations between groups. As a result of the analysis, it was determined that the females obtained from the cage unit of the farm in Kahramanmaraş (G3) and the pond unit of the farm in Kayseri (G5) displayed significantly higher values, while the lowest VSI was in the females obtained from pond unit of the farm in Kahramanmaraş (G1) (Table 5).

Table 5. Condition factor (K), hepatosomatic index (HSI), and viscerosomatic index (VSI) values computed for sexes, regardless of unit or farm

Sex	**K**	**HSI**	**VSI**
Female	1.41±0.32	1.26±0.27^{b}	8.90±3.01
Male	1.42±0.1	1.51±0.31^{a}	8.53±2.07

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$).

VSI is a method typically used to estimate the effect of nutrition on the visceral part of the fish by revealing the level of fat in this part (Korkut et al., 2007). Based on this data, an interpretation can be made regarding the extent to which the fish can metabolize the fat in the diet. For this reason, it is a frequently applied tool in aquaculture studies, especially in feeding trials. It has also been reported from feeding studies in trout. Yıldız (2005) found the VSI values of rainbow trout between 16.2% and 17.19% after Vitamin E supplementation at various levels. Similarly, Dernekbaşı and Hamzaoğlu (2018) reported that the VSI values of rainbow trout were between 11.64% and 16.10%. These values are considerably higher than those obtained in this study. Moreover, Dernekbaşı (2012) reported a VSI value range between 10.03% and 11.99% in rainbow trout after canola oil application. These values, on the other hand, are more close values to the results obtained in the present study. As can be understood from these values, the diet did not pose a significant problem in terms of quality and quantity, and the fat in the diet was adequately metabolized by the samples used in the research.

The K, HSI, and VSI values were calculated for total male and total female individuals, regardless of unit or farm. Consequently, it was determined that the condition factor and viscerosomatic index values did not differ between the sexes, while the hepatosomatic index values were higher in male individuals (Table 6).

Table 6. Condition factor (K), hepatosomatic index (HSI), and viscerosomatic index (VSI) values computed for units, regardless of farm or sex.

Unit	**K**	**HSI**	**VSI**
Pond	1.35±0.11	1.40±0.09	8.30±3.01^{b}
Cage	1.37±0.24	1.37±0.12	9.12±1.23^{a}

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$).

In the evaluation made based on the units, where the samples were obtained from, there was no difference for condition factor and hepatosomatic index values, while the VSI value was found to be higher in individuals reared in cages.

Nutritional Composition

The nutritional compositions of rainbow trout obtained from different environments are given in Table 7.

Table 7. Nutritional composition of rainbow trout obtained from different environments (%)

Farm and unit where fish samples were obtained from	Protein	Lipid	Moisture	Ash
(G1) Kahramanmaraş Pond Female	20.11±0.06^{a}	5.74±0.07^{c}	73.79±0.08^{c}	1.49±0.03
(G2) Kahramanmaraş Pond Male	18.08±0.07^{d}	7.16±0.10^{a}	73.23±0.12^{cd}	1.37±0.08
(G3) Kahramanmaraş Cage Female	20.16±0.15^{a}	5.15±0.08^{d}	73.35±0.21^{c}	1.40±0.01
(G4) Kahramanmaraş Cage Male	18.65±0.17^{c}	7.36±0.09^{a}	71.99±0.12^{e}	1.40±0.10
(G5) Kayseri Pond Female	19.12±0.06^{b}	4.69±0.17^{e}	74.55±0.34^{b}	1.38±0.03
(G6) Kayseri Pond Male	18.72±0.13^{c}	3.37±0.01^{f}	75.84±0.54^{a}	1.46±0.03
(G7) Kayseri Cage Female	19.89±0.22^{a}	5.16±0.02^{d}	73.94±0.13^{bc}	1.42±0.03
(G8) Kayseri Cage Male	17.48±0.11^{e}	6.73±0.13^{b}	72.57±0.06^{de}	1.37±0.01

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$). Sample groups of each environment are numbered from one (G1) to eight (G8) and are displayed in the table.

According to the analysis results for protein, lipid, moisture, and ash; no statistically significant difference was found between the ash values of the samples. However, the differences for the other three parameters were significant. The highest protein value was observed as 20.16% in female individuals obtained from the cage unit of the farm in Kahramanmaraş and the lowest value was determined to be 17.48% in male individuals obtained from the cage unit of the farm in Kayseri. Statistical differences were also observed in terms of lipid values.

The highest lipid value was observed in the Kahramanmaraş cage male group (G4) and Kahramanmaraş pond male group (G2), while the lowest was determined in the Kayseri pond male group (G6). In terms of the moisture detected in the fish meat, the highest moisture was found in the Kayseri pond male group (G6), whereas the lowest was observed in the Kahramanmaraş cage male group (G4).

Sexes and units were compared in terms of nutritional composition (Table 8), as in other parameters.

Table 8. Nutritional composition of the samples according to sex, regardless of farm or unit (%)

Sex	Protein	Lipid	Moisture	Ash
Female	19.82±0.48^{a}	5.19±0.42^{b}	73.90±0.51	1.42±0.51
Male	18.23±0.55^{b}	6.15±0.98^{a}	73.41±0.92	1.40±0.09

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$).

While high protein and low lipid values were observed in females, on the contrary, males displayed lower protein and higher lipid values. There was no difference in moisture and ash contents in the analyzes performed by comparing only sexes. The lower lipid ratio of females could be explained by the higher energy expenditure of females, which have a higher growth performance.

Table 9. Nutritional composition of the samples according to the unit, regardless of farm or sex (%)

Unit	Protein	Lipid	Moisture	Ash
Pond	19.01±0.78	5.25±0.86^{b}	74.35±0.98^{a}	1.42±0.07
Cage	19.04±0.97	6.10±0.91^{a}	72.96±0.81^{b}	1.40±0.08

± Indicates standard deviation. The letters on the values in the same column indicate statistical differences ($p<0.05$).

As can be seen in Table 9, there were no significant differences in terms of protein and ash in the pond and cage samples compared without taking the sexes into account, but there were significant differences in terms of lipid and moisture. While cage individuals were found to contain significantly more fat, the moisture was found significantly higher in pond individuals.

When the nutritional composition values determined in various similar studies conducted on rainbow trout were compared with the findings of the present study, it was observed that the differences were in the lipid content rather than protein, ash, and moisture. Çelik and Kızak (2018) reported that there was no statistical difference in terms of the nutritional composition between the rearing environments of market-size rainbow trout individuals sampled from cages and concrete ponds. According to the results, they found the highest crude protein ratio 20.63, the highest lipid ratio 2.25, the highest ash ratio 1.39, and the highest dry matter ratio 24.44. Of these values, the crude lipid ratio is considerably lower than the one obtained in the present study. This suggests that such a significant difference in the lipid ratio may have resulted from the difference in feed ingredients. However, to come to an unambiguous conclusion, it is essential to obtain information regarding environmental factors.

Similar to the present study; moisture, protein, lipid, and ash contents of rainbow trout captured from Atatürk Dam Lake were determined as 71.65, 19.60, 4.43, and 1.36, respectively (Çelik et al., 2008). What is remarkable here is that the lipid contents of wild individuals are lower, as also reported in previous research. It has been stated that this difference is related to food type, high-fat diet content, and farmed fish's limited activity (Periago et al., 2005; Baki et al., 2015; Tarricone et al., 2022). Souza et al. (2015), in the study where they investigated the nutrient contents in rainbow trout of different sizes (330 g – 370 g and 371 g – 440 g), found no differences in protein (18.43) and ash (1.70) values. However, they reported that larger individuals had higher lipid rates (7.96 and 9.04) and lower moisture rates (71.15 and 74.30). In another research conducted on fish samples of the same species obtained from three different fish farms, Dernekbaşı and Hamzaoğlu (2018) found protein ratios between 17.36 and 19.90, lipid ratios between 4.24 and 7.24, moisture ratios between 76.16 and 77, and crude ash ratios between 1.55 and 1.62.

It should be noted that the differences in the chemical composition of fishes vary depending on various biotic and abiotic factors such as species, rearing conditions, season, sex, age, gonad development, and nutrition (Brukert et al., 2008).

CONCLUSION

As a result, it was observed that the female individuals generally had higher meat yield rates compared to the male individuals. When the individuals reared in pond and cage environments were compared, no difference was found in terms of the meat yield. Therefore, it can be concluded that culturing predominantly female individuals may have positive effects on the total meat yield. Regarding the condition factor, no aggregation was observed. Although the highest value was determined to be in the Kahramanmaraş cage male group, all individuals of both sexes sampled from cage and pond units displayed high condition factor values. The HSI value was found to be the highest in Kahramanmaraş pond male individuals and the lowest in Kahramanmaraş pond female individuals, however, similar or close values were not determined in the majority of other samples. The lowest HSI observed in females could be explained by the fact that females are more active physiologically and develop faster than males. A highly heterogeneous distribution was observed in the VSI values. It was found as the highest in Kayseri pond female individuals and the lowest in Kahramanmaraş pond female samples. The VSI value was found to be higher in both females and cage individuals. Interestingly, these values showed a similar trend to the HSI values. When the samples were compared in terms of nutritional composition, it was determined that females had higher protein values, while males had higher lipid values. There was no difference between the sexes in terms of moisture and ash. When the pond and cage environments were compared, statistical differences were only observed in lipid and moisture ratios. It was determined that the lipid amount was higher and the moisture ratio was lower in the individuals reared in cages. It is thought that more interesting results can be obtained in such studies if individuals are obtained from the same genetic source, rearing starts simultaneously, feeding and nurturing are applied with the same method, and other drivers are as homogeneous as possible.

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Tıbbi ve Aromatik Bitkilerden *Origanum* Türlerinin Su Ürünlerinde Kullanım Alanları

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Makale Bilgisi

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Anahtar Kelimeler:
- Tıbbi ve aromatik bitki
- Bitkisel yağ
- *Origanum* spp.
- Su ürünleri

Öz

Tıbbi ve aromatik bitkiler insanlık tarihinin başlangıcından itibaren öncelikle ilaç ve tedavi amaçlı olmak üzere gıda, kozmetik, endüstriyel ve baharat amaçlı kullanılmaktadır. Su ürünleri yetiştiriciliğinde ise başta balık refahı olmak üzere, çalışma kolaylığı sağlamak ve sağlıklı bir üretim gerçekleştirebilmek için tıbbi ve aromatik bitkilerden yararlanılmaktadır. Aromatik bitkilerden elde edilen başta esansiyel yağlar ve diğer bileşiklerinin birçok alanda kullanımı son zamanlarda giderek yaygınlaşmaktadır. *Origanum* spp. türleri tıbbi ve aromatik bitkiler içerisinde yer alan bitki türleridir. Bu türlerin içermiş olduğu etken maddelerin balıklar üzerine etkisi oldukça fazladır. Söz konusu türlerden elde edilen ekstraktlar ve yağlar bilimsel çalışmalarında odak noktası haline gelmiştir. Bu çalışmada da *Origanum* spp. türlerinden *Origanum vulgare, O,. vulgare sp. hirtum, O majorana* ve *O. heracleoticum* L. *O. onites*'in su ürünleri alanında kullanımı üzerinde durulmuştur.

Usage Areas of Medicinal and Aromatic Plants *Origanum* Species in Aquaculture

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Abstract

Medicinal and aromatic plants have been used for food, cosmetics, industrial and spice purposes, primarily for medicine and therapeutic purposes since the beginning of human history. In aquaculture, medicinal and aromatic plants are used in order to provide ease of work and to realize a healthy production, especially for fish welfare. The use of essential oils and other compounds obtained from aromatic plants in many fields has recently become increasingly common. *Origanum* spp. are plant species included in medicinal and aromatic plants. The effect of the active substances contained in these species on fish is quite high. Extracts and oils from these species have become the focus of his scientific studies. In this study is emphasized the use of *Origanum spp. Origanum vulgare, O,. vulgare sp. hirtum, O majorana* and *O. heracleoticum, O. onites* in aquaculture.

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GİRİŞ

Günümüzde tıbbi ve aromatik bitkilerin kullanımına ilgi giderek artmaktadır. Bu tıbbi ve aromatik bitkiler terimi birlikte kullanılsalar da anlam olarak birbirinden farklıdır. İnsanlar ve hayvanlarda oluşan hastalıkların sağaltımı için kullanılan bitkiler tıbbi bitki olarak ifade edilirken; kokulu bitkiler ise aromatik bitki şeklinde adlandırılmaktadır (Göktaş ve Gıdık, 2019; Çelik 2020). Bu bitkilerin tedavi amaçlı kullanımı M.Ö. 5000' lere Mezopotamya uygarlığına kadar uzandığı ve 250 bitkisel ürünün bu amaçla kullanıldığı rapor edilmiştir (Çelik 2020). Bitkilerin kullanım oranları Asya, Afrika ve Orta Doğu ülkelerinde yaygın olup ülkelerdeki gelişmişlik durumlarına göre de farklılık gösterebilmektedir (Acıbuca ve Bostan Budak, 2018). Doğadan toplanarak kullanılan bu bitkilerin artık büyük bir kısmının üretimi hem dünyada hem ülkemizde yapılabilmekte ve kültür koşullarında yetiştirilebilmektedir (Acıbuca ve Bostan Budak, 2018). Tıbbi ve aromatik bitki olarak 174 aile, 1251 cins ve yaklaşık 12.000' den fazla tür ve alt türe sahip ülkemiz birçok türün gen merkezi konumundadır (Kendir ve Güvenç, 2010).

Origanum, Lamiaceae familyasına mensup tıbbi ve aromatik bitkilerin içinde yer alan ve tıbbi ve aromatik bakımından önemli cinslerdendir. *Origanum* L. ismi Yunanca iki kelime olan "oros" (dağ) ve "ganos" (parlaklık) kelimelerinden türetilmiştir (Fonnegra ve Jiménez, 2007). Dünya üzerinde 2. Dünya Savaşı'ndan sonra İtalya'dan dönen ABD askerlerinin pizza yapımında

Origanum türlerini kullanılmış olmaları ile bu bitkilerin tanınmasını ve üne kavuşmasını sağlamıştır. Daha sonraki zamanlarda da pizzalarda, etli yemeklerde, salatalarda, çorba ve sos yapımında fazlaca kullanılmaya başlanmasının yanı sıra parfümeri ve ilaç sektöründe de yer almaya başlamıştır (Tunca ve Yeşilyurt, 2017). Bu türler çoğunlukla Akdeniz, Kuzey Afrika, Avrupa-Sibirya ve İran-Sibirya bölgelerinde yayılış göstermektedir. *Origanum* cinsi dünya üzerinde 43 tür (51 takson) ve 19 hibrit tür ile bilinmektedir (Dirmenci vd., 2018a; 2018b; 2019). *Origanum* cinsi ülkemizde ise 14'ü endemik 23 tür (26 takson) ve 9'u endemik olan 11 hibrit ile temsil edilmektedir (Dirmenci vd. 2019).

Origanum Türlerinin Su Ürünleri Alanında Kullanımı

Origanum türleri su ürünleri sektöründe antimikrobiyal etki, anestezik madde, yem ilave maddesi ve su ürünleri işleme teknolojisinde son zamanlarda yaygın çalışılan bir konu haline gelmeye başlamıştır (Cihangir ve Diler 2016; Diler vd., 2017; Wahdan vd., 2019; Abdel-Latif vd., 2020; Pathirana vd., 2021). Bu bitkilerin içerdiği başta timol ve karvakrol olmak üzere diğer etken maddelerde, yapılan çalışmaların genelinde olumlu sonuçlar meydana getirmiş ve kullanılabilirlikleri kabul edilmiştir. Tablo 1'de *Origanum* spp. bitki türlerinin su ürünleri alanında kullanım şekilleri ve etkileri üzerine yapılan çalışmalar derlenmiştir.

Antimikrobiyal etkisi

Yüksek düzeyde uçucu yağ içeren *Origanum* türlerinin antibakteriyel etkiye sahip karvakrol, timol, p-cymen, y-terpinen gibi çok sayıda aktif metabolitleri vardır (Karousou ve Kokkini, 2003). Lamiceaea familyasına ait bu türlerin antibakteriyel etkilerinin yanında antifungal, antioksidan, anti-enflamatuar olarak kullanım potansiyeline de sahiptir (de Moraes França Ferreira vd., 2014; Diler vd., 2017). Su ürünlerinde Ekici vd. (2011) balıklardan izole edilen patojenlere karşı bazı bitkisel uçucu yağlarının antibakteriyal aktivitesini araştırdıkları çalışmalarında *O. vulgaris*in bakteriyel hastalıklara karşı doğal tedavi edici etkisi nedeniyle antibiyotiklere alternatif olarak kullanılabilme potansiyeli olduğunu ve bakteriyel balık patojenleri üzerine antibakteriyal aktivitesinin olduğu belirlemişlerdir. Ökmen vd. (2012)'de gökkuşağı alabalığı (O*ncorhynchus mykiss)* dan izole ettikleri *Aeromonas hydrophila* üzerine in vivo ve in vitro koşullarda *O. vulgare sp. hirtum ve O. onites'*in antimikrobiyal etkisini çalışmışlar ancak antibiyotik yerine kullanılamayacağını belirlemişlerdir. Özdemir vd. (2021) İzmir Kekiği (*O. onites*)'in esansiyel yağlarının gökkuşağı alabalığı (O*ncorhynchus mykiss)* yumurtalarından izole ettikleri *Saprolegnia parasitica*'da antifungal etkilerini araştırmışlardır. Çalışma sonunda İzmir Kekiği (*O. onites*)'in esansiyel yağlarının olumlu etkilerinin olduğunu ve formaldehit kullanımının yerini alabileceğini bildirmişlerdir. Dolayısıyla *Origanum* türleri, içermiş olduğu çok sayıda aktif metabolitleri ile antimikrobiyal olarak su ürünlerinde kullanılabilmektedir. Yousefi vd. (2021) Mercan Köşk *(O. majorana)* ile sazan balığı (*Cyprinus carpio*) üzerine yaptıkları çalışmada balık yemine 200 mg kg^{-1} ilavesinin *A. hydrophila*'ya karşı direnç kazanımına olumlu etki ettiğini ve kullanımının uygun olduğunu bildirmiştir.

Anestezik madde olarak kullanımı

Anestezi uygulaması su ürünleri alanına 1939'da girmiş ve 1940'lı yıllardan sonra hız kazanarak yaygın hale gelmeye başlamıştır. Kelime anlamı olarak hissetmemek anlamına gelen ve Yunanca kökenli olan bu kelime, sinirsel fonksiyonların farmakolojik olarak baskılanmasına bağlı vücudun bütününde ve ya bir kısmında duyarlılık kaybı olarak tanımlanmaktadır. Anestezi için uygulanan maddelere anestezik ismi verilmektedir. Anesteziklerin yapısı, balıklar üzerine uygulanması, etki süreleri birçok araştırmacı tarafından ortaya konulmaya çalışılmıştır. Aromatik bitkilerden de elde edilen anestezik maddelere olan ilgi su ürünlerinde giderek artmaya devam etmektedir. Bu bitkilerin doğada hali hazırda bulunmalarının yanı sıra üretiminin kolay olması, kalıntılar oluşturmayarak insan sağlığını riske atmaması, parçalanarak kısa zamanda toprak ve su kirliliklerine yol açmamaları, doğaya ek toksik madde yaymaması gibi başlıca özellikler nedeniyle bitkilere ve bunlardan elde edilen madelere olan ilginin artma sebeplerindendir. Bu bitkilerden elde edilen anestezik etkisi olan metabolitler eugenol, mentol, metil salisilat, myrcene, 1,8-sineol, linalool, limonen, timol, karvakrol şeklinde sıralanabilmektedir. *Origanum* türleri de aneztezik maddelerden karvakrol, timol gibi etken maddelere sahiptir. Bodur vd. (2018) çalışmasında *Origanum* ve Okaliptüs yağını anestezik olarak kullanıldığı ve *Origanum* yağının düşük dozda daha yüksek etkinlik gösterdiğini bulmuştur. Başka bir çalışmada ise yayın balığı (*Rhamdia quelen*) üzerine Mercan Köşk (*O. majorana*)'ün anestezik olarak sedasyon ve bayılmaya etkisi sırayla 100 µL L^{-1} ve anestezik etkisi ≥ 200 µL L^{-1} olduğu tespit edilmiştir (da Cunha vd., 2017). Becker vd. (2021) *Farfantepenaeus paulensis* ve *Litopenaeus vannamei* iki karides türünde Mercan Köşk (*O. majorana*) yağını anestezik olarak kullanmıştır. 800 µL L^{-1} oranda *O. majorana*'da ayılmanın daha uzun olduğunu tespit etmiştir. *Origanum* yağı ile yapılan anestezik çalışmaları etkin bir anestezik madde olabileceğini ortaya çıkarmıştır.

Yem katkı maddesi olarak kullanımı

Su ürünlerinde diğer hayvan besleme alanlarında olduğu gibi yem katkı maddeleri üzerine çalışılan bir konudur. Balık yemlerine ilave madde olarak *Origanum* türlerininde kullanıldığı çalışmalarda mevcuttur. Örneğin; Kekik (*O. vulgare*)' den elde edilen yüksek düzeyde uçucu yağlar yem katkısı olarak tarafından gökkuşağı alabalığı (*Oncorhynchus mykiss)* de büyüme performansına, yemden yararlanma ve yaşama oranında balık yemine 3,0 mg kg^{-1} oranına kadar etkili olduğunu bildirmişlerdir (Cihangir ve Diler, 2016). Ayrıca, Diler vd. (2016) tarafından İzmir Kekiği (*O. onites*)*'* in gökkuşağı alabalığı (*O. mykiss)*'nda büyüme, lizozim ve antioksidan aktivitesinin yanı sıra *Lactococcus garvieae*'ye karşı direncin etkisi incelenmiş ve hastalık direncine olumlu etkisinin yanında balık yemine uygulanabilir olduğunu sonucuna varmışlardır. Diler vd. (2017) tarafından diğer bir araştırmada gökkuşağı alabalığı (*O. mykiss*)'nda balık yemine ilave edilmesi balıklarda büyümeyi destekleyici, lizozim ve antioksidan aktiviteyi ve aynı zamanda patojenlere karşı direnci artırıcı bir etki gösterdiğini bildirmişlerdir. Ergül (2018) yaptığı çalışmada gökkuşağı alabalıklarının (*Oncohhynchus mykiss*) yemlerine 2 farklı konsantrasyon da (0.25 ve 0.50 ml kg^{-1}) kekik (*Origanum onites*) ekstraktı ilavesinin balıkların büyüme, bağırsak ve deri

histolojisi, bağırsak mikroflorası üzerine etkisini araştırmıştır. Balıklarda final ağırlık ve canlı ağırlık artışı değeri sırasıyla 77.50±0.70 g ve 38.00±1.41 g olarak en iyi 0.25 ml kg^{-1}grubunda olduğunu, spesifik büyüme oranında ise kontrol grubuna göre diğer gruplarda farklılığın ($p<0.05$) önemli olduğunu ancak yem dönüşüm oranı ve yaşama oranında fark olmadığını bildirmiştir. Balıkların bağırsaklarında bulunan psikrofilik aerobik, enterobactericeae, mezofilik aerobik, pseudomonas ve laktik asit bakterileri incelenmiş gruplar arasında önemli fark tespit edememiştir ($p>0.05$). Ancak deride 0.50 ml/kg ve 0.25 ml kg^{-1} ekstrakt ilaveli gruplarda goblet hücre sayısının kontrol grubunda fazla olduğunu ($p<0.05$) ayrıca bağırsak histolojisinde villus boyu ve enininde kontrol grubundan daha iyi sonuç verdiğini bildirmiştir. Yousefi vd. (2021) tarafından sazan balığı (*Cyprinus carpio*)'da büyüme performans üzerine etkileri, hematolojik, antioksidan, hümoral ve mukozal bağışıklık tepkileri ve *A. hydrophila*'ya karşı direnci, yeme 200 mg kg^{-1} ilavesi uygun olduğunu bildirmişlerdir. Yapılan çalışmalar *Origanum*'un yem katkısı olarak bir çok çalışmaya konu olduğunu ve kullanımının olumlu etkiler gösterdiğini ortaya koymuştur.

Su ürünleri işleme teknolojisinde kullanımı

Bir ürünün pazarlanmasında diğer sektörlerde olduğu gibi su ürünleri sektöründe de ürünün işleme sonrası paketleme, depolama ve uzun raf ömrü üzerine çalışılan konulardandır (Özyılmaz 2007; Çetinkaya 2013; Kenar 2020). Ürünlerin bozulmadan uzun süreli saklanması pazarlamada önemli hususlardandır. *Origanum* türleri su ürünleri işleme ürünlerinin raf ömrünü uzatmada kullanılmaktadır. Taşkaya (2010) yaptığı çalışmasında baş ve iç organları çıkarılmış hamsilere (*Engraulis encrasicolus* L. 1758), *Origanum vulgare* L.subsp. *hirtum* uçucu yağı uygulanmış ve 4±1°C'de depolamıışlar ve depolanma süresince kimyasal, mikrobiyolojik ve duyusal kalite parametrelerini incelemişlerdir. Bu uygulamanın raf ömrü üzerine etkisini araştırmıştır. Bu çalışmanın sonucunda 4°C'de hamsi filetolarının raf ömrünü uzattığını ve duyusal olarak *Origanum*'un balık etinde kullanılabilir olduğunu tespit etmiştir. *Origanum* spp' in kullanıldığı bir başka çalışma olan Akarsu (2016)'da vakum ile paketlenen gökkuşağı alabalığı (*Oncorhynchus mykiss* Walbaum, 1792) filetolarında *Origanum onites*'in farklı ekstratları uygulanarak 21 günlük depolama süresince meydana gelen biyokimyasal, fizikokimyasal, mikrobiyolojik, tekstürel ve duyusal değişimleri incelenmiştir. Toplam aerobik mezofilik bakteri sayısının tüm gruplarda 13. gün sınır değerleri içinde olduğunu, toplam aerobik psikrofilik bakteri sayısının ise 21 günlük depolama süresince kalite sınır değerlerini aşmadığını tespit etmiştir. Dolayısıyla yapılan çalışmalar ışığında *Origanum* türlerinin su ürünleri işleme teknolojisinde kullanıldığı ve olumlu sonuçlar verdiği ortaya koyulmuştur.

SONUÇ VE ÖNERİ

Çevre, insan ve balık sağlığı hususunda kimyasal içerikli ürünler tehdit oluşturabilmektedir. Fakat bu tarz problemlerin önüne bitkisel kaynaklı ürünlerin zararlı olarak görülen kimyasal kökenli ürünlerin yerine kullanımı ile geçebilmek mümkündür. Dolayısıyla bitkisel kökenli maddelere yönelim giderek artmaktadır. İnsanlık tarihinden itibaren kullanılan tıbbi ve aromatik bitkiler ile bu bitkilerden elde edilen özütler çeşitli amaçlarla bu kapsamda kullanılmaktadır.

Sürdürülebilirlik canlı ile çevre etkileşiminin dengede tutulabilmesi ile mümkün olabilmektir. Dolayısıyla çevreye zarar vermeyen ürünlerin kullanımı bu dengeyi sürdürebilmektedir. Su ürünleri sektöründe bu denge göz önüne alınarak kimyasaldan uzak üretimler güncel konular olmaya başlamıştır. Bu da bitkisel ürünlerin kullanımını öne çıkarmıştır. Başta yetiştiricilik sektöründe yem katkısı olarak immunostimulantlar, kemoterapotikler veya büyümeyi artırıcı yem katkı maddelerinin yanı sıra anestezik maddeler yaygın olarak kullanılmaktadır.

Tüketiciler ve üreticiler açısından doğal ve kimyasal olmayan ürünlerin kullanımı insanda kanser riskinin artmaya başladığı için son yıllarda bu aromatik bitkiler özellikle tercih sebebi olmaya başlamıştır. Bitkisel maddelerin kanserojen olmama, uyarıcılara zarar vermeme, balık dokusunda birikim yapmama gibi özelliklere sahip olduğu gösterilmektedir.

Origanum türleri su ürünleri sektöründe antimikrobiyal etki, anestezi, yem ilave maddesi ve işleme alanlarında son zamanlarda yaygın çalışılan bir konu haline gelmeye başlamıştır. Bu bitkilerin güvenilirlikleri yapılan bilimsel çalışmalar ile de ortaya koyulmuş ve koyulmaya devam etmektedir.

Sonuç olarak su ürünleri üretiminde bu bitkilerin, farklı şekillerde ve daha etkin kullanılmaya başlanması hem su ürünleri sektörü hem de tıbbi aromatik bitki sektörü açısından fayda sağlayacağı düşünülmektedir. *Origanum* türleri üzerine yapılan bu derleme çalışması ile balıklar üzerinde büyümeyi artırıcı, hastalıkların tedavisi, antimikrobiyal etkisi ve bağışıklık güçlendirici veya anestezik madde olarak etkisini araştırmak üzere yapılacak olan gelecekteki çalışmalara ışık tutacaktır. Bitkisel kökenli maddelerin etkisi ile ilgili çalışmaların artırılması kanaatindeyiz.

Tablo 1. *Origanum* bitki türlerinin kullanım şekilleri ve etkileri

***Origanum* Bitkisi**	**Kullanılan tür**	**Bitkinin Uygulanan Kısmı**	**Uygulama Şekli**	**Etkisi**	**Referans**
Kekik (*Origanum vulgare*)	Alabalık ve Levrek patojeni	Uçuçu yağ	Agar difüzyon ve mikrodilüsyon	Bakteriyel balık patojenleri üzerine antibakteriyal aktivitesinin olduğu ve antibiyotiğe alternatif doğal tedavi edici olduğunu belirlemişlerdir.	Ekici vd. (2011)
O. vulgare sp. hirtum ve *O. onites*	Gökkuşağı alabalığı (*Oncorhynchus mykiss*) patojeni	Uçucu yağ	Agar difüzyon ve mikrodilüsyon	Antibiyotiklere alternatif olamayan ancak bağışıklık uyarıcı ve direnç geliştirici olduğunu bildirmişlerdir.	Ökmen vd. (2012)
İzmir Kekiği (*O. onites*)	Gökkuşağı alabalığı (*O. mykiss*) yumurtasından izole *Saprolegnia parasitica* mantar	Uçucu yağ	Mikrodilüsyon	Esansiyel yağlarının olumlu etkilerinin olduğunu ve formaldehit kullanımının yerini alabileceğini bildirmişlerdir.	Özdemir vd. (2021
Mercan Köşk *(O. majorana)*	Sazan balığı (*Cyprinus carpio*)	Uçucu yağı	Oral	Büyüme performansı, hematolojik, antioksidan, hümoral ve mukozal bağışıklık tepkileri ve A. hydrophila'ya karşı direnci üzerine yeme 200 mg kg^{-1} ilavesi uygun olduğunu bildirmiştir.	Yousefi vd. (2021)
Origanum sp.	Levrek (*Dicentrarchus labrax*)	Uçucu yağı	Banyo	Yeni bitki bazlı anesteziklerin etkileri stres ve refah parametreleri üzerine etkilerine bakılmış ve *Origanum* düşük konsantrasyonda yüksek etki gösterdiği bildirilmiştir.	Bodur vd. (2018)
Mercan Köşk (O majorana)	Yayın balığı (*Rhamdia quelen)*	Uçucu yağı	Banyo	Anestezik olarak sedasyon ve bayılmaya etkisi sırayla 100 µL L^{-1} ve anestezik etkisi ≥ 200 µL L^{-1} olduğu tespit edilmiştir.	da Cunha vd. (2017)
Mercan Köşk *(O majorana)*	Karides (*Farfantepenaeus paulensis*) ve (*Litopenaeus vannamei*)	Uçucu yağı	Banyo	800 µL L^{-1} oranda *O majorana* da ayılmanın daha uzun olduğunu tespit edilmiştir.	Becker vd. (2021)

Tablo 1.(Devam) *Origanum* bitki türlerinin kullanım şekilleri ve etkileri

Kekik (*O. vulgare*)	Gökkuşağı alabalığı (*O. mykiss*)	Uçucu yağı	Oral	Büyüme performansına, yemden yararlanma ve yaşama oranında balık yemine 3,0 mg kg^{-1} oranına kadar etkili olduğunu bildirmişlerdir.	Cihangir ve Diler (2016)
İzmir Kekiği (*O. onites*)	Gökkuşağı alabalığı (*O. mykiss*)	Uçucu yağı	Oral	Hastalık direncine olumlu etkisinin yanında balık yemine uygulanabilir olduğunu sonucuna varmışlardır.	Diler vd. (2016)
Kekik (*Origanum vulgare*)	Gökkuşağı alabalığı (*O. mykiss*)	Uçucu yağı	Oral	büyümeyi destekleyici, lizozim ve antioksidan aktiviteyi ve aynı zamanda patojenlere karşı direnci artırıcı bir etki gösterdiğini bildirmişlerdir.	Diler vd. (2017)
İzmir Kekiği (*O. onites*)	Gökkuşağı alabalığı (*O. mykiss*)	Uçucu yağı	Oral	0.25 ve 0.50 ml kg^{-1} oranlarda ekstrakt ilavesinin balıkların büyüme, bağırsak ve deri histolojisi, bağırsak mikroflorası üzerine etkisinin olduğunu ve kontrol grubundan daha iyi sonuç verdiğini tespit etmiştir.	Ergül (2018)
Origanum vulgare L.subsp. *hirtum*	Hamsi (*Engraulis encrasicolus)*	Uçucu yağı	Pipetaş	4°C'de hamsi filetolarının raf ömrünü uzattığını ve duyusal olarak Origanum'un balık etinde kullanılabilir olduğunu tespit etmiştir.	Taşkaya (2010)
İzmir Kekiği (*O. onites*)	Gökkuşağı alabalığı (*O. mykiss*)	Soğuk ve sıcak demleme, destilasyon ve kaynatma ekstraktı	Vakumlu paket içi	13. ve 21. Günlerde bakterilerin kalite sınır değerini aşmadığını belirlemiştir.	Akarsu (2016)
Kekik (*O. vulgare*)	Sazan balığı (*Cyprinus carpio*)	Uçucu yağ	Oral	*A. hydrophila* enfeksiyonuna karşı direnci, bağışıklıkla ilgili genler, Optimum seviyede 15 g kg^{-1} diyette etki etmiştir.	Abdel-Latif vd. (2020)
Mercan Köşk (*O. heracleoticum* L.)	Yayın balığı (*I. punctatus*)	Uçucu yağ	Oral	Büyüme, antioksidan etki ve *A. hydrophila*'ya karşı direnç çalışılmış ve büyüme destekleyicisi olabileceği ve antioksidanı artırabilir olduğunu bildirmiştir.	Zheng vd. (2009)

Tablo 1.(Devam) *Origanum* bitki türlerinin kullanım şekilleri ve etkileri

Kekik (*O. vulgare*)	Zebrafish (*Danio rerio*)	Ekstrakt	Oral	Büyüme Performansı, Serum ve Mukus Doğal Bağışıklık Karşı Tepkiler ve Direnç *A. hydrophila* Mücadelesi, Genel olarak, en büyük etkiler, %1 diyete dahil edilen bireylerde gözlediler, *O. vulgare* bitkisinden elde edilen ekstraktın büyük bir etkiye sahip olduğunu göstermektedir.	Rashidian vd. (2021)
Kekik (*O. vulgare*)	Sazan balığı (*C. carpio*)	Uçucu yağ	Oral	Büyüme performans üzerine etkileri, hematolojik, antioksidan, hümoral ve mukozal bağışıklık tepkileri ve *A. hydrophila*'ya karşı direnci, yeme 200 mg kg^{-1} ilavesi uygun olduğunu bildirmişlerdir.	Ghafarifarsani vd. (2021)
Kekik (*O. vulgare*)	Gökkuşağı alabalığı (*O. mykiss)*	Ekstrakt	Oral	Diyete dahil edilmesinin spesifik olmayanlar üzerindeki etkisi bağışıklık tepkileri ve Hematolojik Parametreler, %1 oranı daha yüksek immünolojik tepkiler kaydetmişlerdir.	Pourmoghim vd. (2015)
Mercan Köşk *(O. majorana)*	Sazan balığı (*C. carpio*)	Ekstrakt	Oral	Büyüme performansında, kan biyokimyasallarında, bağışıklık tepkilerinde ve antioksidan kapasitesinde faydalı değişiklikler, %1 oranındaki karışım dozu en uygun tespit edilmiştir.	Rudiansyah vd. (2022)
Kekik (*O. vulgare*)	Kızıl karınlı tilapya (*Tilapia zillii*)	Uçucu yağı	Oral	*Vibrio anguillarum* ile intraperitoneal enfeksiyon bağışıklık düzenleyici etkisi olduğu bildirilmiştir.	Mabrok ve Wahdan (2017)

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