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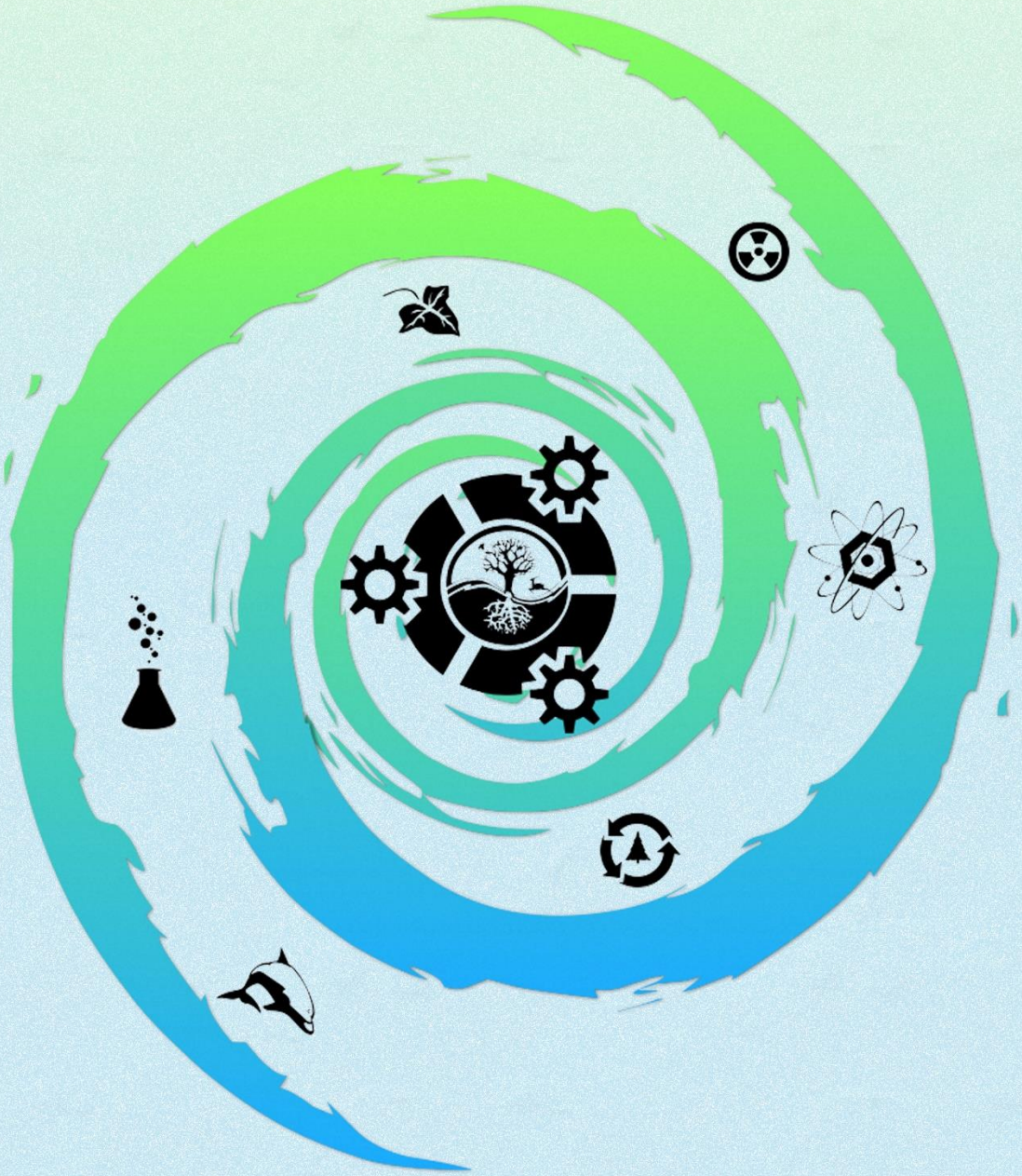

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An Important Forage Source for Animals: Small Grain Pastures

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ABSTRACT

An approximate 40-65% of the qualified roughage needs of farm animals in Turkey can be met according to different calculations. Natural rangelands are important sources in this regard. However, there are serious problems in the management of these areas. Particularly, untimely and heavy grazing is one of the main reasons for the deterioration of vegetative cover. Grain pastures are one of the best options for both reducing the qualified roughage deficit as well as in the solution of certain problems related to grazing in rangelands. Grass yield and quality of cool climate cereals are high, and they reach grazing maturity before natural rangelands in spring, then they can be grazed until later in fall and even could be used as winter rangeland in regions with cool winters. They can also be used for double production (grass + grain). In this respect, the importance and potential of grain pastures in the rangeland-based livestock system have been evaluated in this paper.

Hayvanlar İçin Önemli Bir Kaba Yem Kaynağı: Tahıl Meraları

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ÖZET

Farklı hesaplamalara göre, Türkiye'de çiftlik hayvanlarının nitelikli kaba yem ihtiyaçlarının yaklaşık %40-65 kadarı karşılanabilmektedir. Bu açıdan doğal meralar önemli bir kaynak olmakla birlikte, yönetimlerinde ciddi sorunlar yaşanmaktadır. Özellikle zamansız ve ağır otlatmalar meraların bitki örtülerinin bozulmasının temel sebepleridir. Tahıl meraları hem nitelikli kaba yem açığının azaltılması hem de meralarda otlatmaya bağlı sorunların çözümünde en iyi seçenekler arasındadır. Serin iklim tahıllarının ot verimi ve kalitesi yüksektir, ilkbaharda doğal meralardan önce otlatma olgunluğuna ulaşırlar, sonbaharda daha geç tarihlere kadar otlatılabilirler ve hatta serin kışlara sahip yörelerde kış merası olarak yararlanılabilirler. Ayrıca ikili üretim (ot + tane) amacı ile de kullanılabilirler. Bu derlemede tahıl meralarının meraya dayalı hayvancılık sisteminde önemi ve potansiyeli değerlendirilmiştir.

GİRİŞ

Hayvancılıkta üretim maliyetlerinin yaklaşık %70'ini yem giderleri oluşturmaktadır (Emsen, 1994; Bozaran & Ayhan, 2017; Harmanşah, 2018; Kara & Eroğlu, 2018). Bunun da büyük bir bölümünü kaba yemler teşkil etmektedir (Çakır vd., 1995). Kaba yemler bilhassa küçükbaş hayvancılıkta zaman zaman rasyonun tümünü oluşturmaktadır. Enerji ihtiyacı yüksek olan yüksek verimli hayvanlarda bile toplam tüketilen yem içerisindeki kaba yemlerin payı %50'nin üzerindedir (Çakır vd., 1995).

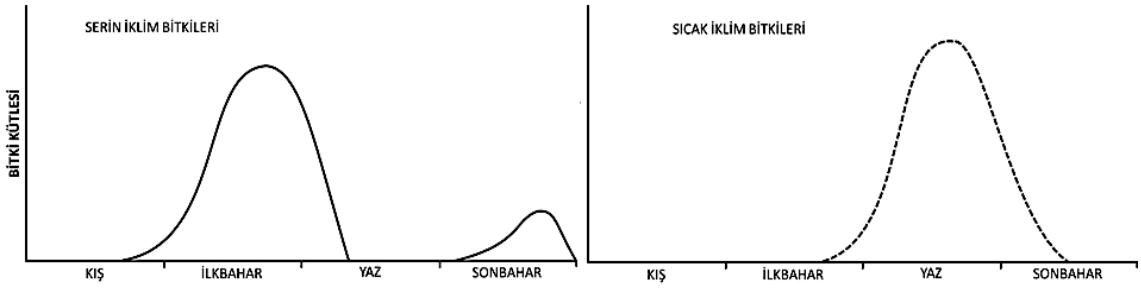
Yeşil dönemlerinde yüksek kaliteli ve ucuz yem kaynağı olmaları hasebiyle doğal meralar en önemli kaba yem kaynaklarıdır. Bu sebeple hayvancılığı meraya dayalı olarak planlamak ve yürütmek hem sektördeki kârlılığı artıracak hem de kaliteli hayvansal ürün üretimi sağlayacaktır. Bu bakımdan doğal meraların ıslahı ve sürdürülebilir yönetimi, hayvancılıkta karşılaşılan darboğazların aşılmasına ciddi katkı sunacaktır. Bu durum gelecek nesiller için daha da önemlidir. Artan nüfus ile birlikte artacak hayvansal ürün talebini karşılayabilmek için meralar rakipsiz yem kaynaklarıdır. Gelecekte insanoğlu muhtemelen laboratuvar ürünü et ve süt gibi hayvansal ürünlerle de tanışacak, ancak bunların hiçbiri doğal meralarda otlayan hayvanların ürünlerinin yerini alamayacaktır (Kılıç Ekici, 2011; Sürek & Uzun, 2020).

Meraların hayvanlara ucuz yem sağlaması sadece ot miktarı ve kalitesine bağlı değildir. Aynı zamanda merada otlayan hayvanların daha sağlıklı olması, bakım ve tedavi masraflarını da en aza indirmektedir. Tedavi sırasında kullanılan ilaçlar için yapılan harcama yanında, bu ilaçlar belirli süre hayvansal ürün kalitesini de düşürmektedir. Hatta zaman zaman hayvanlarda kalıcı verim kayıpları da yaşanmaktadır.

Sonuç olarak ucuz, kaliteli ve sağlıklı hayvansal üretim meraya dayalı olarak yapılan yetiştiricilik ile mümkün olmaktadır. Fakat bu konuda karşımıza çıkan en önemli sorun, doğal meraların yıl boyu yem üretememeleridir. Değişen iklim faktörleri bu kısıtlamanın temel sebebidir. Yazın artan sıcaklık ve azalan yağışın getirdiği kuraklık, kışın ise düşen sıcaklıklar mera bitkilerinin büyümesini baskılamakta ve durdurmaktadır. Doğal olarak bu durumda bitkiler en lezzetli oldukları vejetatif dönemlerinden uzaklaşırlar. Bitkilerin üretimleri durur ve otlarının besleme değerleri ciddi ölçüde azalır. Örneğin, Bandırma'da yürütülen bir araştırmada (Gökkuş vd., 2017), doğal mera otu mayıs başında %11,86 ham protein (HP) ve %54,60 toplam lif (NDF) içerirken, bu oranlar eylül ayında sırasıyla %5,61 ve %67,53 olarak tespit edilmiştir. Yani protein oranı yarıdan fazla azalmış, lifli bileşikler ise %24 düzeyinde artmıştır. Genelde yaz, sonbahar başı ve kış aylarına rastlayan bu dönemlerde hayvanlar merada istedikleri miktar ve kalitede yem bulamadıkları için, yetiştiriciler ya hayvanları barınakta beslemek zorunda kalmakta ya da önemli miktarda kaba ve kesif yem takviyesi ile merada otlatmaya devam etmektedirler. Özellikle, kışın hayvanları meraya çıkarmak için ek yem vermek bile hayvansal üretimin sürdürülebilirliği için yeterli olmayabilir.

Türkiye meralarının büyük bir kısmı serin iklim bitkilerinden meydana gelmektedir. Serin iklim bitkileri genellikle sıcaklık ve nem şartları daha uygun olduğu için ilkbahar ve sınırlı ölçüde sonbaharda büyürler. Akdeniz'in özellikle düşük rakımlı (0-500 m) sıcak vejetasyon katında katırtırnağı, mersin, kermes meşesi ve sandal ağacı gibi odunsu türlerin yanında (Ketenoğlu vd., 2014), *Paspalum distichum*, *Paspalum paspaloides*, *Cynodon dactylon*, *Bothriochloa ischaemum* ve *Pennisetum orientale* gibi sıcak iklim bitkileri de mera bitki örtüsüne dahil olur (Avağ vd., 2012) ve meraların yaz mevsiminde yeşil kalmalarına yardımcı olurlar (Şekil 1).

Yaz ve kış mevsimlerinde doğal meraların yem açığını kapatmanın en iyi çözümü tahıl meralarının kurulmasıdır. Sonbahar sonu, kış ve ilkbahar başında serin iklim, yazın ise sıcak iklim tahılları ile oluşturulacak rotasyon meraları, hayvancılık sistemi için en ideal çözümlerdir. Serin/soğuk dönem meraları için soğuğa dayanabilen serin iklim tahılları (buğday, arpa, çavdar, yulaf ve tritikale) ve yaz meraları için de otlanmadan sonra yeniden büyüyebilme yetenekleri ve kuraklığa dayanıklılıkları sebebiyle darılar (kocadarı ve Sudanotu ile bunların melezleri, dallıdarı vb.) doğal meraların tamamlayıcıları olarak bitki-hayvan birleşik üretim sisteminde yerlerini almaktadır.



Şekil 1. Serin ve sıcak iklim otsu mera bitkilerinin yıl içerisindeki büyüme eğrileri

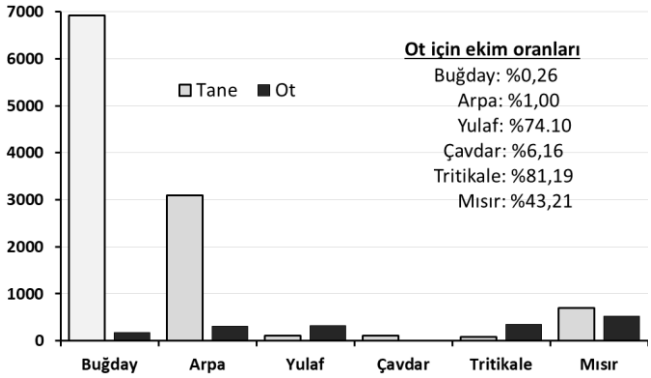
Dünyada ve Türkiye'de Tahılların Durumu

Tahıllar tarla bitkileri içerisinde dünyada ekim alanı, üretimi ve dolayısıyla tüketimi bakımından ilk sıraları almaktadır. Dünyada en çok ekim alanına sahip ilk beş bitkinin (sırasıyla buğday, mısır, çeltik, soya ve arpa) dördünü tahıllar oluşturmaktadır (Tablo 1). Türkiye'de de yetiştiriciliği yapılan bitkiler içerisinde tahıllar önde gelen bitki grubunu teşkil etmektedir (Tablo 2). Çoğunlukla tanesinden yararlanılan tahıllar insanların ve çiftlik hayvanlarının beslenmesinde başvurulan en önemli kaynaklar arasında yer almaktadır. Hatta bazı tahılların yem amacıyla üretimleri, yaygın olarak yetiştirilen korunga ve fiğ gibi yem bitkileri ile yarışır konuma gelmiştir. Özellikle mısırın ot (hasıl + silaj) üretimi, yoncanın ot üretiminin de üzerine çıkmıştır (Tablo 2).

Türkiye'de kaba yem amaçlı tahıl yetiştiriciliğinde son on yılda ciddi mesafe alınmıştır. Bu sebeple, Türkiye İstatistik Kurumu (TÜİK) 2012 yılından beri ot üretimi amaçlı tahıl yetiştiriciliğini tarım istatistiklerine dahil etmiştir. Tritikale ve yulaf artık tane üretiminden çok ot üretimi amacıyla yetiştirilmekte, mısır ekim alanının ise yarıya yakını ot üretimine tahsis edilmektedir (Şekil 2). Ancak, ot amaçlı ekilen tahılların ne kadarının otlatılarak değerlendirildiği ile ilgili istatistiki veri yoktur. Ayrıca, tane üretimi amacıyla ekilen serin iklim tahıllarının bir bölümü otlatıldıktan sonra taneye bırakılmaktadır. Bu alanlar da tane üretimi alanı olarak kayıtlarda yer almaktadır.

Türkiye'de TÜİK (2020) verilerine göre toplam 60,7 milyon ton ot (yeşil ot + silaj) üretilmiştir. Bunun içerisinde serin ve sıcak iklim tahıllarından üretilen toplam ot miktarı 32,8 milyon tondur (%54). Tahıllardan üretilen otun 27,2 milyon tonunu silaj oluşturmaktadır (TÜİK, 2020). Buna göre tahılların bir kısmını yem bitkileri içerisine dahil etmek daha doğru olacaktır.

Gerek doğal çayır bitkileri gerekse tarım alanlarında yetiştirilen yem bitkilerinin biçim zamanı için ileri gelişme dönemleri, otlatma zamanı için ise erken gelişme dönemleri dikkate alınmaktadır. Bu sebeple hasıl ya da silaj maksadı ile biçim yapıldığında genelde tanelerin süt olumu beklenirken (Açıkgöz, 1991), otlatmada serin iklim tahıllarında 15-25 cm, darılarda ise 40-50 cm boylanma esas alınmaktadır (Altın vd., 2011). Bitkiler erken dönemlerinde daha yüksek ot kalitesine sahip olduklarından (Ball vd., 2001; Gürsoy & Macit, 2020), otlatılarak yararlanılan tahılların ot kalitesi, biçilerek yararlanılan otların kalitelerinden çok daha yüksektir. Yani tahıl meraları, aynı türlerin ot (hasıl) üretimlerine göre hayvanlara daha besleyici yem sunmaktadır.



Şekil 2. Bazı önemli tahılların tane ve ot üretimi amaçlı ekim alanları (ha)

Konunun geniş olması sebebiyle bu makalede yalnızca serin iklim tahılları ele alınmıştır.

Otlatma Amaçlı Serin İklim Tahılları

Serin iklim tahılları geniş bir uyum yeteneğine sahiptir ve yem üretimi bakımından tarımsal gelire büyük katkı sağlarlar. Yalnız dane, yalnız ot/otlatma

Tablo 1. Dünyada tahılların ekim alanı ve üretim durumu (FAO, 2019)

İklim	Tahıl	Hasat Alanı (ha)	Üretim (ton)
Serin iklim tahılları	Buğday	215.901.958	765.769.635
	Arpa	51.149.869	158.979.610
	Yulaf	9.418.493	23.104.147
	Çavdar	4.213.392	12.801.441
	Tritikale	3.807.661	14.060.433
Sıcak iklim tahılları	Mısır (tane)	197.204.250	1.148.487.291
	Çeltik	162.055.938	755.473.800
	Kocadarı	40.074.667	57.893.378
	Darı	31.653.878	28.371.792
	Soya	120.501.628	333.671.692

Tablo 2. Türkiye'de en çok yetiştirilen tarla bitkilerinin ekim alanları ve üretim miktarları (TÜİK, 2020)

Tahıl	Ekim Alanı (ha)	Üretim (tane/yeşil ot) (ton)
Buğday	6.940.102	20.500.000/348.838
Arpa	3.128.481	8.300.000/537.066
Mısır	1.217.894	6.500.000/27.313.091
Ayçiçeği	728.853	2.067.004
Yonca	662.889	19.290.519
Nohut	511.561	630.000
Yulaf	437.282	314.528/3.850.475
Fiğ	375.944	4.542.965
Pamuk	359.220	1.773.646 (kütlü)
Şekerpancarı	338.108	23.025.738
Korunga	174.495	1.934.697
Patates	147.994	5.200.000

veya her iki amaçlı üretim esnekliği ve çiftçilerin büyük ölçüde benimsemelerinden dolayı tahıllar yetiştirme avantajına sahiptir (Watson vd., 1993; Holman vd., 2011). Özellikle pazarda ürün fiyatlarında dalgalanma dönemlerinde birçok yörede ikili üretim tercih edilmektedir. Serin iklim tahılları diğer kaynaklardan (meralar gibi) sağlanan yemin az olduğu bilhassa sonbahar, kış ve erken ilkbaharda daha fazla öneme sahiptir. Yüksek kalitede yem sağladığından, hayvanların ek enerji ve protein ihtiyacını en aza indirirler. Kış merası olarak kullanılmalarının ötesinde, örtü bitkisi olarak da önemlidirler (Kumssa vd., 2020; Ronga vd., 2020).

Yem bitkisi-hayvan üretim sisteminin entegre bir parçası olan tahıllar, diğer yem bitkisi türlerinin verimli olmadığı serin mevsimlerde otlatılabilirler. Ilık sonbahar ve az karlı ılıman kış, tahılların hızlı büyümesini sağlamakta ve ideal serin mevsim otlakları sunmaktadır. Çift amaçlı üretilebilen bir ürün olarak tahılların, otlayan hayvanlar tarafından yabancı otların ve hastalıkların bastırılması gibi fark edilmeyen başka üstünlükleri de vardır (Dove & Kirkegaard, 2014; Bell vd., 2019; Martin vd., 2020). Bununla birlikte tahılların vejetatif aşamada otlatılması, yönetim uygulamalarına ve yetiştirme koşullarına bağlı olarak tane verimini azaltabilir. Özellikle uzun süreli ve ağır otlatma tahıl

(buğday) verimini önemli ölçüde azaltmaktadır (Torell vd., 1999; Edwards & Horn, 2017). Bitki-hayvan entegre yöntemlerinden biri olarak çift amaçlı tahıl yetiştiriciliği, artan çevre dengesi, geçim kaynaklarının çeşitlendirilmesi ve ekonomik streslere karşı esneklik yoluyla sürdürülebilir kalkınmaya katkı sağlayabilir ve böylece riskleri azaltabilir.

Bitki-hayvan bütünleşmesinin bir başka yönü, tahılların yem olarak kullanılmalarının yanı sıra örtü bitkisi olarak da önemli olmalarıdır (Mold & Rhees, 2020). Örtü bitkileri toprağı öncelikle su ve rüzgâr erozyonundan korur, toprak kalitesini iyileştirir, besin döngüsünü artırır ve yabancı otları azaltır (Toungos & Bulus, 2019).

Sıcak iklim türlerinin ağırlıkta olduğu otlaklarda serin iklim tahılları ile oluşturulan meralar, sıcak iklim bitkilerinin üretim miktarı ve kalitesinin düştüğü kış aylarında besin açısından yüksek kaliteli yem sağlanmasında kritik rol oynarlar. Yem üretimine dayalı hayvancılık sistemi bitkisel üretimle birlikte tarım ekonomisinde önemli bir yere sahiptir. Hem otlatma hem de tane üretimi amacıyla tahılları yönetmek, bölgedeki bitki-hayvancılık sistemini destekleyen alternatif ve sürdürülebilir bir uygulamadır. Serin mevsim tahıllarının kaba yemi, üreticilerin tane ve besi hayvanlarının piyasa değerlerine göre üretim sonuçlarını istedikleri gibi ayarlayabildiği daha esnek ve kârlı bitki-hayvancılık sistemleri sağlamaktadır. Yazlık yıllık yem bitkileri ile bütünleştirildiğinde, kışlık tahıl kaba yemleri birim alanda en iyi net getiriyi sağlayabilir (Kumssa vd., 2020).

Tahıllar genellikle kışın diğer meraların çoğundan daha hızlı büyür ve otlatmadan sonra da kısa sürede toparlanır. Ayrıca otlanmadan kaynaklanan stresi bertaraf etmelerini sağlayan yüksek kardeşlenme kapasitesine sahiptirler.

Tahılların mera olarak avantajını en üst düzeye çıkarmak için uygun bir yönetim gerekir. Örneğin, erken ekim meranın otlatma için erken kullanılmasını sağlamak için önemlidir. Ancak canlı ve cansız stresler varsa, erken ekim mümkün olmayabilir. Bitkiler fide halindeyken (iyi köklenmediklerinde) çok erken otlatma, bitkilerin sökülmesine ve ayrıca çiğneme nedeniyle ciddi hasara yol açmaktadır (Torell vd., 1999). İkili üretim sisteminde, en ekonomik getiriyi elde etmek için otlatmanın sonlandırılması kritik önem taşımaktadır. Otlatmanın sona ermesini geciktirmek, sonraki tane verimini önemli miktarda azaltmaktadır.

Genel olarak tahıllar geniş uyum yetenekleri ve otlak, hasıl, silaj ve ot gibi kaba yem olarak kullanımları şeklindeki çok yönlülükleri nedeniyle önemlidirler. Tahılların her biri iklim isteklerindeki bazı farklılıklar sebebiyle belirli bir mevsimde (sonbahar, kış veya ilkbahar) daha fazla yem sağlayabilirler ve otlatma sistemlerinde rekabet avantajına sahiptirler. Çiftçiler bitkilerin özelliklerine, mevcut yönetim uygulamalarına ve üretim hedeflerine göre doğal meralarda yem açığı yaşanan dönemlerde mera ihtiyacına uyan bitkiyi seçebilirler.

Tahıl Meralarının Besleme Değeri

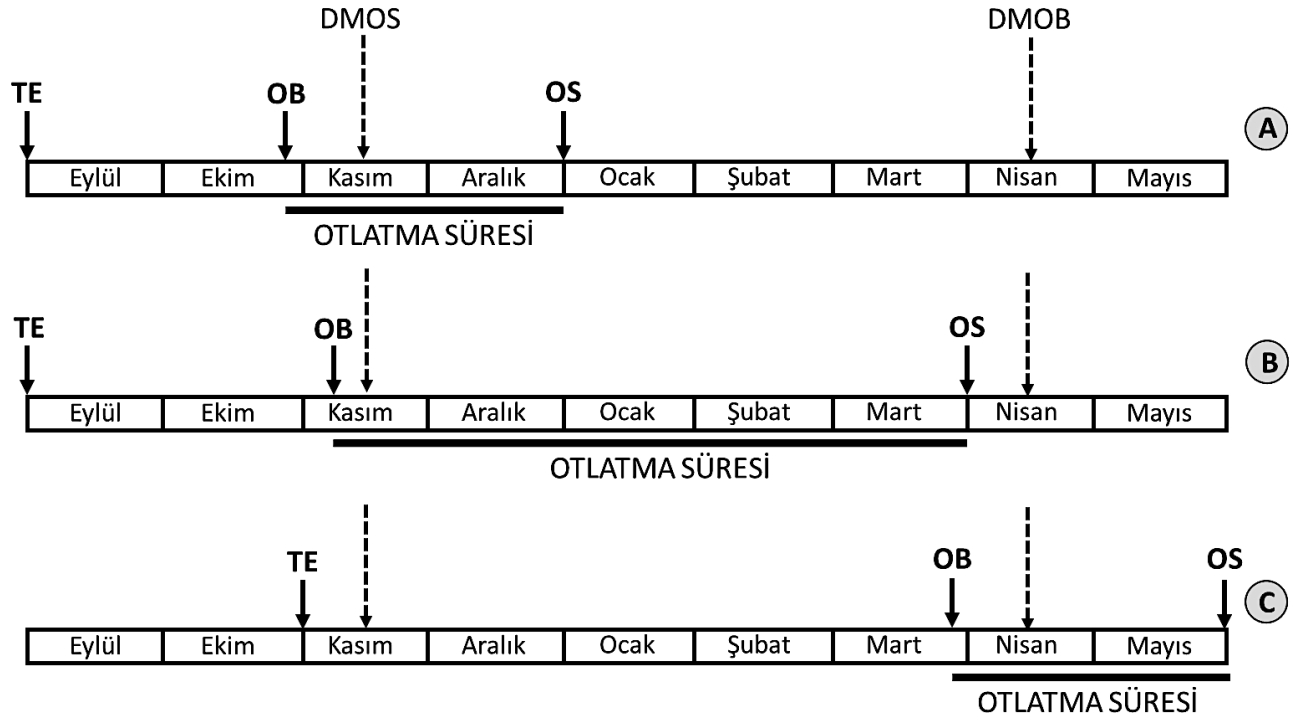
Büyümenin başlangıç dönemlerinde yapısını oluşturan hücrelerin büyük çoğunluğu genç hücrelerden meydana geldiği ve bu hücrelerde çeper yapısında bulunan lifli bileşikler tam olarak oluşmadığı için, bitkiler genç dönemlerinde yüksek besleme değerlerine sahiptir. Tahılların otlatılmasına da bitkilerin genç dönemlerinde başlanmaktadır.

Meranın ot kalitesi yetiştirilen bitki türleri, bitkilerin gelişme düzeyi, büyüme sırasında yeterli nem ve toprak verimliliği de dahil olmak üzere bir dizi faktöre bağlıdır (Bates, 2007). Otlatılarak değerlendirilen tahıllar çiftlik hayvanlarının besin maddesi gereksinimlerini önemli ölçüde karşılamaktadır (Lemus, 2021). Bu sebeple buğday merasında otlayan keçiler doğal merada otlayanlara göre besin ihtiyaçlarını daha iyi karşıladıkları için otlamada daha kısa süre geçirmişlerdir (Tölü vd., 2013).

Tahıl meralarının ham protein içeriği %18-22 arasında değişmektedir (Ditsch & Bitzer, 1995). Ancak, sapa kalkma sonrasında bu oran düşer. Zira münavebeli otlatılan tritikale merasında yapraklar ortalama %18,9 ham proteine sahip olurken, sapların ham protein oranı %9,2'ye düşmektedir (Genç & Baytekin, 2015). Büyümekte olan bir sığır için yaklaşık %12 ham protein içeren yem gerekir ve bu nedenle tahıl meraları protein takviyesine gerek duyulmadan

Tablo 3. Yulaf ve tritikale ile oluşturulan ilkbahar ve sonbahar meralarında otun ham protein (HP) ve toplam lif (NDF) içerikleri (%)

Mera	İlkbahar		Sonbahar	
	HP	*NDF*	*HP*	*NDF*
Yulaf merası	14,43	43,76	20,13	40,66
Tritikale merası	14,07	46,80	22,45	40,56
Doğal mera	8,10	61,46	6,26	74,78



Şekil 3. Batı Anadolu şartlarında tahıl meralarının muhtemel otlatma süreleri. (A) Geç sonbahar merası, (B) Kış merası ve (C) İlkbahar merası. TE: Tohum ekimi, OB: Otlatma başı, OS: Otlatma sonu, DMOS: Doğal meranın otlatma sonu, DMOB: Doğal meranın otlatma başı

hayvanların ihtiyacını kolaylıkla karşılar (Watson vd., 1993). Buğday otu düşük lif içeriği yanında yüksek protein, mineral, vitamin ve enerji değerine sahiptir (Holman vd., 2011; Kumssa vd., 2020). Buğday meralarında otun protein içeriği %25'in üzerinde ve lif kapsamı da düşük (%40-49 NDF ve %20-30 ADF) olduğundan, diğer kaba yem bitkilerinden daha çok tane yemlere benzeyen sindirilebilirliğe sahiptir. Bu durum buğday (tahıl) meralarında otlayan buzağıların günde 1 kg'dan fazla ağırlık kazanmasını mümkün kılmaktadır (Beck & Jennings, 2015). Yulaf ve tritikale ile tesis edilen ilkbahar ve sonbahar meralarının besleme değerleri de doğal mera otlarından daha yüksektir (Tablo 3). İlkbahar tahıl merasına göre daha erken dönemde otlatılan sonbahar tahıl meralarında otun ham protein değeri %20'nin üzerine çıkmakta, NDF ise %40 civarına inmektedir (Gökkuş vd., 2017).

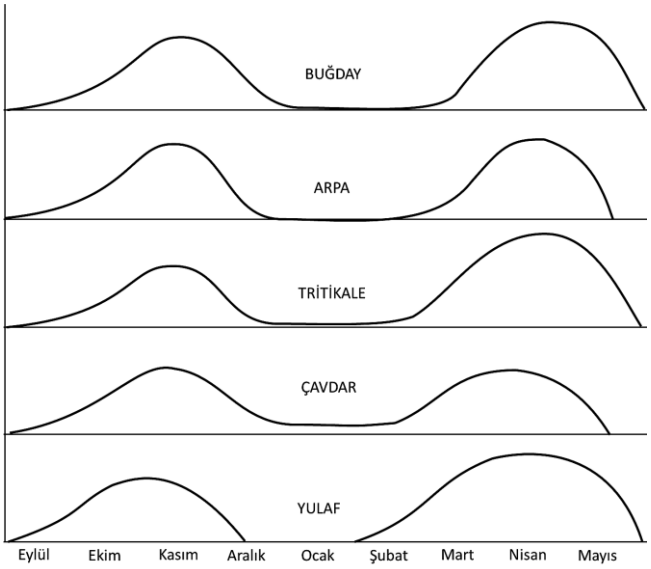
Tahıl Türlerinin Özellikleri

Birisi insanların geliştirdiği, kalan dördü de doğal olan toplam beş serin iklim bitkisi türünün besleme değerleri, gelişme dönemleri, üretim güçleri, çevre istekleri ve otlanmaya tepkileri gibi birçok yönden farklılıkları bulunmaktadır.

Buğday

Buğday çok yönlü tahıllardan biridir. Yetiştirme koşullarının uygun olduğu her yerde hem ot hem de ikili üretim (ot + tane) sistemi içerisinde başarıyla yetiştirilebilir ve bu bitki-hayvan entegre işletmelerine ekonomik avantaj sağlar. Doğru çeşit seçimi halinde, ikili üretim yalnız tane veya yalnız yem bitkisi olarak yönetmekten daha iyidir. Fakat buğday erken büyüme ve toplam yem üretimi bakımından diğer tahılların biraz gerisindedir. Buğday çoğu toprağa iyi uyum

sağlar ve nemli killi topraklara diğer tahıl türlerine göre daha hoşgörülüdür. Kışlık buğday üretim sisteminde yem verimini en üst düzeye çıkarmak için bitki genellikle sonbaharda erken ekilir ve kışı çok sert geçmeyen yörelerde sonbaharın sonlarında otlatmaya başlanabilir. Toprak neminin yeterli olması durumunda buğday merası 4-5 ay otlatılabilir (Torell vd., 1999). Kışa arpa ve yulaftan daha dayanıklı olduğu için sonbaharın sonlarına doğru da ekilebilir. Bu durumda otlatmaya erken ilkbaharda başlanır.



Şekil 4. Marmara Bölgesinde serin iklim tahıllarının ot üretimleri (Bölgelerin iklim özelliklerine göre tahılların gelişimi ve üretimi değişecektir)

Arpa

Arpa diğer tahıllar kadar kışa dayanıklı olmadığı için kıştan önce iyi gelişmelidir. Bu sebeple arpanın sonbaharın başlarında ekilmesinde yarar vardır. Sonbaharda hızlı büyür ve lezzetli ot üretir. Güz ve kış başlangıcında diğer tahıllardan daha üstündür. Toplamda daha az ot üretir, fakat diğer türlere göre otunun sindirilebilirliği ve kalitesi daha yüksektir (Watson vd., 1993).

Yulaf

Dünyada tane ve yem için yaygın olarak yetiştirilen bir tahıldır. Tane ve farklı hayvan yemi formları için ağırlıklı olarak ılıman, serin ve subtropikal iklimlerde üretilir. Yazlık yulaf öncelikle tane için üretilirken, kışlık tipi genellikle yem (ot ve otlatma) için ve bazı durumlarda çift amaçlı ürün olarak yetiştirilir. Hatta yulafın yalnız tane üretimi yerine ikili üretimi daha çok ekonomik getiri sağlamaktadır (Kelman & Dove, 2009). Özellikle kışlık yulaf Türkiye'de de önemli bir yem bitkisidir. Hızlı büyür ve hava sıcaklığının bitki için en uygun olduğu sonbahar ve ilkbaharda çok rekabetçi yem üretir. Genellikle buğdaya kıyasla sonbaharda daha fazla ot ürettiği için, sonbahar ortasından kış başına kadar otlayan hayvanlar için iyi bir seçenektir. Bunun yanında yulafta sap uzaması buğdaydan daha yavaş olduğundan, otlatmaya da daha dayanıklıdır (Kelman & Dove, 2009). Ancak, donma sıcaklıklarına duyarlılığı nedeniyle kışın buğday, çavdar ve tritikaleye göre çok daha az yem üretir ve sert kışlardan zarar görür (Kumssa vd., 2020). Bu sebeple kışa dayanıklı çeşit geliştirmek, yem amaçlı kışlık yulaf için ana ıslah hedeflerinden biridir (Kelman & Dove, 2009). Ayrıca, diğer tahıllara göre yulaf genel olarak çeşitli hastalıklara karşı daha duyarlıdır ve düşük girdili tarım sistemlerinde iyi gelişmez. Bu nedenle marjinal alanlar için tavsiye edilmez. Otunun lezzetli olmasından dolayı yulaf genellikle tahıllar arasında otlayan hayvanlar tarafından en çok tercih edilenidir.

Çavdar

Tahıllar arasında kışa en dayanıklı olanıdır. Çoğu hastalık, don, kuraklık ve düşük toprak pH'sı ve verimliliğine karşı hoşgörülüdür. Özellikle stresli yetiştirme koşullarında en iyi verim gücüne sahiptir. Çavdar kuvvetli kök sistemi nedeniyle özellikle hafif dokulu kumlu topraklarda diğer tahıllardan daha verimlidir (Watson vd., 1993). Sonbahardan kışa kadar buğdaydan daha hızlı büyür ve daha fazla yem üretir. Güvenilir ve fazla yem üretimi ve çayır tetanosu potansiyelinin düşük olması sebebiyle kış otlatması için en güvenilir tahıl olarak görülür (Baker, 2016).

Çavdar yabancı otları bastırma ve diğer mahsullerden sonra kalan toprak azotunu temizleme konusundaki rekabetçi yeteneği nedeniyle sürdürülebilir tarım için uygun bir örtü bitkisidir. Kışa dayanıklılığı, yüksek kütle üretimi ve kalıntılarının yabancı otlara karşı etkileri (allelopatik etki) sebebiyle (Adhikari vd., 2018; Flood & Entz, 2018) kışlık örtü bitkisi olarak kullanılması uygundur. Kolay tane döktüğü için çavdarın en büyük dezavantajı, sonrasında ekilecek buğday için mücadeleci bir yabancı ot olmasıdır. Bu sebeple, sonrasında tanesi için buğday üretilecek alanlara ekilmemesi önerilir.

Tritikale

İki ebeveyn türünden en iyi özellikleri birleştirmek için buğday ve çavdarın melezinden elde edilen insan yapımı bir bitkidir. Bu yapay tahıl soğuğa karşı dayanma gücünü, hastalıklara direncini ve olumsuz toprak ve iklim şartlarına uyumunu erkek ebeveyn olan çavdardan, verim düzeyi ve beslenme kalitesini dişi ebeveyn olan buğdaydan miras almıştır. Islah edilmiş tritikale çeşitleri yüksek ot ve tane üretimine sahiptir. Çeşitli canlı ve cansız stres faktörlerinin etkili olduğu olumsuz yetiştirme şartlarında tercih edilebilecek alternatif bir bitkidir. Özellikle tane yemi ve/veya kaba yem olarak üretildiği için hayvancılık sistemlerinde önemli bir yere sahiptir. Dünyanın birçok yöresinde yüksek yem üretiminden dolayı hasıl ya da otlatma amacıyla yetiştirilmektedir. Otlayan hayvanlar için çavdardan daha yüksek ot kalitesine sahiptir. Ayrıca silaj üretimi için de tercih edilen bir yem bitkisidir.

Tahılların Otlatılması

Serin iklim tahılları otlatma, silaj veya ot üretimi için kullanılabilen çok amaçlı ürünlerdir. Saf tahıl tesislerini otlatmak, otlatma mevsimini sonbaharın sonlarına ve kış başlarına kadar uzatmanın önemli bir yoludur. Hatta kışı ılık geçen yerlerde kış boyunca otlatmak da mümkündür. Diğer taraftan tahıllar güçlü fide yapıları ve soğuk/serin şartlara iyi uyum sağlamaları sebebiyle, doğal meralar otlatma olgunluğuna ulaşmadan önce otlatma olgunluğuna gelirler (Torell vd., 1999). Böylelikle doğal meraların en önemli sorunu olan erken otlatmanın önüne geçebilirler. Türkiye'de meraların bozulmasının en önemli nedeninin de erken otlatma olduğu düşünülürse (Gökkuş, 2020), tahılların önemi daha iyi anlaşılacaktır. Bu amaçla tahıllar genellikle kışlık ara ürün olarak ekim nöbetinin içerisinde yerini alırlar. Ayrıca erozyonu azaltan ve önceki ürüne uygulanan azotun kalanını kullanan bir örtü bitkisi işlevi görürler.

Serin iklim tahılları serin iklimlere dayanıklı olmaları, çok değişik topraklara uyum göstermeleri, tesislerinin kolaylığı, otlanmadan sonra hızla yeniden toparlama yetenekleri, gübreye iyi tepki vermeleri ve ot kalitelerinin yüksekliği gibi özellikleri sebebiyle ülkemizde ve dünyanın çoğu yöresinde hayvanların kaba yem ihtiyaçlarını gidermek üzere otlatılarak değerlendirilmektedir. Otlatmada iki yol izlenir: (a) sadece otlatma amacıyla mera oluşturmak ve (b) ikili üretim sistemi içerisinde önce otlatıp daha sonra taneye bırakmak.

Tahıl Merası

Bu üretim sisteminde serin iklim tahılları hem hayvanlara yüksek kaliteli yem sunmak hem de otlatma mevsimini uzatmak amacıyla yetiştirilir. Tahıllar bir yıllık türlerden oluştuğu için, bunlarla kurulan meraların ömrü ve otlatma süreleri, tarım alanlarının normal ekim nöbeti içerisinde kolaylıkla yer alabilmelerini sağlar.

Serin iklim tahılları ile tesis edilen meralar bilhassa ilkbaharda önemli olmakla birlikte, iklime, sulama imkânlarına ve ekim zamanına bağlı olarak da sonbahar sonu ve kış aylarında çiftlik hayvanları için çok değerli bir yem kaynağıdır (Şekil 3). Sonbahar sonu ile kış başı arasında ya da kışı serin (soğuk değil) geçen yörelerde kış boyunca otlatma yapmak için yaz sonu ile sonbahar başı arasında ekilmelidir. Bu dönemde topraklar kuru olduğundan, toprakların tava getirilmesi ve sonrasında güz yağışları düşene kadar çıkan fideleri kuraklık stresinden korumak için mutlaka sulama yapılması gerekir. Doğal yağışa dayalı yetiştiricilikte (kuru tarım), sonbahar yağışları yetersiz ve düzensiz ise, sonbahar başında ekim ve dolayısıyla kış öncesi otlatmak için tahıl merası kurulabilmesi mümkün olmayacaktır. Yağış yetersiz değilse ya da sulama imkânı varsa, sonbahar başında ekilen bitkiler yaz sonunda kalan ısı ile süratle büyürler ve sonbahar sonunda otlanabilecek duruma gelirler.

Kış merası kışı ılıman geçen yörelerde kurulabilir. Sonbahar sonu ve özellikle kışın otlatma yapmak amacıyla kurulacak tahıl meralarında çavdar ve kışlık buğday gibi soğuğa daha dayanıklı türler tercih edilmelidir. Zira kışa en dayanıklı tür olan çavdar hava sıcaklıkları 4,5°C'nin altına düşene kadar dinlenme dönemine girmez. Ancak, kış soğuklarına kalmadan sonbaharda olabildiğince erken otlatmak istenirse, arpa ve yulaf gibi hızlı gelişen türler düşünülmelidir. Yeterince erken ekim bu türlerin iyi kardeşlenip hayvanların ihtiyaçlarını karşılayacak kadar yem üretmelerini sağlar.

Erken ilkbaharda otlatmak amacıyla kurulacak tahıl meralarının ekimi sonbaharda tane üretimi için uygun olan tarihlerde yapılır. Burada da yine bitkilerin kış donlarından zarar görmeyeceği, ancak kışa girmeden önce yeterince kardeşlenmesinin sağlanacağı tarihler seçilmelidir. Örneğin, tane için uygun ekim zamanının 1-31 Ekim olduğu bir yörede bahar merası için ekimlerin 15 Ekim tarihine kadar tamamlanması iyi bir tercih olacaktır. Ekimin ekim ayı öncesinde yapılması halinde, bitkiler daha çok gelişip daha fazla boylanarak kışa girecekleri için kıştan zarar görme riski de yükselecektir. Sonbaharda bitkilerin aşırı otlanması halinde de don zararı yaşanabilmektedir.

Otlatma amacıyla tahıllar belirtilen ekim zamanlarında 2,5-5 cm derinliğe ekilir ve tür, çeşit ve yörenin iklim özelliklerine göre bir seferde 8-12 kg/da azot ve fosfor uygulanır (Ditsch & Bitzer, 1995; Bates, 2007; Genç & Baytekin, 2015). Bitki örtüsü, toprak, verimlilik ve mevsim otlatılacak hayvan sayısını belirler.

Tahıl meralarının başarısı otlatma yönetimine bağlıdır. Bitkiler iyi köklendiği ve kardeşlendiğinde, genellikle ekimden yaklaşık 6-8 hafta sonra, sonbahar merasında otlatmaya başlanabilir. Yem kalitesi olgunlukla birlikte belirgin şekilde düştüğü için, bitkilerin otlanmasına vejetatif aşamada başlanır ve otlatma süresince vejetatif durumda tutulur. Merada otlanma sonrasında bitkilerin yeniden büyümeleri için dinlenmelerine fırsat verilmelidir. Bu sebeple tahıl meralarında mutlaka münavebeli ya da şerit otlatma yapılmalıdır. Bu otlatma sistemleri yem kullanım verimliliğini yaklaşık %15-20 artırmaktadır (Beck & Jennings, 2015). Dinlenme sürecinde bitkilerin kendilerini toparlayabilmeleri için bırakılan anızda yeterli yeşil yaprak dokusu bulunmalıdır. Ortalama bitki boyu 20-25 cm yüksekliğe ulaştığında otlatmaya başlanabilir ve yoğun otlatılır. Ot yüksekliği 7,5-10 cm'ye indiğinde ise hayvanlar meradan çıkarılır. Yeniden 20-25 cm'ye ulaştığında, tekrar otlatılır. Örneğin buğday 5 cm'den daha az anız kalacak şekilde otlatılmamalı ve 12,5-20 cm boylanana kadar da otlatmaya başlanmamalıdır (Beck & Jennings, 2015). Buradaki temel kural, "*bitkiler bir karış olunca otlatmaya başla, dört parmak olunca son ver*" şeklinde olmalıdır.

Özellikle ilkbahar tahıl meralarının devamlı olarak otlatılması, meranın yeterli ve düzenli kullanımına engel olur. Çünkü ilkbahar başındaki serin havalar biraz ısınmaya döndüğünde (ilkbahar ortalarına doğru) bitkiler hızla büyümeye başlarlar. Otlatma kapasitesine uygun sayıda hayvan bırakıldığında bile, hızlı büyüyen bitkilerin tümü tüketilemez. Bitkiler boylanır ve ot kaliteleri düşmeye başlar. Hayvanlar merada daha kısa boylu ve sapları kalınlaşmamış bitkileri tercih ederler. Burada otlanan bitkiler yeniden otlanır, otlanmayanlar ise kalır. Kalan bitkiler büyümeye ve başak/salkım oluşturmaya başlar. Eğer başaklar arpadaki gibi kılçıklı ise hayvanlar artık bu bitkilere hiç yaklaşmazlar. Ayrıca merada gezinen hayvanlar fazla boylanmış bitkileri çiğnemek suretiyle de otu tüketmeden ziyan ederler. Hatta bitkilerin özellikle küçükbaşların boyunu aşacak kadar büyüdükleri yerlerde, hayvanlar korkularından dolayı bu yerlere girmezler ve sonuçta buralar otlanmadan kalır.

İlkbahar tahıl meralarında, yaz mevsiminin yaklaşması ile yükselen sıcaklıklar bitkilerin gelişmesini baskı altına almaya başladığında, bitkilerde vejetatif gelişme sona erer. Genelde otlanma sebebiyle başak/salkım gelişimi de engellendiğinden, üretim faaliyeti durur ve bitkiler sararmaya başlarlar. Bu durumda kalan bütün anız da otlatılarak otlatmaya son verilir. Eğer sulu tarım sistemi uygulanıyorsa, yazlık ana ürün için gerekli toprak hazırlıklarına başlanır. Tahıl meralarında bitkilerin kartlaşmalarına izin verilmediği için, otlamanın tamamlanması sonrasında kalan bitki artıkları daha düşük C/N oranına sahiptir. Bu da ekim nöbetinde tahıl merasından sonra ekilecek bitkiler için toprakta daha kolay ayrışan bir artık kaldığı anlamına gelir.

Tahıl meralarının üretimi yıldan yıla ve tür/çeşitlere göre önemli farklılıklar gösterir. Genel olarak çavdar otlatma mevsimi boyunca yüksek toplam üretime sahip olup, onu tritikale, buğday ve arpa izler (Şekil 4). Bununla birlikte, çavdar diğer tahıllara göre ilkbaharda daha erken saplı ve lezzetsiz hale gelir. Çavdar buğday veya arpadan daha az lezzetli ve lif bakımından daha zengin olduğundan, sığırların otlaması sırasında elde ettikleri canlı ağırlık kazançları normalde buğday, tritikale ve arpa meralarında daha fazladır (Watson vd., 1993). Buğday ekim tarihi ve

iklim şartlarına bağlı olarak güz ve ilkbahar boyunca toplam 250-1240 kg/da arasında kuru ot üretir. Bunun mevsimsel dağılımı çeşide, gübreleme rejimine ve hava koşullarına bağlıdır (Beck & Jennings, 2015).

Tahıl merası kurulacak topraklarda drenaj sorunu olmamalıdır. Kil içeriği yüksek topraklar ve balçıklaşmaya meyilli tarlalar tahıl merası için uygun değildir. Böyle arazilerde bitkiler fazla sudan zarar görebilecekleri gibi otlayan hayvanlar da çamura batar, bitkileri ezerek çamura gömer ve meradan yeterince yararlanamazlar. Kış merası olarak kullanılacaksa, drenaj sorunu daha büyük önem arz eder. Drenaj sorunu olmayan hafif dalgalı araziler genellikle tahıl meralarının oluşturulması için en kullanışlı yerlerdir. Kumlu topraklarda çavdar ve arpa en iyi performansı gösterir. Daha ağır topraklarda buğday ve tritikale en iyidir. En iyi sonbahar otlatması, genellikle nemli (ıslak değil) taban topraklarında elde edilir. İlkbaharda en iyi otlatma çoğunlukla erken ısınan yüksek arazilerde sağlanır (Watson vd., 1993).

İkili Üretim

Serin iklim tahıllarının hızlı gelişmeleri ve kendilerini yenileme kabiliyetleri sebebiyle bazı entegre bitki-hayvan üreticileri esasen tane üretmek amacıyla ektikleri tahılları büyümenin erken dönemlerinde otlatarak da değerlendirirler. Böylelikle bir yandan belirli bir süre çok yüksek kaliteli yemlerle hayvanlarını beslerken, diğer yandan tane üretimlerini sürdürürler. Bu, tarım işletmelerine ciddi iktisadi kaynak sağlar. Bu yüzden hem bitkisel üretim hem de hayvancılık yapan çok sayıda tarım işletmesi ikili üretimi tercih ederler. Bu sistemin başarısı, tahıl türlerinin seçimine, ekim tarihine, otlatmanın zamanlamasına ve otlatılacak hayvan sayısı ile ilgili yönetim kararlarına ve iklim faktörlerine bağlıdır. Ayrıca, sistemi modellemek için bu faktörlerin tahılların büyümesini, fenolojisini ve tane verimini nasıl etkilediğine dair ayrıntılı bilgiye gerek vardır (Kelman & Dove, 2009). İstatistiklerde yer almasa da bu kullanım biçimi ülkemizin pek çok yöresinde uygulanmaktadır. Örneğin, araştırma sonucu olmamakla birlikte, Çanakkale'de yapılan gözlem ve tespitlerde tahıl (buğday) alanlarında otlayan koyun ve keçilerin süt üretimlerinin doğal merada otlayanlardan daha yüksek olduğu görülmüştür.

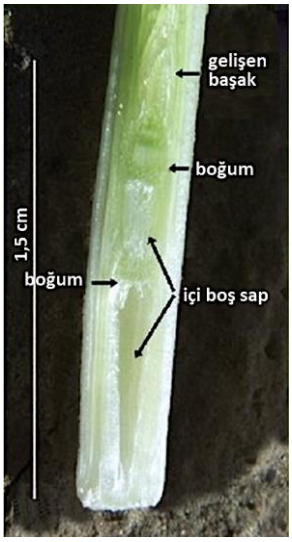
İkili üretimde tahıllar kış sonu veya ilkbahar başında sapa kalkma aşamasına kadar otlatılabilir. Sonraki ilkbahar büyümesinin çoğu tane üretimine ayrılır. Ayrıca bazı yıllarda tane için hasat edilmesinden daha kârlı bir seçenek olabilen tam bir otlatma programına da alınabilirler. Otlanan bitkilerin kış mevsiminde kendilerini toparlamaları zorlaştığı için ikili sistemde sonbahar otlatması sınırlı olarak yapılabilir.

Çift amaçlı üretim sisteminin en riskli tarafı, tane veriminin azalmasıdır. Bu duruma yol açmamak için otlatma yoğunluğu ve zamanına çok dikkat edilmelidir. Yoğun otlatma bitkilerin yeniden büyümeleri için daha az fotosentez dokusu bırakır (Parsons vd., 1983; Trlica, 1992). Hayvanların terk etmeleri gereken gelişme döneminden daha uzun süre otlamaya devam etmeleri halinde ise başak veya salkım oluşumu engellenir. Zira kın içerisinde yükselen sapın ucundaki başak/salkım otlanırsa, bu sap bir daha uzamaz ve sonucunda başakçık topluluğu oluşmaz (Barnhart, 1999; Jewiss, 2006). Erken çıkarılması durumunda ise işletmenin kârı azalır. Burada iyi bir denge kurulmalıdır.

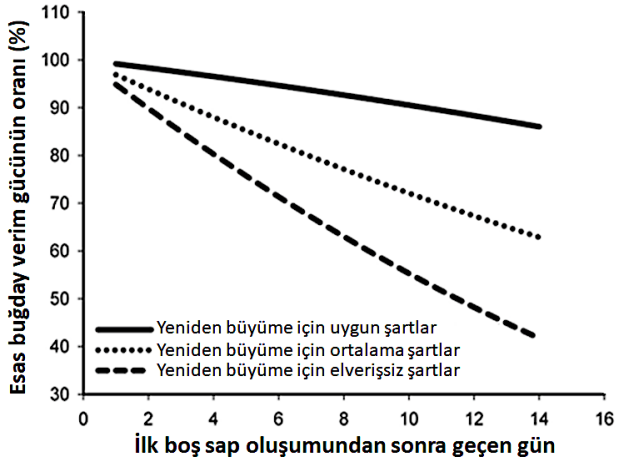
İkili üretim sisteminde hayvanların alanı terk etmeleri gereken dönemi belirlemek için buğday üzerinde yoğun araştırmalar yürütülmüştür (Edwards & Horn, 2017). Bu araştırmalar sonucunda buğdayın ilk oluşan içi boş sap uzunluğunun önemli olduğu ortaya konmuştur. Bu yaprak kını içerisinde gelişmekte olan başak taslağının altında 1,5 cm sapın meydana geldiği zamandır (Şekil 5). İlk içi boş sapın görüldüğü dönem, aynı zamanda bitkilerin sapa kalkma dönemine denk gelmektedir. Bu sebeple buğday dışındaki diğer tahıllar için de sapa kalkma başlangıcı otlatmaya son verme zamanı olmalıdır.

İlk boş sapı kontrol etmek için otlanmamış bir alandan 4-5 bitki sökülür. En büyük kardeşler (ana sap) seçilir. Saplar maket bıçağı ile tabandan başlayarak boyuna açılır. Gelişmekte olan buğday başağının altında 1,5 cm oyuk sap varsa (Şekil 5), buğdayın ilk boş sap zamanı, yani otlatmanın sona erdirilmesi gereken zaman gelmiş demektir. İlk boş gövde oluşumundan sonra yapılan otlatmanın büyüme şartlarına göre buğdayın tane verimini günde %1-5 kadar azalttığı vurgulanmıştır (Şekil 6). Çoğunlukla ilk boş gövde oluşum zamanını geçen sürelerde sığırların

otlatılmasından elde edilen ek ağırlık artışı, tahıl verimindeki kaybı dengelemek için yeterli olmaz (Edwards & Horn, 2017).



Şekil 5. Gelişmekte olan buğday başağının altında oluşan boş gövde kısmı (Edwards & Horn, 2017)



Şekil 6. İlk boş gövde oluşumundan sonra otlatmanın tahıl verimini azaltması (Şekilde otlatmanın sona ermesini takiben buğdayın yeniden büyümesi için elverişli (düz çizgi), elverişsiz (kesikli çizgi) ve ortalama (noktalı çizgi) şartlarda ilk boş gövde oluşumundan sonraki sürelerde otlatılması halinde muhtemel verim kayıpları gösterilmektedir) (Edwards & Horn, 2017)

Otlanmadan sonra kalan yeşil yaprak alanı miktarı da buğdayın kendini toparlamasını önemli ölçüde etkiler. Yeşil yaprak dokusu buğdayın büyümesini sağlayan fabrikadır. Otlatma bitiminde ne kadar çok yeşil yaprak dokusu kalırsa, verim gücü o kadar büyük olur. Bu nedenle, ağır veya çamurlu koşullarda otlatılan buğday alanlarının kendilerini toparlaması zordur. Kısa süreli hafif otlatmalar çoğunlukla buğdayda tane veriminin azalmasına sebep olmaz.

Erken ilkbaharda hayvanların alandan çıkarılmasından sonraki serin ve nemli şartlar buğdayın geri kazanımı için uygundur. Bu çevre şartları buğdayın üreme konumuna geçmeden önce otlatmada kaybettiği vejetatif büyümenin bir kısmını geri kazanması için fazladan zaman sağlar. Bu sebeple nemli/yarı nemli ekolojiler ikili üretim sistemine daha uygundur (Kelman & Dove, 2009). Kurak mevsim ya da yılda ise ikili üretim sisteminin başarısını otlatma süresi, bitki büyüme evresi ve otlayan hayvan sayısı gibi faktörler etkiler (Gupta vd., 2019). Aynı zamanda kış şartları otlatmaya elverişli olduğu bölgelerde buğdayın çift amaçlı yetiştiriciliği yalnız tane veya yalnız ot üretimine göre daha karlıdır (Doole vd., 2009).

İkili üretimde tahıllar otlayan hayvanlar tarafından fidelerin sökülemeyeceği iyi bir kök oluşturmalarından sonra otlatmaya başlanır ve sapa kalkma döneminde son verilir. Bu tür üretim sisteminde verilecek gübre miktarı, tane üretimi için önerilen miktar kadardır. Gübrenin bir kısmı ekimle birlikte taban gübresi olarak verildikten sonra, kalanı hayvanların tarladan çıkarılmasından sonra uygulanır.

Otlatmada Karşılaşılan Beslenme Sorunları

Serin iklim tahılları ile tesis edilen meralarda otlayan hayvanlarda genellikle beslenme sorunları yaşanmaz. Olanlar da yönetim ve uygun besleme programı ile kolayca kontrol edilir. Ancak bazen yüksek verimli hayvanlarda ve yüksek azot uygulamalarında kimi sorunlar görülebilir. Bu sorunlar arasında (a) çayır tetanosu, (b) şişme ve (c) nitrat zehirlenmesi yer alır.

Çayır (Ot) Tetanosu

Çayır tetanosu kandaki düşük Mg seviyesi ile tanımlanır. Bu yüzden "hipomagnesemi" olarak da adlandırılır. Ancak esasen K, Ca ve Mg arasındaki oranın değişimi ile alakalıdır. $K/(Ca+Mg)$ oranı 2,2 değerinin üzerine çıktığı zaman çayır tetanosu riski yükselir (Algan & Aydın, 2017). Bu sorun hızlı ilkbahar büyümesinin ekseriya serin (7-15°C) bulutlu günleri izlediği zaman da ortaya çıkar. Bu sebeple genelde sonbaharda görülmez. Tetanos kurudaki ya da genç

hayvanlara göre sağım dönemindeki yüksek süt veren ineklerde daha fazla görülür. Hayvanların yem tüketimi azalır ve bununla bağlantılı olarak canlı ağırlık ve verim kaybı yaşanır, kas kasılmaları olur ve sonucunda hayvan ölümleri görülebilir (Dahlen & Stoltenow, 2014). Otlatmaya başlamadan en az birkaç hafta önce tuz, melas veya tane ile karıştırılmış Mg oksit verilmesi ile tetanos riski azaltılır.

Şişme

Genelde serin iklim tahıllarında şişme riski azdır. Ancak ot yeşil olduğunda şişme riski arttığı ve otlayan hayvanlar da yeşil ot tükettikleri için, tahıl meralarında zaman zaman şişme sorunu yaşanabilir. Şişkinlik hayvan işkembesindeki mikro floradan hızla parçalanabilen çözünür protein ve şekerlerin salınmasıyla oluşur. Bunlar işkembe içeriği tabakasının üstünde stabil bir köpük maddesinin oluşmasına sebep olabilir. Fermantasyon gazları bu tabakadan geçerken işkembenin kasılmalarıyla kolay kolay bozulmayan bir köpük oluşur. Kalsiyum eksikliği işkembe kasılmalarının seyrelmesine ve zayıflamasına neden olduğundan, şişmeye katkıda bulunabilir (Beck & Jennings, 2015). Serin ve nemli şartlar şişmeyi artırır. Şişkinlik gözlenirse, tedavi olarak şişme önleyici ilaçlar verilmelidir.

Nitrat Zehirlenmesi

Kışlık tahıllara yüksek düzeyde azot verilmesi durumunda nitrat zehirlenmesi ortaya çıkabilir. Özellikle 22,5 kg/da'ın üzerindeki azot uygulamaları üretimi büyük ölçüde artırmadığı gibi, yüksek nitrattan dolayı çiftlik hayvanlarının zehirlenmesine sebep olur (Beck & Jennings, 2015). Kuraklık ve soğuk gibi bitki büyümesini azaltan hava şartları bitkideki nitratı hayvanlarda zehirlenmeye yol açacak seviyelere kadar artırabilir (Strickland vd., 2017). Hayvanlar nitrat içeriği düşük taze ve kuru yemlerle beslendikten sonra otlatıldıklarında, yüksek nitrat zehirlemesi riski taşıyan tahıl meralarında zarar görmeyebilirler. Ayrıca aç hayvanlar potansiyel tehlike arz eden bitkilerle otlatılmama ve ağır otlatma yapılmamalıdır (Block, 2020). İşkembedeki mikroorganizmalar zamanla daha yüksek nitrat seviyelerine uyum sağlayabildikleri için, küçük miktarlarda yüksek nitratlı yemlerin sık tüketilmesi, geviş getiren hayvanlar tarafından olumsuz etkiler yaşanmaksızın tüketilebilecek toplam nitrat miktarını arttırır (Robson, 2018).

Bu sorunların yanında kışlık buğday merasını otlayan hayvanlarda kan üre düzeyleri de artabilir ve bu ineğin verimliliğini olumsuz etkiler (Holman vd., 2011).

SONUÇ VE ÖNERİLER

Tahıl meralarının yüksek besleme değerleri yanında, otlatma mevsimini uzatması ve hayvanların ek yem ihtiyacını azaltması gibi önemli yararları vardır. Bu sebeple doğal meralardaki otlatma baskısını hafifletmede en iyi seçenekler içerisindedir. Ayrıca tahılların yetiştirme kolaylığı, mekanizasyonunun yaygınlığı, çiftçi tarafından iyi tanınması ve ekim nöbeti sistemlerine kolaylıkla dahil olabilmesi gibi avantajları da söz konusudur. Bu sebeplerle tahılların ot ve/veya otlatma amaçlı kullanımları giderek yaygınlaşmaktadır. Serin iklim tahılları kışı sert geçmeyen yerlerde sonbahar ortasından ilkbahar ortasına kadar, kışı sert geçen yerlerde ise sonbaharın son yarısı ile ilkbaharda otlatılabilecek ot üretirler. Ayrıca piyasa şartlarına bağlı olarak ikili üretim (ot + tane) de mümkündür. Tahılların otlatma amaçlı yetiştiriciliğinde otlatmaya başlama ve son verme zamanlarına çok dikkat edilmelidir. Otlatmaya bitki boyu 20-25 cm'ye ulaşınca başlanıp, 7-8 cm anız kalınca sonlandırılmalıdır. İkili üretimde ise tahıl fideleri kuvvetli kök oluşturduktan (genelde ekimden 6-8 hafta sonra) itibaren sapa kalkma başına kadar otlatılmalıdır.

Etik Standartlara Uyum

Yazarların Katkısı

HHÖ literatür araştırmasını gerçekleştirdi, AG çalışmayı planladı, makaleyi yazdı. Her iki yazar da makalenin son halini onaylamıştır.

Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını beyan etmektedir.

Etik Onay

Yazarlar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

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Asymmetric Reflection of Shocks in Baltic Dry Index to Istanbul Freight Index

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ABSTRACT

Since the maritime freight markets have inelastic supply structures in the short run, freight is considered an indicator of trade volume. Freight rates can rise rapidly when fleet utilization is high, as supply, which does not increase in the short run due to time of ship building, cannot respond to increases in demand. In this sense, the relationships between the relevant freight indices can be examined in order to determine the regional reflections of global commercial developments. The aim of this study is to examine the effects of the shocks in Baltic Dry Index (BDI), which is an indicator of dry bulk trade in the global sense and considered as a leading indicator of the world economy by many researchers, on Istanbul Freight Index (ISTFIX), which is an indicator of trade in the Mediterranean and Aegean in the regional sense. The dataset covers the period between 31.12.2007 and 19.02.2018, and consists of 524 weekly observations. Asymmetric causality test is used in order to reveal relationship between variables. According to the findings, a significant causality relationship was determined only from negative shocks in BDI to negative shocks in ISTFIX. This situation shows that the contraction in global trade is immediately reflected in the ISTFIX region, while the expansion in trade is not immediately reflected.

INTRODUCTION

The most important and key market among the maritime markets is the freight market. According to the developments in this market, there are changes in prices and supply-demand balances in the second-hand market, the shipbuilding market and the demolition market. When freight rates tend to increase, second-hand ship prices begin to rise in parallel. Because both the profit from the market has increased and the demand for second-hand ships has increased due to the increase in freight, a reflection of the rise in economic activities. When second-hand prices increase, the demand for constructing new ships increases and the prices here are also positively affected (Buxton, 1991). Since, even old ships can do a profitable business under high freight conditions, there may be a decrease in the number of ships going for demolition, and this may cause an increase in demolition prices (Randers & Göluke, 2007). Then, the

situations in other markets are shaped according to the movements of the freights. This condition in freight market continues by forming continuous cycles throughout the history (Metaxas, 1988). Therefore, understanding and analyzing the behavior of freights makes it possible to take a proactive position both in freight market as well as in other maritime markets, and reduces the risks arising from uncertainty (Kavussanos et al., 2010).

In addition to ship owners, cargo owners are also directly affected by the developments in the freight market. Rising freight prices mean increased transportation costs for exporters and importers. Since this situation affects the final prices of the products, the demand for the related products is affected. Therefore, there is an interaction between transportation cost and trade volume (Korinek & Sourdin, 2010). On the other hand, although increasing transportation costs do not cause a decrease in trade in countries with intense foreign trade activities, they cause an increase in the prices of domestic products. This situation results in inflationary pressures in the domestic markets of the countries and becomes a situation that can affect the welfare of all households. Because goods transported by sea are necessary products for both industry and households (Chevallier & Ielpo, 2013). For this reason, the freight market is in an important position for both ship owners, cargo owners and the economies of countries. Consequently, many theoretical and empirical studies to understand their structures take place in the maritime literature. The results obtained from these studies may also differ. The results may vary, as the events occurring in the periods covered may differ. Or the results may change due to the way freight rates are handled. Some studies use spot rates, some studies use time charter rates, and some studies use freight indices to represent freight level in the market. Additionally, the results may differ depending on the method used, regardless of the data type. Some studies use linear methods, while others use nonlinear non-parametric methods. Of course, each method and model should be considered as parts that make up a whole by considering the subject from different angles.

The literature side of the research topic is quite wide, because due to the mentioned importance of freight, many researchers aimed to understand the mechanism and determine the affecting factors. It is difficult to cover all of them in this section and may distract us from the focus of our study. For this reason, the studies on ISTFIX in the literature will be mainly reviewed. Freights move over time by generating cyclical movements. While these cycles sometimes see very low points, sometimes they can reach very high points (Stopford, 2009). These upper peaks can present very profitable opportunities for ship owners. For this reason, it is very important to determine the factors affecting the freight on the way to the summit. In this context, in a study conducted by Açık et al. (2018), price bubbles representing the peaks in ISTFIX freights were determined, and then the factors affecting the formation of these bubbles were selected and their effect levels were examined. Exchange rate and oil price were included in the logit model as the main factors and they found that 1 unit increase in the exchange rate greatly increased the probability of bubble formation in the freight rates. This situation clearly shows the effect of the exchange rate on foreign trade and therefore on the demand of maritime transport.

Maritime transport has a derived demand structure (Branch & Robarts, 2014). For this reason, developments in the economy and any event affecting the economy may also affect maritime transport. In particular, the effects of major economies in the world on maritime transport are also very large (Efes et al., 2019). Even major economic crises cause crises in the maritime sector and freight market. The 2008 global economic crisis caused a break in the global economy. Whether this break also causes a break in the ISTFIX indices has been examined by Köseoğlu & Mercangöz (2012). As a result of the analyzes they applied with unit root tests with structural breaks, they determined that the 2008 crisis caused a break in the freight rates in the region. This situation reveals once again the dependence of shipping on the global economy. It also reveals the importance of leading indicators for maritime.

Macroeconomic indicators used to measure the economic situation are generally kept on a monthly, quarterly or annual basis. However, even a few days in maritime transport have a great importance on profitability. In this respect, the need for higher

frequency indicators representing the economic situation is obvious. Setting off with this research question, Başer & Açık (2018) examined whether the Turkish stock market could be used as a leading indicator for freights in the ISTFIX region. Thus, they aimed to determine a leading indicator for maritime transport by taking advantage of the immediate reflection of the economic situation in the country to the stock market. According to their results using asymmetric causality analysis, negative shocks in the stock market are the cause of negative shocks in the freight index. This shows that the negative news and events in the country are reflected instantly on maritime transport and reveals that the stock market can be used as a leading indicator for possible future demand decreases.

The prices of products in the world are both affected by the demand for them and affect the demand for them. Therefore, there is a possible relationship between demand and price (Radetzki, 2008). As a result of increased demand, the prices of commodities may increase and there may be a slight decrease in demand as a result of this increased price. Or demand may increase as a result of decreasing price. Therefore, there is likely to be a correlation between commodity prices and freight levels. Setting out with this research question, Açık & Başer (2020) aimed to determine whether there are significant asymmetrical relationships between the freights in the ISTFIX region and the prices of the major transported goods in the region. As a result of their analyses using steel, coal and wheat prices, it has been observed that the relationship among wheat prices differed partially. While there is a positive to positive and negative to negative relationship in coal and steel prices, there is a positive to negative and negative to positive relationship among wheat prices. It shows that the interaction may differ according to the type of commodity.

Results of the research study, conducted by Zeren & Kahramaner (2019), are closely corelated with the obtained results of this study. Zeren & Kahramaner (2019) examined the relationship between BDI and ISTFIX using cointegration and causality analysis methods. According to the obtained results, they determined a significant causality relationship from the BDI variable to the ISTFIX variable. The main reason for this is the transportation of large tonnage cargoes in BDI and the transportation of the cargoes coming with these vessels to the distribution points by ISTFIX vessels, which are smaller tonnage vessels. Because large ships cannot carry cargo to every region due to the different demands on parcel sizes and the technical capacity limits of regional ports. For this reason, large parcels should be divided into smaller parcels and to be moved to different regions.

When the literature is examined in general, all studies can be seen as a part of a whole. The study, which is in parallel with our point of view, is the study by Zeren & Kahramaner (2019). However, their results considered the relationship as one-dimensional. There may also be positive and negative dimensions of the relationship. In our study, we aimed to improve the size of the research by using asymmetric analysis, taking into account possible differentiations according to negative and positive situations in the relationship. In this respect, we aimed to make an original contribution to the literature by presenting a complementary study.

In this study, it is aimed to examine the possible impact from global markets to regional markets such as ISTFIX in order to understand the behavior of the index, which has not been the subject of empirical studies much. Although the tonnage of ships in the region is relatively small, the cargoes transported constitute very important added value for the economy of the region. In addition, the transported tonnage is on a scale that cannot be underestimated in terms of economic value. For this reason, any information that provides an understanding of the possible current structure and future movement of freight in the region is an important element that interests many stakeholders. In this respect, it is aimed to determine whether the shocks in the Baltic Dry Index, which is considered to be the most important indicator of the global maritime market, have an effect on ISTFIX, and if so, in what direction. The main reason for this is that since BDI is an indicator on a global scale and represents raw material traffic, it responds more dynamically to macroeconomic events and expectations about the future situation of the economy. Thus, the reaction movements in the BDI may cause and lead the reaction movements in the regional freight

markets. When the structure of the data was examined, it was decided to apply the asymmetric causality analysis since it was seen that the dataset was far from linearity and deviated too much from the mean. Thus, the possible relationships between the shocks contained in the variables can be examined with four different combinations by implemented method. According to the findings, negative responses (shocks) in the BDI cause negative responses (shocks) in the ISTFIX index. Negative events in the international market are felt first in BDI and then in ISTFIX. Therefore, BDI can be used as a leading indicator for regional freight markets and relevant stakeholders can take proactive positions for future moves by following BDI. As one of the few studies in the literature that examines the possible relationship between global and regional indices, this study is thought to present an original contribution.

In the second part of the study, the data set and method used in the research are introduced. In the third part, the results of the applied analyzes are presented. In the last part, general evaluations and suggestions for future work are presented.

MATERIAL AND METHOD

BDI and ISTFIX variables are used in the research. BDI variable is one of the most important indicators of dry cargo transportation. It can be stated that it represents the income level for the ship owners and the transportation cost for the cargo owners (Geman, 2009). It can provide signals for possible future production activities by showing the current situation in international raw material transport and demand (Lawson, 2008; Langdana, 2009). It consists of a combination and weighted average of many dry bulk shipping routes on a global scale. In addition to such main indices, there are also local indexes that measure regional maritime traffic. The ISTFIX index is an index developed to monitor the situation in the market of coaster-type ships that trade mainly in the Black Sea, the Marmara, the Mediterranean and the Continent (Ünal & Derindere Köseoğlu, 2014). Such indices are very useful tools for keeping track of both the level of current transport incomes for shipowners and the level of current transport costs for cargo owners. They can also be followed to ensure transport safety for policy makers.

The dataset used covers the period between 31.12.2007 and 19.02.2018 and consists of 524 weekly observations. The ISTFIX variable is an index value published weekly. To match the dataset, analyzes were performed by taking the weekly averages of the daily values for the BDI variable. The movements of the variables in the period under consideration are presented in Figure 1. Although their general trends are similar, differences in their movements can be observed in some periods. In addition, the effects of the 2008 crisis can be seen very clearly in the chart. Both indices, which saw historical peaks, suddenly saw historical lows with the effect of shrinking demand and increasing ship supply.

Descriptive statistics of the variables used in the study are presented in Table 1. The table also includes the return series consisting of the log differences of the series. According to the descriptive statistics of the raw and return series, inferences can be made about the structure of the series. For example, according to the maximum return values, BDI showed a maximum increase of 42% in a week, while ISTFIX showed a maximum increase of 9.5%. According to the minimum return values, while BDI depreciated at most 43% in one week, ISTFIX depreciated at most 23%. According to these results, it can be said that BDI has a much more volatile structure. In addition, variability can be measured according to the ratio of the standard deviation to the mean. When we proportion for BDI values, a value of 105% is obtained, while this ratio is 36% for ISTFIX. The standard deviation of the BDI variable is higher than its mean. This is another important sign that the variability is much greater in BDI. In addition, high Kurtosis values indicate high tail effects in the series. This situation distorts the normal distribution properties of the series and generates a major obstacle to obtaining appropriate results with linear methods. For this reason, the application of a nonlinear method such as asymmetric causality analysis is necessary in order to achieve significant results.

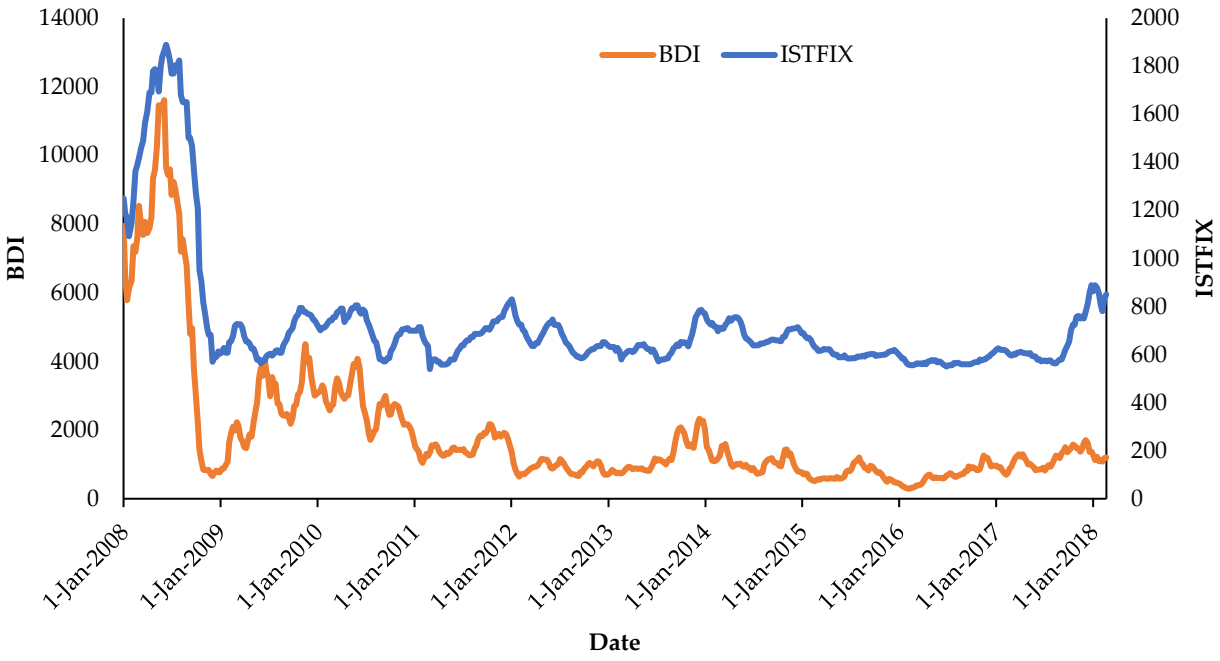

Figure 1. Graphical display of the variables (Bloomberg, 2018; ISTFIX, 2018)

Table 1. Descriptive statistics of the variables (Bloomberg, 2018; ISTFIX, 2018)

Variables	BDI	ISTFIX	R BDI	R ISTFIX
Mean	1879.7	724.8	-0.003	-0.000
Median	1155.5	646.0	-0.001	0.000
Maximum	11612.0	1889.0	0.428	0.095
Minimum	291.0	539.4	-0.434	-0.236
Std. Dev.	1975.7	262.0	0.095	0.027
Skewness	2.79	3.08	-0.122	-2.19
Kurtosis	11.01	11.98	4.49	18.3
Jarque-Bera	2086.5	2591.1	49.9	5558
Probability	0.00	0.00	0.00	0.00
Observations	524	524	523	523

It is decided to apply the asymmetric causality test proposed by Hatemi-J (2012) to determine the relationship between the BDI and ISTFIX indices in this study. The method used distinguishes shocks in variables as positive and negative. It then tests the relationship between shocks with four combinations (Shahbaz et al., 2017). Thus, any negative shock or positive shock does not have to stay in a relationship only with its own kind. In other words, significant relationships can be detected between positive shocks and negative shocks, and positive and negative shocks can also enter into statistical relationships among themselves. Considering that the players or variables in the market may react differently to the shocks they are exposed to, these findings are quite compatible with the market realities. This makes the findings of the method used valuable. There is no requirement for stationarity in the series in which the asymmetric causality test is applied. Instead, the maximum degrees of integration are determined (Umar & Dahalan, 2016), and it is decided whether an extra lag should be added to the estimated VAR models (Hatemi-J & Uddin, 2012). This is mainly because the method follows a Toda & Yamamoto (1995) process.

In the asymmetric causality test, the cumulative sums of the positive and negative shocks in the series are obtained, so that the relationships between different combinations can be tested. The cumulative shocks in BDI and ISTFIX can be expressed mathematically as equations (1) and (2):

$$BDI_t^+ = \sum_{i=1}^{+} \varepsilon_{1i}^+ , BDI_t^- = \sum_{i=1}^{-} \varepsilon_{1i}^- \quad (1)$$

$$ISTFIX_t^+ = \sum_{i=1}^{+} \varepsilon_{2i}^+ , ISTFIX_t^- = \sum_{i=1}^{-} \varepsilon_{2i}^- \quad (2)$$

In the next process, the null hypothesis of non-causality is tested by using Wald statistics in the analyzes applied using the cumulative sums of shocks (see Hatemi-J (2012) for detailed information).

The maximum degree of integration can be determined by unit root or stationarity tests. If a unit root is detected in one or both series, the maximum integration degree is determined as 1 and analyzes are performed considering this value. To determine this, it is preferred to apply augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (Kwiatkowski et al., 1992) tests.

The ADF test is a unit root test, and the null hypothesis indicates that the series contains a unit root. The ADF test, which is simply an improved version of the DF test, can be shown as follows (equation 3):

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 y_{t-1} + \beta_2 y_{t-2} + .. + \beta_p y_{t-p} + \upsilon_t \quad (3)$$

Then, using the t statistic presented in equation (4), it is tested whether there is a unit root in the series:

$$t_\alpha = \hat{\alpha}/\big(se(\hat{\alpha})\big) \quad (4)$$

According to the final result obtained by calculating t stat, the null of unit root hypothesis is tested (see Dickey & Fuller (1979) for detailed information). The KPSS test, on the other hand, is the stationarity test and the null hypothesis shows that the series are stationary. The calculation process can be expressed simply as equation (5):

$$y_t = x_t'\delta + \upsilon_t \quad (5)$$

Then, unlike the ADF test, the test statistic is calculated using the LM test in order to determine whether the series is stationary or not (equation 6):

$$LM = \sum_t S(t)^2/(T^2 f_0) \quad (6)$$

According to the obtained LM statistics, the null hypothesis that the series are stationary is tested (see Kwiatkowski et al. (1992) for detailed information). Considering these two tests as supportive and complementary tests, they have included in the analysis.

In the method used, bootstrap simulation technique is used to calculate the critical values, and this eliminates the necessity of having a normal distribution of the data used in the analysis. Considering that the structure of most financial series is subject to many unexpected events and shocks, this provides a great advantage (Hatemi-J, 2012). GAUSS statistical software and codes are used for the analysis.

RESULTS AND DISCUSSION

For the asymmetric causality test to be applied, the series do not have to be stationary. The maximum integration degrees need to be known. Accordingly, ADF and KPSS tests were applied to the series and presented the results in Table 2. The null hypothesis of the ADF test states that the series contains a unit root. The null hypothesis of the KPSS test states that the series is stationary. According to the results obtained, the ADF test shows that both variables do not contain unit roots at the level at 90% confidence level, while the KPSS test shows that both variables are not stationary at the level. When the results of the ADF test were considered at the 95% confidence level, the null hypothesis can only be rejected for the BDI variable. According to these results, based on the results of the KPSS series, it was decided that the series are not stationary, and their integration degree is 1. The analyzes were conducted in the next process accordingly.

GAUSS codes were used while performing the asymmetric causality test. The maximum number of lags was set as 12. Akaike information criterion (AIC) was chosen as the information criterion used to determine the most appropriate lag. It was also applied 1000 bootstrap simulations to calculate critical values. The maximum integration degree was determined as 1 as a result of the stationarity test. The test results applied as a result of all these values are presented in Table 3. According to the test results presented for 4 combinations, the null hypothesis of non-causality was rejected for only 1 result. According to this result, negative shocks in BDI are the cause of negative shocks in ISTFIX. Negative news in the BDI is also reflected in the ISTFIX index. However, no causal relationship was found between positive shocks.

Table 2. Results of unit root and stationarity test

Test	Variable	Level		First Difference	
		Intercept	*Trend and Intercept*	*Intercept*	*Trend and Intercept*
ADF	BDI	-2.9662**	-3.5904**	-14.505***	-14.511***
		(0.048)	(0.0315)	(0.000)	(0.000)
	ISTFIX	-2.6545*	-2.6107	-8.0441***	-8.0817***
		(0.082)	(0.275)	(0.000)	(0.000)
KPSS	BDI	1.7545	0.2427	0.0894*	0.0198*
	ISTFIX	0.9412	0.2189	0.1458*	0.0302*

Note: ADF critical values: -2.57 for *10%, -2.87 for **5%, -3.44 for ***1% at Intercept; -3.13 for *10%, -3.42 for **5%, -3.98 for ***1% at Trend and Intercept. KPSS critical values: 0.34 for *10%, 0.46 for **5%, 0.74 for ***1% at Intercept; 0.11 for *10%, 0.14 for **5%, 0.21 for ***1% at Trend and Intercept. P-values for ADF were included in parentheses.

Table 3. Results of asymmetric causality test

Parameters		B+I+	B+I-	B-I-	B-I+
Optimal Lag; VAR(p)		4	4	9	4
Additional Lags		1	1	1	1
Test Stat (MWALD)		6.33	2.70	78.0	6.44
Asym. chi-sq. p-value		0.17	0.60	0.00*	0.16
Critical Val.	1%	13.8	14.5	23.5	15.5
	5%	10.0	10.2	18.4	11.0
	10%	8.13	8.18	15.4	8.57

Note: *B* indicates the BDI; *I* indicates the ISTFIX; * indicates the null of noncausality hypothesis is rejected.

GAUSS codes were used while performing the asymmetric causality test. The maximum number of lags was set as 12. Akaike information criterion (AIC) was chosen as the information criterion used to determine the most appropriate lag. It was also applied 1000 bootstrap simulations to calculate critical values. The maximum integration degree was determined as 1 as a result of the stationarity test. The test results applied as a result of all these values are presented in Table 3. According to the test results presented for 4 combinations, the null hypothesis of non-causality was rejected for only 1 result. According to this result, negative shocks in BDI are the cause of negative shocks in ISTFIX. Negative news in the BDI is also reflected in the ISTFIX index. However, no causal relationship was found between positive shocks.

CONCLUSION

Maritime transport is a sector that requires huge investments, since the capital costs of ships are very high in parallel with their sizes. Naturally, the expectations of investors are to obtain high returns. When the historical course of the freight markets is followed, it is seen that these earnings expectations are met in some periods. However, it is seen that there are ship owners who do business at a loss during the periods of very long stagnation. For this reason, possible variables and predictive indicators that affect freight prices are of vital importance for ship owners. It is the dream of every ship owner to minimize the risk of loss and increase the probability of gain by taking a position in the market according to signals given by these variables and indicators. Additionally, since freights constitute important transportation costs for

cargo owners, leading indicators are needed to predict the present and future costs, and to take a commercial position accordingly. In this direction, it has been examined the possible effect of BDI, one of the global indicators for both ship owners and cargo owners, on freight rates in the ISTFIX region by causality analysis during this study. Thus, it is aimed to determine which changes in the BDI might cause and what kind of changes occur in the future ISTFIX index values. As can be seen from the descriptive statistics, the series have non-normal distribution characteristics. This shows that the variability of the series is very high and they are exposed to a lot of unexpected circumstances, especially, the volatility of the BDI variable is very high. It was decided that asymmetric causality analysis would be appropriate in order to determine the relationships between variables that are far from such a normal distribution characteristic and the analyzes are applied in this regard. According to the results of this study, the negative shocks in the BDI are the cause of the negative shocks in the ISTFIX index. Considering the basic logic of causality analysis, it is examined whether the present and past values of a single one variable explain the present and future values of other variable in a meaningful way. In this direction, the causality between negative shocks can be understood that negative shocks in the BDI variable will cause negative shocks in the ISTFIX variable in future. In this respect, both ship owners and cargo owners engaged in commercial activities in the ISTFIX region can be prepared for future changes by determining their own positions according to present negative developments in BDI. The relationship between negative shocks may be due to differences in cargo types. While cargoes transported in BDI, mostly, consist of cargoes such as iron ore, coal and wheat; processed products such as steel are also transported in ISTFIX. Therefore, decreases in raw material demand may indicate that there will be decreases in future economic activities. This may cause a decrease in ISTFIX freight levels. Another reason may be the effect from oil prices. The decrease in costs may be reflected as a decrease in freight, and this may occur primarily on large ships in the BDI region. Of course, in order to speak more clearly, it is necessary to analyze empirically by including oil prices in the model.

In future studies, the relationship between the variables can be examined with different methods. Since the cargoes of the ships used in the BDI index and the ships used in the ISTFIX index are different, the demand structures for these cargoes are also different. For this reason, developments that affect one index may not affect the other index or may affect it less. Methods that can include the characteristics of the cargoes in the analysis can provide more comprehensive results. In addition, while the relationship between the index is significant in some periods of time, it may not exist in some periods. This situation can be analyzed by methods such as the time-varying approach. Furthermore, it can be discussed which factors developed in periods of causality and what the possible effects of these factors might be. Thus, inferences can be made about how the freights will react against similar circumstances that are likely to develop in future.

Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

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

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First Observations on the Stomach Contents of Devil Firefish, *Pterois miles* (Bennett, 1828) in the Gulf of Antalya, Turkey

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ABSTRACT

The present study examined stomach contents of 35 individuals of *Pterois miles* (Bennett, 1828) captured using scuba diving gears in Antalya Gulf. Total length and total weight in the specimens of *P. miles* collected from the Gulf of Antalya were 13.1-35.2 cm (mean±SD; 19.98±4.40) and 36.88-456.6 g (mean±SD; 103.82±91.29), respectively. The dominant prey were fish (IFO=106.67%, IP=59.38%) and the rest were crustaceans (IFO=53.33%, IP=40.63%). It was determined that *P. miles* was carnivorous and predominantly piscivorous. This study is the first to show how kind of consumption preys *P. miles* obtained from the Gulf of Antalya. The result of this study strengthens the existing knowledge on the consumption preys of devil firefish in the eastern Mediterranean. The distribution of this species continues in the Turkish Seas. The fishery and consumption of lionfish should be improved. The development of a lionfish fishery could provide a management tool to ameliorate impacts to coastal ecosystems of the Mediterranean Sea.

INTRODUCTION

Following the opening of the Suez Canal, the Mediterranean has been heavily exposed to Indo-Pacific species for a long time (Zenetos et al., 2012; Katsanevakis et al., 2014; Ayas et al., 2018). The ever-increasing sea water temperature in the Mediterranean with the effect of climate change causes the transition of tropical species to the Mediterranean, the formation of populations and the expansion of their distribution (Lejeusne et al., 2010; Kletou & Hall-Spencer, 2012; Ayas et al., 2018). One of the last species of this tropical process is the devil firefish, which has recently crossed into the Mediterranean. In the Mediterranean, one *Pterois miles* (Bennett, 1828) was recorded off the coast of Israel in 1991 (Golani & Sonin, 1992), *P. miles* was notified from Lebanon, Cyprus, Turkey, Greece and Tunisia (Bariche et al., 2013; Turan et al., 2014; Crocetta et al., 2015; Iglésias & Frotté, 2015; Oray et al., 2015; Turan and Öztürk, 2015; Dailianis et al., 2016; Jimenez

et al., 2016; Kletou et al., 2016; Mytilineou et al., 2016; Özgür Özbek et al., 2017; Al Mabruk & Rizgalla, 2019). Biological invasions threaten marine environments as they can harm native species at all trophic levels (Savva et al., 2020). The invasion and settlement of alien species is a major threat to marine biodiversity, structure and function, with economic and human health implications (Otero et al., 2013; Turan et al., 2017). The introduction of *P. miles* into the Mediterranean has posed a potential threat to the native species (Ayas et al., 2018). The successful range expansion and reproduction of lionfish being attributed to a broad set of biological traits, including their wide ecophysiological tolerance, high fecundity and rapid growth, predator defences and general feeding habits (Savva et al., 2020). Lionfish continue to spread to areas close to their thermal boundaries, although population density is declining where they first invaded (Savva et al., 2020).

The high feeding rates of lionfish pose a serious threat to its benthic ecosystems (Kulbicki et al., 2012; Turan et al., 2017). Lionfishes are predator species (Ayas et al., 2018). They are generalist carnivores and can feed on a wide variety of fish and crustaceans, although large individuals prefer almost exclusively fish (Côté et al., 2013; Kletou et al., 2016; Zannaki et al., 2019; Savva et al., 2020).

The aim of our study is to define stomach content of *P. miles* obtained from the Gulf of Antalya and its potential impact on the ecosystem.

MATERIAL AND METHOD

A total of 35 *P. miles* were collected with the use of scuba diving gears at depths of 8-22 m in the Gulf of Antalya (between 36°52'54.49"N and 30°41'37.67"E) on October 16, 2018 and May 15, 2019 in the daytime.

The lionfish was observed at depths ranging from 3 to 43 m and the majority were found on vertical rock walls or at the entrance of small caves. The specimens were immediately transferred to the laboratory. The total length (TL) measured with measuring board (cm) and the total weight weighed by the digital balance to the nearest 0.1 g. Fish were dissected to determine the sexes. The sex determination was made by examining the ovaries with the naked eye and under a light microscope. The ovaries and testes were removed, weighed to the nearest 0.1 g.

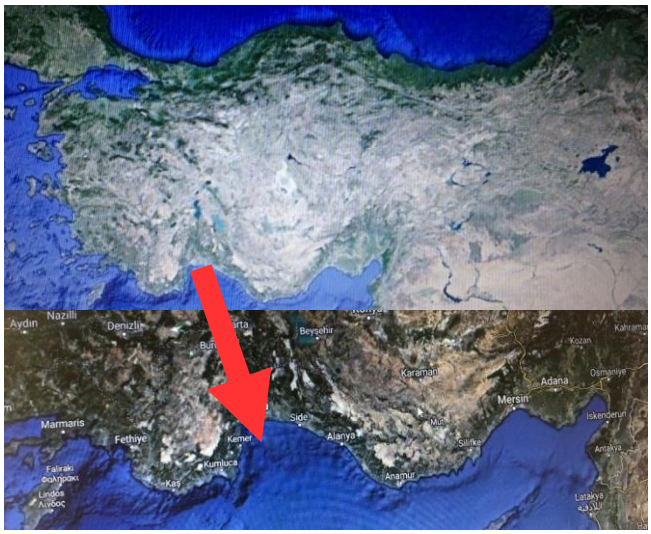

Figure 1. The Gulf of Antalya, Turkey (photos taken from Google Earth, 2021)

Figure 2. *Pterois miles* from the Gulf of Antalya

The food items in each stomach were identified to the lowest-possible taxa using light microscopy. When identification was not possible because of advanced digestion, the prey items were classified as "unidentified". The number of empty stomachs was also recorded. The pebble stones were considered as "accidental items". Weight and length measurements of undigested species were taken. The otoliths extracted from the stomach contents were examined under a light microscope and the genus and species determinations were made (Lombarte et al., 2006). The prey items divided into main taxon categories to facilitate dietary comparisons and eliminate biases associated with comparisons based on variable levels of identification (Savva et al., 2020).

To analyse the data obtained from the stomach content analysis, the methods described by Hyslop

(1980) and Kelleher et al. (2000) were used, and the following indices (Eq. (1) and Eq. (2)) were calculated:

$$IFO = \frac{n}{N_s} \times 100 \quad (1)$$

$$IP = \frac{n'}{N_p} \times 100 \quad (2)$$

Where I_{FO} is the frequency of occurrence, *IP* is the percentage of prey, *n* is the number of stomachs containing a certain prey, *Ns* is the total number of stomachs examined, *n'* is the total number of individuals of a certain prey and *Np* is the total number of prey individuals. According to IP values, prey categories were distinguished as preferential (I_P>50%) and secondary (10%<I_P<50%) (Savva et al., 2020; Zannaki et al., 2019)

RESULTS

In this study, the specimens of *P. miles* displayed the total lengths of 13.1 to 35.2 cm (19.98±4.40) and the total weights of 36.88 to 456.6 g (103.82±91.29) in the material collected from the Gulf of Antalya.

The gender of one sampled individual was determined as male. The gender of the others was found as female.

The majority of *P. miles* (20 samples) ranged from 15.0 to 20.0 cm. 9 individuals were found in the length class of 20.0 to 25.0 cm. The eight preys were detected in the stomach of 9 individuals. The length of 8 prey varied between 0.3-1 cm. The prey size could not be determined in other length groups.

It was determined that 24 (I_{FO}=68.57%) of the stomachs of 35 individuals was full and 11 (I_{FO}=31.43%) was empty. There were digested foods (I_{FO}=34.29%) in the stomach of twelve individuals (Table 1).

The stomach content analysis yielded 34 stomach items, of which 32 were considered as prey items belonging to 12 prey categories. The dominant prey item was bone fishes (I_{FO}=106.67%, I_P=59.38%) and secondly was crustaceans (I_{FO}=53.33%, I_P=40.63%). Among fishes, unidentified species was the dominant category in terms of frequency and abundance. It was found that 9 otoliths in the stomach contents of *P. miles* belonged to *Oblada melanura* (I_P 9.38, I_{FO} 13.33), *Gobius geniporus* (I_P 6.25, I_{FO} 6.67), *Serranus scriba* (I_P 3.13, I_{FO} 6.67), *Siganus rivulatus* (I_P 3.13, I_{FO} 6.67), *Chromis chromis* (I_P 3.13, I_{FO} 6.67) and *Scorpaena porcus* (I_P 3.13, I_{FO} 6.67). It was not determined to which species the 2 otoliths belonged. The 10 crustaceas in the stomach contents of *P. miles* was found as *Hemigrapsus* sp. (I_P 18.75, I_{FO} 13.33), *Pachygrapsus* sp. (I_P 9.38, I_{FO} 13.33) and *Scyllarus pygmaeus* (0.19 g) (I_P 3.13, I_{FO} 6.67) (Table 1).

DISCUSSION

In our study, the total lengths and the total weights of *P. miles* specimens were found to be between 13.1-35.2 cm and 36.88-456.6 g, respectively. The gender of one sampled individual was determined as male. The gender of the others was found as female. The reason for this difference in the sex distribution may be related to the number of samples, the sampling location and depth. It was determined that 24 (I_{FO}=68.57%) of the stomachs of 35 individuals was full and 11 (I_{FO}=31.43%) was empty. The reason for this may be related to the size of the specimens, the feeding of the specimens and nutrient availability at the sampling area.

In our study, the predominant prey was fish (I_{FO}=106.67%, I_P=59.38%) and the rest were crustaceans (I_{FO}=53.33%, I_P=40.63%). We determined that *P. miles* was carnivorous and predominantly piscivorous. Similarly, these results had been reported from the eastern side of Cyprus and Rhodes Island (Zannaki et al., 2019; Savva et al., 2020).

The distribution of this species continues in Turkish Seas (Özgür Özbek at al., 2017; Bilge et al., 2017; Turan, 2020; Özgül, 2020). This species, which is an invasive species, can adversely affects natural species after it settles in its environment (Bariche et al., 2013; Otero et al., 2013; Turan et al., 2017; Ayas et al., 2018; Savva et al., 2020; Taşkavak et al., 2021). The rapid response was the first line of defense to mitigate the effects of lionfish invasion (Morris et al., 2009; Kletou at al., 2016). The removal of lionfish by divers was reported to reduce its abundance at shallow depths (Morris et al., 2009; Kletou at al., 2016). In order to reduce the lionfish population and stocks in Turkey, a study can be conducted to catch these species with underwater rifles by divers. Additionally, although awareness-raising activities have been carried out for fishermen, divers, the public and inspectors in Turkey (H, 2019; AT, 2019;

AA, 2020), it is not enough for the awareness of this species, its consumption (meat high in protein) and suppression of its population and stocks (Ayas et al., 2018; TRTnews, 2019). For this reason, awareness raising activities should continue to be given weight so that the public can recognize, catch and consume lionfish in Turkey. In order for the public to consume lion fish more safely, products that have been cleaned of poisonous spines by experts should be sold (H, 2020).

On the other hand, the blue-spotted cornetfish *Fistularia commersonii* and the groupers (*Epinephelus striatus, Myceteroperca tigris, Ephinephelus marginatus and Ephinephelus costae*) were reported to be natural predators of this species (Bernadsky & Goulet, 1991; Mumby et al., 2011; Bariche et al., 2013; Turan et al., 2017). Additionally, predation by large carnivores such as groupers and sharks was also stated to represent one of the best controls for invasive devil firefish (Bernadsky & Goulet, 1991; Muñoz et al., 2011). Additional research is needed to understand predatory interactions between lionfish and native predators. This study is the first to show how kind of consumption preys *P. miles* obtained from the Gulf of Antalya.

By ensuring the continuity of legal regulations for the protection of the population and stocks of groupers and sharks in Turkey (CN 5/1, 2020, CN 5/2, 2020), it should be determined its population, stocks, feeding, effects on local species and fisheries of this species and whether is the predator of the lionfish in Turkey seas, which was reported to be consumed by sharks, the grouper and *F. commersonii.*

Table 1. Prey categories found in the stomachs of the individuals of *Pterois miles*

Stomach contents	n	n'	I_P	I_{FO}
Pisces				
Unidentified Pisces	7	8	25	46.67
Otolith				
Unidentified Otolith	2	2	6.25	13.33
Oblada melanura	2	3	9.38	13.33
Gobius geniporus	1	2	6.25	6.67
Serranus scriba	1	1	3.13	6.67
Siganus rivulatus	1	1	3.13	6.67
Chromis chromis	1	1	3.13	6.67
Scorpaena porcus	1	1	3.13	6.67
Total pisces	16	19	59.38	106.67
Crustacea				
Unidentified Crustacea	3	3	9.38	20
Crab				
Hemigrapsus sp.	2	6	18.75	13.33
Pachygrapsus sp.	2	3	9.38	13.33
Lobster				
Scyllarus pygmaeus	1	1	3.13	6.67
Total crustacean	8	13	40.63	53.33
Accidental				
Pebble stones	2	2		13.33
The digested food	12			34.29
The full stomach	24			68.57
The empty stomach	11			31.43

Note: *n*, number of stomachs containing a certain prey; *n'*, the total number of individuals of a specific prey; I_P, percentage of prey index; I_{FO}, frequency of occurrence index.

CONCLUSION

The current information on the diet of *P. miles* is that they are carnivorous and can feed on a wide variety of fish and crustaceans. The result of this study strengthens the existing knowledge on the consumption preys of devil firefish in the eastern Mediterranean. The distribution of this species continues in the Turkish Seas. The increased densities observed over time, coupled with its generalist diet and consumption of ecologically and socio-economically important fish, could result in the competition of native predators of the same trophic level and further degradation of local marine communities in an already anthropogenically stressful marine environment. The fishery and consumption of lionfish should be improved. The fishing gears should be developed to catch lionfishes concentrated in rocky-stony area. The development of a lionfish fishery could provide a management tool to ameliorate impacts to coastal ecosystems of the Mediterranean Sea. The information and promotion activities should be continued in order to increase and popularize the consumption of lionfish by the public.

Compliance With Ethical Standards

Authors' Contributions

MG designed the study and collected samples by diving.

RT carried out the transport of samples to the laboratory and laboratory work, statistical analysis and data management.

JK provided the laboratory facilities.

The species identification from otolith was executed by MG and RT. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

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

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Age and Growth Parameters of African Catfish (*Clarias gariepinus* Burchell, 1822) From Asi River, Turkey

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ABSTRACT

This study aimed to determine the age and growth parameters of the African catfish *Clarias gariepinus* (Burchell, 1822) from the Asi River. A total of 185 fish samples have been collected from the Asi River, located in the Eastern Mediterranean region of Turkey, from December 2018 to March 2019. Samplings were carried out with fyke-nets. Lengths and weights of samples ranged from 20.47 to 62.46 cm and 74.4 to 1874.2 g, respectively. The sex ratio (1:1.06) was biased toward males (p>0.05). In terms of length-weight relationship, b-values were calculated as 2.98, 2.83, and 2.94 for female, male, and whole samples, respectively. Isometric growth was determined. The Fulton condition factor (CF) value for all samples was calculated as 0.7591±0.009. The ages of fish samples ranged from I to IV, and the dominant age and total length (TL) groups of the population were the I and II age groups. The von Bertalanffy growth parameters were estimated as L_∞=58.5 cm, K=0.41 year^{-1}, $t_0 = -0.7$, Φ′=3.15 for females; L_∞=68.3 cm, K=0.35 year^{-1}, $t_0 = -0.6$, Φ′=3.21 for males and L_∞=58.2 cm, K=0.39 year^{-1}, $t_0 = -0.4$, Φ′=3.12 for whole collected samples. As a result, climate change and its effects, especially the construction of dams in certain parts of the river for agricultural irrigation purposes and the resulting lack of management negatively affect the natural living stocks of the Asi River. Therefore, it can be said that the *C. gariepinus* stocks in these areas are overexploited. Legal arrangements should be made in this region to correct these conditions.

INTRODUCTION

Freshwater fishing provides the main food source and it is an important part of the ecosystem approach. However, research and legal regulations in wetlands are limited as compared to general fishery worldwide (Zhang et al., 2020). The Asi River enriches the protein source alternatives of the people of the region, and

Clarias gariepinus has an important place as a food source. The aquatic biodiversity of the river is at serious risk, since, its geographical location was severely impacted by the global climate change (Smith et al., 2014).

C. gariepinus (Burchell, 1822) is a tropical and subtropical catfish species. *C. gariepinus* lives in various water resources such as lakes, ponds and streams both in deep and shallow waters (Turan & Turan, 2016). In present, *C. gariepinus* has been reported in four continents namely Africa, Asia, Europe and South America, and in sixty-nine countries. However, this species spreads in sixty-three countries (Froese & Pauly, 2019). This species has been evaluated as "Least Concern (LC)" according to the IUCN Red List of Threatened Species since 2019 (Konings et al., 2019). At Turkey, it is widely distributed in the southern and the central Anatolian freshwaters i.e., Ceyhan, Seyhan, Göksu, Aksu, Sakarya, and Asi rivers, where it has commercial importance (Yalçın et al., 2002; Turan et al., 2005; Genç et al., 2006). TurkStat (2018) reported that *C. gariepinus* had its annual catching capacity of 2 tonnes in the Asi River and 206 tonnes in the Turkish freshwaters in 2018. Also, this species has been reported to be reared in several areas in the world (Turan et al., 2022).

The Asi River, which flows into the Eastern Mediterranean Sea after passing through Syria from the Samandağ district of Hatay, after crossing Syria, originating from the Bekaa valley of Lebanon, is an essential resource for agricultural irrigation and fishing (Demirci et al., 2020). *Clarias gariepinus*, *Anguilla anguilla* Linnaeus, 1758 and several Cyprinid species (*Cyprinus carpio* Linnaeus, 1758, *Capoeta capoeta* Güldenstädt, 1773, *Capoeta trutta* Heckel, 1843, *Capoeta damascina* Valenciennes, 1842, *Capoeta barroisi* Lortet, 1894, *Capoeta angorae* Hankó, 1925, *Barbus lorteti* Sauvage, 1882, *Garra rufa* Heckel, 1843) have been reported in previous studies in the Asi River (Demirci & Yalçın, 2010, 2015; Özcan & Altun, 2015; Demirci et al., 2016a; Alagöz & Turan, 2017; Bayçelebi, 2020; Alagöz, 2021a; Alagöz, 2021b; Demirci & Yalçın, 2021). Fishing in this river is done with set nets, fyke nets and various types of handlines (Demirci & Demirci, 2009, Şimşek et al., 2021; 2022).

The perception of fisheries has changed every day in accordance with the "sustainable ecosystem" (Şimşek & Demirci, 2018). Studies on fisheries biology and population dynamics are crucial issues for fisheries management (Can & Demirci, 2012; Demirci et al., 2018). Therefore, growth parameters have been an essential indicator to evaluate fishing pressure on fish stocks (Demirci et al., 2016b; Turan et al., 2021). Age and growth factors of *C. gariepinus* from different regions have been reported previously (Idumah Okogwu, 2011; Bokhutlo et al., 2015; Mehanna et al., 2018; Behmene et al., 2021; Nsapu, 2021). In addition, the latest information about the growth parameters of this species was reported in the region approximately 20 years ago (Yalçın et al., 2002). Therefore, there is an urgent need for the current information about this species' age and growth parameters in the region. Therefore, this study aims to estimate the growth parameters of this species in terms of length, weight and age factors for the Asi River Basin fishery.

MATERIAL AND METHOD

The Asi River originates on the threshold of Baalbek in Bekaa, Lebanon, heading north and entering Syria (Figure 1). After merging with the streams Burc and Karasu, the river passes through Antakya and reaches the Mediterranean Sea in the south of Samandağ, Turkey (Demirci & Demirci, 2009; Kılıç & Can, 2017). The total length of the Asi River is approximately 400 km, and approximately 94 km of Asi River flows through the Turkish territory (Yalçın Özdilek et al., 2006; Kılıç & Yücel, 2019). The river is located in the Mediterranean climate zone which practices hot and arid summers (Kılıç, 2018). Annual precipitation of the Asi River Basin is recorded as 816 mm, mean temperature is noted as 16.8°C and annual total flow of the river is reported as 1.17 km^3/year (Kılıç et al., 2018).

Samples were collected between December 2018 and March 2019 using fyke-nets (mesh size 12-18 mm, Polyamide (PA) material). Although this fish species is distributed along the Asi River, only Güzelburç has been determined as a location. Because, the Güzelburç region has a higher catching capacity since having less river current (Demirci & Demirci, 2009).

The sampled fish were placed in boxes and then immediately brought to the laboratory. Total lengths (TL) to the nearest 1.0 mm and wet weights (W) to the nearest 0.01 g were measured (Lin et al., 2011). The specimens were dissected, and sexes were determined aiming to test for differences in sex ratio, a chi-square test for goodness of fit was also used. Vertebrae were used for age determination and readings were carried out twice by the first reader and independently by a second reader.

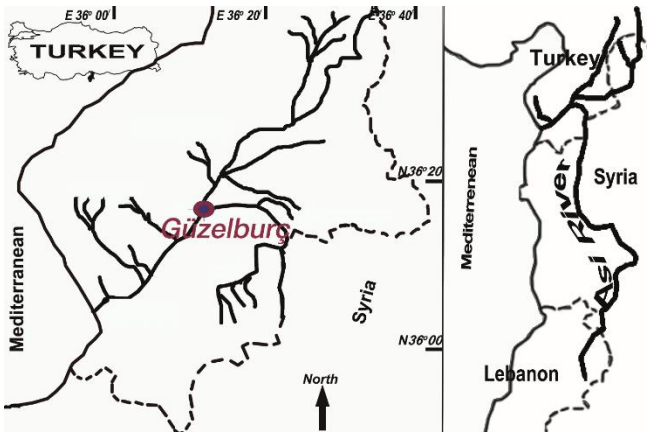

Figure 1. Study area in the Asi River basin (*Left side:* Asi River tributaries in the territory of Turkey, Sampling location is indicated, *Right side*: Total area of Asi River, also covering the international territories)

Relationships between the length and weight of *C. gariepinus* were calculated for female, male, and all individuals with Eq. (1) according to Ricker (1975).

$$W = aL^b \quad (1)$$

The parameters of the Eq. (1) were estimated on the log-transformed data (Eq. (2)):

$$\log W = \log a + b \log L \quad (2)$$

where W is the weight, L is the total length, and a and b are constants.

Condition factor is used with the aim of correlating the health or fatness of the fish (Froese, 2006). Fulton's coefficient of condition factor (CF) was calculated by Eq. (3).

$$CF = \frac{W}{L^3} \times 100 \quad (3)$$

where; L is the total length (cm) and W is the weight (g) (Bagenal & Tesch, 1978).

Growth curves were fitted using the least-squares method for all subjects using the von Bertalanffy growth equation (Eq. (4)) (Von Bertalanffy, 1938).

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right) \quad (4)$$

where L_t is the total length at age t, L_∞ is asymptotic length, K is the body growth coefficient and t_0 is the theoretical age at zero length (Beverton & Holt, 1959). The solver routines in Microsoft Excel Program 2016 were used to define length growth curves.

The growth performance index, phi prime (Φ') was calculated by Eq. (5) (Pauly & Munro, 1984).

$$\Phi' = \log(K) + 2\log(L_\infty) \quad (5)$$

where K and L_∞ are Von Bertalanffy Growth model parameters.

RESULTS

A total of 185 individuals of *C. gariepinus* were sampled from the Turkish part of the Asi River. 87 individuals were female and 92 were male. The remaining 6 samples could not be able to distinguish by gender. The sex ratio (F:M=1:1.06) was biased toward males and there was no statistically significant difference between the sexes ($p>0.05$) as shown in Table 1.

Table 1. Sex distribution of *C. gariepinus* from Asi River sampling (December 2018-March 2019)

Sex	N	Ratio (%)	Mean TW (g)	Mean TL (cm)
Female	87	47.03	109.7	57.7
Male	92	49.73	105.7	59.3
Undetermined	6	3.24	124.9	73.4
Total	**185**	**100**	**108.1**	**58.5**

Table 2. The age-total length key for the *C. gariepinus* caught from Asi River (December 2018 to March 2019)

Total Length (cm)	Age Groups (Year)				Total
	I	II	III	IV	
20.0-24.9	16	12			28
25.0-29.9	25	35	1		61
30.0-34.9	17	31	6	1	55
35.0-39.9		24	3		27
40.0-44.9		1	6	1	8
45.0-49.9		3	1		4
50.0-54.9			1		1
55.0-59.9					
60.0-64.9				1	1
Total	58	106	18	3	185
$TL_{min-max}$	20.47-33.53	22.29-49.96	25.30-51.42	34.14-62.46	20.47-62.46
TL_{mean}± SD (cm)	27.49±0.43	31.31±0.54	37.58±1.59	46.81±8.31	30.98±0.46
$TW_{min-max}$	73.50-416.20	78.50-866.81	114.40-1082.80	252.60-1874.20	73.50-1874.20
TW $_{mean}$± SD (g)	166.42±8.49	252.81±15.26	475.24±69.14	918.40±69.14	256.54±15.69

Note: *TL*: total length, *TW*: total weight, *SD*: standard deviation

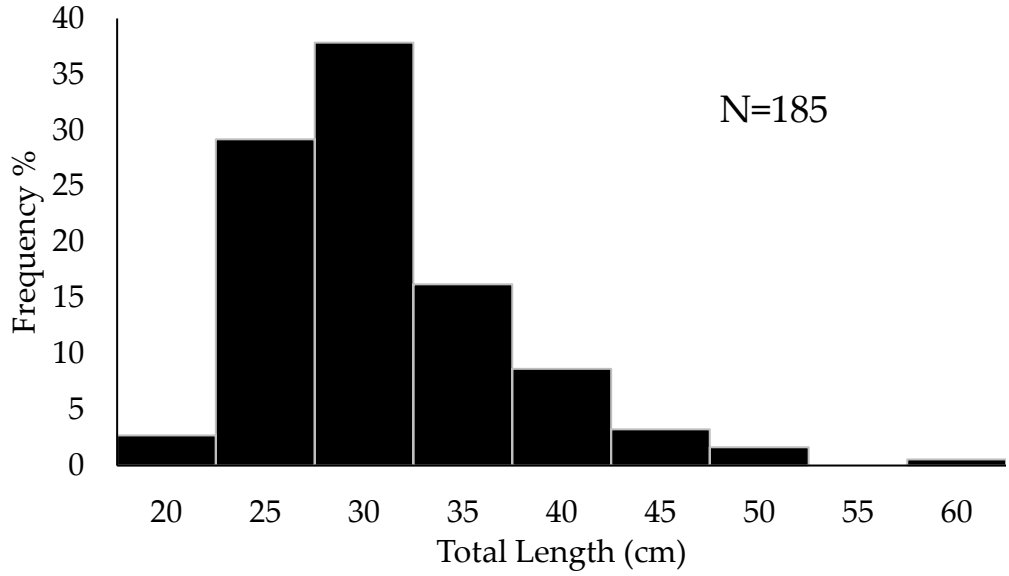

Figure 2. The length-frequency distribution of *C. gariepinus* from Asi River

The fish size ranged from 20.47 to 62.46 cm (TL) and weighed between 73.5 and 1874.2 g. (Figure 2). Standard deviation values of mean TL and mean TW of samples caught from the Asi River were calculated as 30.98±0.46 cm and 256.54±15.69 g, and the ages ranged from I to IV. The dominant age and TL groups of the population were found in the I and II age groups (Table 2).

The length-weight relationship (LWR) regression was calculated for female, male and all sampled individuals of *C. gariepinus*, and it was shown in Figure 3. The length-weight relationships of *C. gariepinus* for female, male and all individuals were recorded as $W=0.0079\times TL^{2.98}$, $W=0.013\times TL^{2.83}$, and $W=0.0092\times TL^{2.94}$, respectively. The exponents of the length-weight relationship, *b*, showed an isometric growth.

Fulton condition factor (CF) value ranged from 0.5583 to 1.3490 for females, 0.3742-1.6043 for males and 0.374-1.604 for all individuals and the mean value with standard deviations was calculated as 0.765±0.011, 0.751±0.015 and 0.7591±0.009 for female, male, and all sampled individuals, respectively.

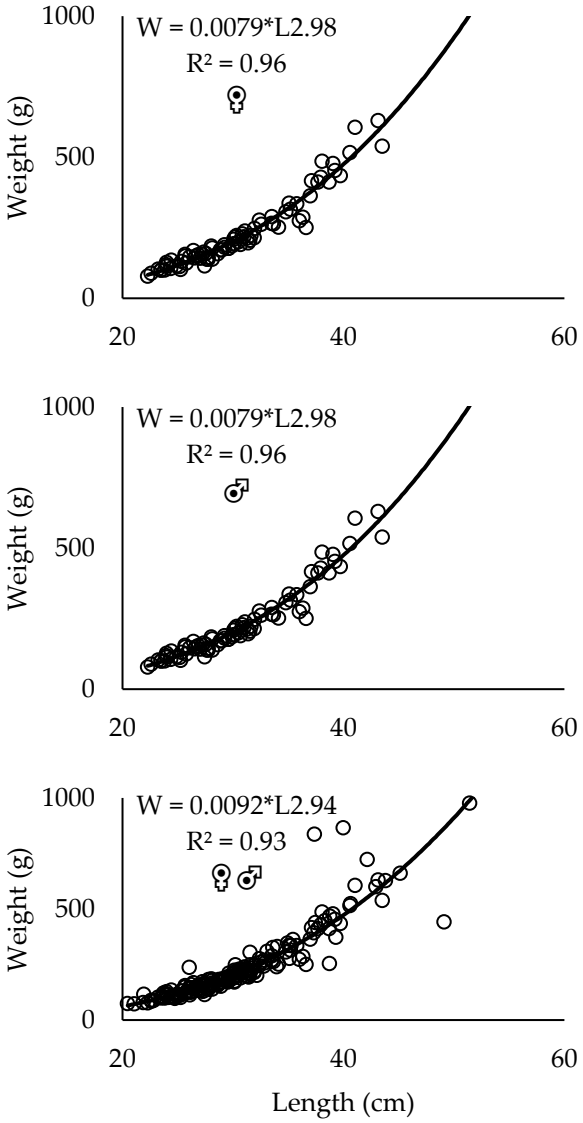

Figure 3. The length-weight relationship of *C. gariepinus* collected from Asi River (December 2018 to March 2019).

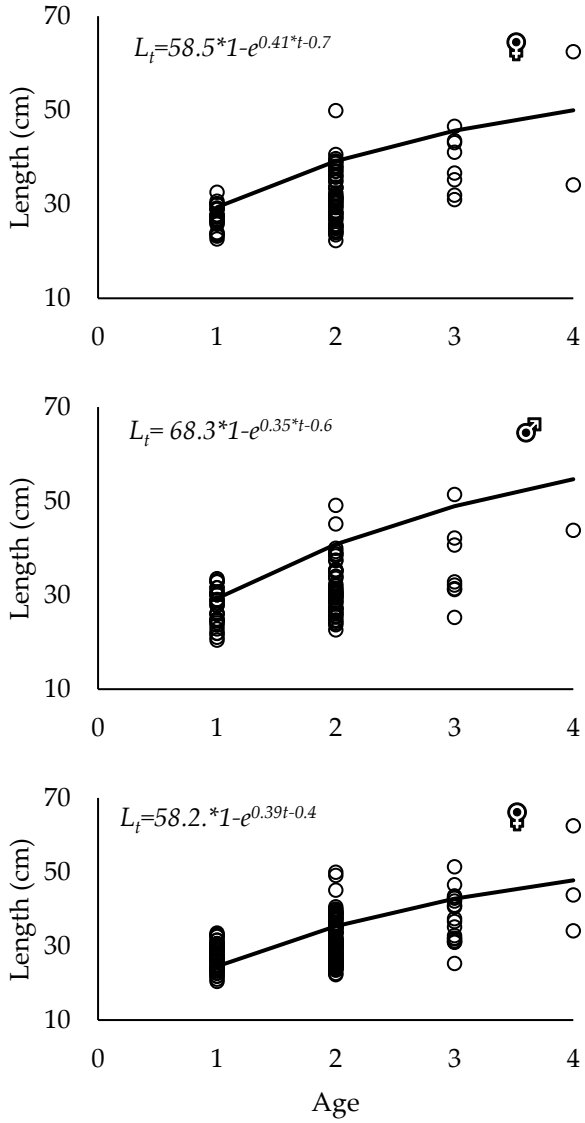

Figure 4. Length at age, with von Bertalanffy curve, of *C. gariepinus* collected from Asi River (December 2018 to March 2019).

The von Bertalanffy growth model has been used for estimating the age, length and growth parameters which were recorded as L_∞ =58.5 cm, K=0.4 year^{-1}, $t_0 = -0.7$ for females, L_∞ =68.3 cm, K=0.35 year^{-1}, $t_0 = -0.6$ for males and L_∞ =58.2 cm, K=0.39 year^{-1}, $t_0 = -0.4$ for whole sampled individuals (Figure 4). Moreover, the growth performance index (phi prime value, Φ′) for female, male and whole sampled individuals have been calculated as 3.15, 3.21, and 3.12, respectively.

DISCUSSION

Asi River is an important resource in terms of fisheries dynamics due to its species diversity. However, the Asi River also flows through intensely urbanized areas and agricultural lands which increases the contamination by agricultural and domestic sources (Genç et al., 2008). At the same time, the construction of dams on the Asi River for agricultural irrigation reduces the water flow in summers, even though the cut of some tributaries. All these activities negatively affect the survival of aquatic animals living in the Asi River. In addition to water scarcity, overfishing also creates important problems for fish stocks (Demirci & Demirci, 2009). Furthermore, the spawning season of *C. gariepinus* found in the Asi River was reported from May to August when the temperature of water ranged between 21°C and 30°C (Yalçın et al., 2001). The present study delivered up-to-date data on the age and growth parameters of *C.*

gariepinus from the Turkish part of the Asi River. Unfortunately, there were no biological data reported in the region since 2003.

Different values of sex ratio can be encountered with the effect of some environmental factors (Bohlen et al., 2008). This variation could be based on several reasons, such as the number of samples, location, season, feeding and maturation phases, different growth rates, mortality, etc. (Innal et al., 2015). This ratio (Female: Male) was reported in previous studies as 1:1.04 (Yalçın et al., 2002); 1:0.47 (Narin, 2003) in the same region and 1:0.77 (Mehanna et al., 2018); 1:0.68 (Behmene et al., 2021); 1:1.24 (Wartenberg et al., 2013); 1:0.47 (Abera et al., 2014) in different areas in the world.

The length distribution of previous studies conducted in the Asi River and other regions was similar (Yalçın et al., 2002; Narin, 2003). Mean length at first sexual maturity has been reported as (L_m) 25.05 cm at first age for *C. gariepinus* in the Asi River (Yalçın et al., 2001). However, the minimum catching capacity for this species is recorded as 35 cm in Turkey's commercial fishery regulations (MAF, 2020). When we evaluate the size of fish according to their age and weight, the smallest individual weight is noted as 73.50 g, and the largest individual weight is 1.87 kg. A very important part of the sampled population varies between 200-400 g as individual weights.

Table 3. Length-weight relationship parameters of *C. gariepinus* reported from different areas

Area	Sex	N	a	b	r^2	Reference
Elands River, South Africa	M	195	0.0070	2.99	-	Van der Waal (1972)
Asi River, Turkey	F	351	0.0100	2.90	-	Yalçın et al. (2002)
	M	366	0.0160	2.74	-	
	A	720	0.0127	2.82	-	
Gölbaşı Lake, Turkey	F	330	0.0075	2.99	0.95	Narin (2003)
	M	154	0.0097	2.91	0.95	
	A	566	0.0076	2.99	0.96	
Epe Lagoon, Nigeria	A	1944	0.0160	2.88	0.97	Fafioye & Oluajo (2005)
Abu-Zaabal Lakes, Egypt	A	-	0.0785	2.37	0.97	Shalloof & El-Far (2009)
Baringo Lake, Kenya	A	54	0.0060	2.93	-	Nyamweya et al. (2010)
Langano Lake, Ethiopia	A	537	0.0123	2.99	0.94	Bongie (2013)
Babogaya Lake, Ethiopia	F	528	0.0143	2.95	0.96	Abera et al. (2014)
	M	420	0.0174	2.90	0.97	
	A	948	0.0156	2.93	0.94	
Naivasha Lake, Kenya	F	-	0.0018	3.30	0.90	Keyombe et al. (2015)
	M	-	0.0031	3.16	0.86	
	A	139	0.0023	3.23	0.88	
Baringo Lake, Kenya	A	2272	0.0147	2.81	-	Macharia et al. (2017)
Manzalah Lake, Egypt	F	701	0.0045	3.13	0.98	Mehanna et al. (2018)
	M	540	0.0037	3.18	0.99	
Lugo Lake, Ethiopia	A	81	0.0157	2.80	0.90	Mekonnen et al. (2019)
Offin River, Ghana	A	353	0.0198	2.71	0.97	Dogah (2020)
Sakaryabaşı, Turkey	A	559	0,0093	2.92	-	Başkurt (2020)
Oued Takhamalte, Algeria	F	50	0.0482	2.49	0.93	Behmene et al. (2021)
	M	34	0.0509	2.46	0.90	
	A	84	0.0608	2.42	0.89	
Asi River, Turkey	**F**	**87**	**0.0079**	**2.98**	**0.96**	**Present study**
	M	**92**	**0.0013**	**2.83**	**0.91**	
	A	**185**	**0.0092**	**2.94**	**0.93**	

Note: *dash* means no data available; *F*: Female; *M:* Male; *A*: All; *N*: number of samples; *a*: intercept of the relationship; *b*: slope of the relationship; r^2: coefficient of correlation.

Table 4. Parameter's comparisons (L_∞, K, t_0) of the von Bertalanffy growth curve and growth performance indices (Φ') for female, male and all individuals reported from different areas

Area	Sex	N	L_∞(cm)	K year^{-1}	t_0	Φ'	Reference
Asi River, Turkey	F	351	82.94	0.15	-1.72	-	Yalçın et al. (2002)
	M	366	85.32	0.14	-0.69	-	
Gölbaşı Lake, Turkey	F	330	56.98	0.23	-1.70	-	Narin (2003)
	M	154	64.85	0.19	-1.72	-	
	A	566	60.24	0.21	-1.61	-	
Laing River reservoirs, Eastern Cape	A	101	140.67	0.17	-0.16	-	Potts et al. (2008)
Kat River reservoirs, Eastern Cape	A	134	93.02	0.19	-0.28	-	
Mid-Cross River, Nigeria	A	1421	80.24	0.49	-3.93	3.10	Idumah Okogwu (2011)
Darlington Dam, Eastern Cape	F	78	86.79	0.17	-2.08	-	Wartenberg et al. (2013)
	M	97	99.96	0.13	-2.72	-	
	A	175	93.17	0.15	-2.43	-	
Lower Okavango Delta, Botswana	A	106	52.87	0.72	-1.35	-	Bokhutlo et al. (2015)
Baringo Lake, Kenya	A	2272	114.30	0.37	-	-	Macharia et al. (2017)
Manzalah Lake, Egypt	A	1241	86.88	0.31	-0.39	-	Mehanna et al. (2018)
Oued Takhamalte, Algeria	A	84	53.84	0.28	-	-	Behmene et al. (2021)
Mai-Ndombe Lake, DRC	A	2001	55.65	0.28	-0.50	-	Nsapu (2021)
Asi River, Turkey	**F**	**87**	**58.5**	**0.41**	**-0.70**	**3.15**	**Present study**
	M	**92**	**68.3**	**0.35**	**-0.60**	**3.21**	
	A	**185**	**58.2**	**0.39**	**-0.40**	**3.12**	

Note: dash means no data available; *F*: Female; *M*: Male; *A*: All; L_∞: Asymptotic length; *K*: body growth coefficient; t_0: Theoretical age at zero length; *Φ'*: phi prime value; *DRC*: Democratic Republic of the Congo.

The length-weight relationship (LWR) has a valuable means of fish stock assessment (Keyombe et al., 2015). If the *b* value, which is an allometric coefficient, is 3.0 then the growth is isometric. In the same manner, if this value is larger or smaller than 3.0 then it means a positive or negative allometric growth can exist (Bagenal & Tesch, 1978). In this study, the growth of *C. gariepinus* was evaluated as an isometric accordingly to the *b* value which is similar to previous studies conducted in similar regions. A comparison between the length-weight relationships for the species was done by using the results of previous studies (Table 3).

The condition factor (CF) is an index reproducing relations between biotic and abiotic elements in the physiological situation of fishes. Le Cren (1951) stated that CF values larger than 1 indicate the suitable condition for fish, but a value lower than 1 was showing the existence of unsuitable environmental conditions. In addition, Perry et al. (1996) informed that fishes with a low condition index are probably understood to have experienced a severe physical environment or lacking nutrition. In this study, it has been calculated that the mean condition factor for female, male and all sampled individuals of *C. gariepinus* were of values of lower than l which showed that *C. gariepinus* are under environmental stress in the Asi River.

The low number of elderly individuals brings to mind the idea that the fishing of *C. gariepinus* creates fishing pressure. Several factors can affect growth parameters i.e., location, season, etc. (Avşar, 1995). Thus, VBGF growth parameters were compared with the literature in different areas (Table 4). The growth coefficient (K=0.39 year^{-1}) found in this study was one of the highest values when comparing previous studies. Nevertheless, the asymptotic length (L_∞=58.2 cm) found in this study was one of the lowest values.

In addition, Yalçın et al. (2002) reported this value as 82.94 and 85.32 for females and males, respectively. Therefore, it can be said that the *C. gariepinus* stocks in the Asi River are under intense pressure. The phi prime (Φ') values calculated for *C. gariepinus* had similar results to previous studies on *C. gariepinus* from different areas (Table 4).

CONCLUSION

In conclusion, this study updated the information on the length distribution, length-weight relationship, age and growth of *C. gariepinus* from the Asi River. In the river, as in all Turkish inland waters, commercial fishing is restricted except for leased areas. However, unfortunately, illegal fishing is carried out intensively. As a result, climate change and its effects, especially the construction of dams in certain parts of the river for agricultural irrigation purposes and the resulting lack of management negatively affect the natural living stocks of the Asi River. Therefore, it can be said that the *C. gariepinus* stocks in these areas are overexploited. Legal arrangements should be made in this region to correct these conditions.

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Compliance With Ethical Standards

Authors' Contributions

EŞ and OS designed the study. EŞ, ZAG and OS analysed the data, performed the experiments. EŞ wrote, revised the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required. Even so, the authors followed all applicable international, national, and/or institutional guidelines for the care and use of animals.

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Determination of Antimicrobial Activities of Essential Oils of Different Thyme Species Grown in Çanakkale Conditions

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ABSTRACT

Turkey is one of the leading countries in the trade of medicinal and aromatic plants due to its geography, and while exporting many medicinal plants, it also imports many plants. Thyme is often used as a spice in meat, fish and many other dishes due to its aromatic properties. It is a scientific fact that the essential oils in thyme have a strong antimicrobial effect. Thymol, which gives the distinctive smell of thyme, is an advanced antimicrobial agent. For this reason, it is recommended by many scientists to use thyme in the preservation of ready-made foods and disinfection of foods. It is an important plant for the country's economy, as it is an important medicinal aromatic plant and meets a large part of the thyme used in the world. Thyme, which is obtained by collecting from nature and cultivating in our country, has been an important research topic for scientists and many positive results have been obtained and continue to be achieved. This research was carried out at Çanakkale Onsekiz Mart University Faculty of Agriculture in 2021 in order to reveal the effect of essential oils obtained from 3 different thyme grown in Çanakkale conditions on 4 different bacteria. As research material, essential oils of Izmir thyme (*Origanum onites*), Istanbul thyme (*Origanum vulgare*) and medical thyme (*Thymus vulgaris*) were obtained by hydro-distillation method, and the anti-bacterial activities of these essential oils were determined against the determined bacteria *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterobacter cloacaurmicium*, *Salmonella typhimurium*. The antimicrobial activities of essential oils were determined by the disc diffusion method. As a result, according to the data obtained from all thyme essential oils, while all of them showed an antimicrobial effect on bacteria, the most antimicrobial activity was seen in *O. onites* and *O. vulgare* essential oils, while the least antimicrobial activity was seen in *T. vulgaris* essential oil. It showed the best activity in *Origanum vulgare*, especially on *S. aureus* (42 mm) and *S. typhimurium* (39 mm) bacteria. In the study, *T. vulgaris* had low activity against *P. aeruginosa* with an inhibition diameter of 19 mm.

Çanakkale Koşullarında Yetişen Farklı Kekik Türlerinin Esansiyel Yağlarının Antimikrobiyal Aktivitelerinin Belirlenmesi

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ÖZET

Türkiye bulunduğu coğrafya itibariyle tıbbi ve aromatik bitkilerin ticaretinde dünyada söz sahibi ülkelerinden birisi olup, birçok tıbbi bitkinin ihracatını yaparken, beraberinde birçok bitkinin de ithalatını gerçekleştirmektedir. Kekik genellikle aromatik özelliklerinden dolayı et, balık ve diğer birçok yemekte baharat olarak kullanılmaktadır. Kekikte bulunan esansiyel yağların güçlü antimikrobiyal etkisinin bulunduğu bilimsel bir gerçektir. Kekiğin kendine özgü kokusunu veren timol ileri düzeyde bir antimikrobiyal etkendir. Bu sebeple daha çok hazır gıdaların muhafazasında ve gıdaların dezenfeksiyonunda kekiğin kullanılması birçok bilim insanı tarafından önerilmektedir. Önemli bir tıbbi aromatik bitki olması ve dünyada kullanılan kekiğin oldukça büyük bir kısmını karşılamasından dolayı ülke ekonomisi açısından önemli bir bitkidir. Ülkemizde doğadan toplanarak ve kültürel tarımı yapılarak elde edilen kekik bilim insanları için önemli bir araştırma konusu olmuş, yapılan çalışmalar ile ilgili birçok olumlu sonuç elde edilmiş ve edilmeye de devam etmektedir. Bu araştırma, Çanakkale koşullarında yetişen 3 farklı kekikten elde edilen esansiyel yağların 4 farklı bakteri üzerine etkisini ortaya koymak amacıyla 2021 yılında Çanakkale Onsekiz Mart Üniversitesi Ziraat Fakültesi'nde yürütülmüştür. Araştırma materyali olarak İzmir kekiği (*Origanum onites*), İstanbul kekiği (*Origanum vulgare*) ve tıbbi kekik (*Thymus vulgaris*) esansiyel yağları su distilasyonu yöntemiyle elde edilmiş ve bu esansiyel yağların antimikrobiyal aktivitesi *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterobacter cloacae* ve *Salmonella typhimurium* bakterileri suşlarına karşı disk difüzyon yöntemi ile belirlenmiştir. Araştırma sonunda kekik türlerinden elde edilen esansiyel yağların tamamının bakteriler üzerinde antimikrobiyal bir etki gösterdiği tespit edilmiştir. En yüksek antimikrobiyal aktivite *O. onites* ve *O. vulgare* esansiyel yağlarında görülürken, en az antimikrobiyal aktivite ise *T. vulgaris* esansiyel yağında görülmüştür. *O. vulgare* bitkisinden elde edilen esansiyel yağ; *S. aureus* (42 mm) ve *S. typhimurium* (39 mm) bakterileri üzerinde en yüksek aktiviteyi göstermiş olup, *T. vulgaris* bitkisinden elde edilen esansiyel yağ *P. aeruginosa* bakterisine karşı düşük antimikrobiyal aktivite (19 mm) göstermiştir.

GİRİŞ

Tıbbi ve aromatik bitkiler dünya ve ülkemiz ekonomisi açısından önemli bir yere sahip olup, esansiyel yağlar; bitkinin bulunduğu yere, zaman ve elde edilen organına göre değişiklik göstermektedir. Esansiyel yağlar oda sıcaklığında sıvı hal alıp, bekletildiğinde kristalleşebilen, bazen renksiz bazen de açık sarı renk alan, yoğun kokusu olan, uçucu bileşiklerdir. Esansiyel yağlar sabit yağlardan farklı bir yapıdadırlar ve su ile karışmazlar. Uzun süre ışık ve oksijene maruz kaldıklarında reçineleşmeye sebep olmakta, bu nedenle ağzı kapaklı ve koyu renkli şişelerde muhafaza edilmesi gerekmektedir. Kimyasal olarak bileşimlerinde terpenler, aldehitler, alkoller, fenoller, esterler, azot ve kükürtlü bileşikler bulunmaktadır (Ceylan, 1983; Kılıç, 2008).

Fenoller esansiyel yağların aktif bileşenleri olup antimikrobiyal etkileri oldukça yüksektir ve antimikrobiyal etkilerinin yüksek olması özel alanlarda ve gıdalarda dezenfektan madde olarak kullanılma imkanı sağlamıştır. Bununla birlikte birçok fenolik bileşik gıda sektöründe antioksidan ve antimikrobiyal gibi özellikleri nedeni ile kullanılmaktadırlar (Kunyanga vd., 2012).

Esansiyel yağların sağlık sektöründe dezenfektan etkisinin yanı sıra hastalıkları tedavi edici özellikleri de ileri düzeydedir. Antimikrobiyal etkileri 1800'lü yılların başlarından beri bilinmektedir ve yoğun olarak

dezenfektan etkisi kullanılmaktadır. Araştırmalarda kullanılan kekiklerin antimikrobiyal, antiseptik, antihelmintik, kardiyovasküler, stimulan özellikleri sebebiyle geniş bir kullanım alanı söz konusudur (Cingi vd., 1991).

Tıbbi bitkiler arasında özellikle kekiğin antimikrobiyal, antifungal, antioksidan gibi özellikleri birçok çalışmada araştırılmış ve çok etkili olduğu ortaya konmuştur (Milad, 2018). *Origanum* türlerinden elde edilen esansiyel yağların *Escherichia coli*, *Staphylococcus aureus*, *Enterobacter cloacae*, *Staphylococcus epidermidis, Klebsiella pneumoniae* ve *Pseudomonas aeruginosa* bakterilerine ve *Candida tropicalis*, *Candida albicans* ve *Torulopsis glabrata* fungus türlerine karşı yüksek oranda antimikrobiyal özellikte olduğu bildirilmiştir (Aligiannis vd., 2001). *Thymus* türlerinin (*Thymus kotschyanus* ve *Thymus persicus*) esansiyel yağlarının da *S. aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Bacillus subtilis* gibi bakterilere karşı yüksek düzeyde antimikrobiyal aktivitesinin olduğu bilinmektedir (Rasooli ve Mirmostafa, 2003).

Origanum vulgare, Thymus vulgaris, Pimenta racemosa ve Eugenia caryophyellata bitkilerinden elde edilen esansiyel yağların incelenmesinde *Origanum* ve *Thymus* bitkilerinin uçucu yağlarının, *Pimenta* ve *Eugenia* bitkilerinin yağlarına kıyasla, *E. coli* bakterisine karşı daha etkili antibakteriyel aktivite gösterdiği saptanmıştır (Burt & Reinders, 2003). *Thymus* türlerinden ekstrakte edilen esansiyel yağlar *in vitro* şartlarda *S. aureus*, *P. aeruginosa*, *Entorobacter aerogenes*, *E. coli* gibi patojen bakterilerinde test edilmiş ve iyi düzeyde antimikrobiyal etkiye sahip oldukları gözlenmiştir (Azaz vd., 2004).

İçerisinde iki kekik türünün de bulunduğu altı farklı bitkiden esansiyel yağ elde edilerek antimikrobiyal aktiviteleri üzerine yapılan çalışmada; *S. aureus, E. coli, Candida albicans* bakterilerine antimikrobiyal aktivitesi etkili olurken, *P. aeruginosa* bakterisinde beklenen etkiyi göstermemiştir (Lisin vd., 1999).

Kekik, karanfil, ıtır, karabiber, muskat tohumu ve mercanköşk bitkilerinden elde edilen esansiyel yağlar 25 farklı bakteriye karşı antimikrobiyal aktivitesi testi yapılmış ve bitki ve hayvan patojeni olan bu bakterilere karşı yüksek düzeyde antimikrobiyal etkileri ortaya konulmuş ve olumlu sonuçlar alınmıştır (Dorman & Deans, 2000).

Kekiğin çeşitli kısımlarından elde edilen esansiyel yağlar 9 Gram negatif (G –) ve 6 Gram pozitif (G +) bakteri ile test edilmiş ve bu bakterilerin tamamına karşı bakteriyostatik aktivitelerinin yüksek olduğu belirlenmiştir. Bunlar içerisinde kekik çiçeğinden ekstrakte edilen esansiyel yağların en yüksek etkiye sahip olduğu belirlenmiştir (Marino vd., 1999).

T. vulgaris, *E. caryophyllata*, *Ocimum gratissimum*, *Melaleuca viridiflora*, *Helichrysum bracteiferum*, *H. lavanduloides*, *H. gymnocephalum* ve *Psiadia altissima* bitkilerinden ekstrakte edilen esansiyel yağlar enteropatojenik özellikli ve gıda sektöründeki zehirlenmelerde etken olan 12 farklı bakteride uygulanmıştır. *T. vulgaris*, *O. gratissimum* ve *E. caryophyllata* bitkilerinden ekstrakte edilen esansiyel yağların daha etkili oldukları tespit edilmiştir (Ramanoelina vd., 1987).

Defne, farekulağı, karanfil ve kekik bitkilerinden elde edilen esansiyel yağlar *E. coli* bakterisine uygulanmış ve olumlu sonuçlar alınmıştır. Fare kulağı ve kekiğin en güçlü bakteriyostatik ve bakterisidal reaksiyon gösterdiği ve sırasıyla defne ve karanfilin takip ettiği belirlenmiştir (Burt & Reinders, 2003).

Bir başka araştırmada *O. onites* esansiyel yağının içeriği GC-MS ile belirlenmiş, 8 farklı bakteri ve 2 farklı mayaya karşı disk difüzyon ve dilüsyon yöntemleri ile antimikrobiyal aktiviteleri tespit edilmiştir. Esansiyel yağın ana bileşenlerinde %51,4 karvakrol, %11,2 linalool, %8,9 ϱ-simen ve %6,7 γ-terpinen tespit edilmiştir. *O. onites* esansiyel yağının bütün standart suşlara karşı antimikrobiyal aktivite gösterdiği tespit edilmiştir (Kaskatepe vd., 2017).

Saraç vd. (2009) *O. onites* ve *O. vulgare* subsp. *hirtum* bitkilerinin esansiyel yağlarını antibiyotiğe direnç gösteren *Stenotrophomonas maltophilia* suşuna karşı test etmiştir. *O. onites* ve *O. vulgare* subsp. *hirtum* bütün bakterileri inhibe etmiş ve inhibisyon bölgeleri sırasıyla 28-32 mm ve 26-33 mm arasında ölçülmüştür. Denemeye alınan bitkilerin esansiyel yağları, karvakrol (%79,32 ve %68,19), ϱ-simen (%4,32 ve %6,81) ve γ-terpinen (%3,94 ve %4,63) olarak bulunmuştur.

Kekik, eskiden beri hem tıbbi hem de aromatik olarak bilinen ve yoğun olarak kullanılan bir bitkidir. Kekik aromatik suyunun mide yatıştırıcı, antiseptik, kan dolaşımına uyarıcı etkisi oldukça yüksektir. Yine bulunduğumuz asrın önemli sıkıntılarından olan obeziteye karşı etkili olup, kolesterolü düşürdüğü bir gerçektir. Bu yüzden kekik ve türevlerinin önemi günümüzde de giderek artmaktadır.

O. onites Ege ve Batı Akdeniz kıyılarında yoğun olarak doğada yetişmekte ve kültürü yapılmaktadır. Türkiye kekik ihracatında *O. onites* %80 ile ilk sırada yer almaktadır. Bitki boyu ortalama 100 cm civarındadır. Esansiyel yağ verimi %2-5 arasında değişmektedir. Esansiyel yağı karvakrol, timol ve α-terpinen bakımından oldukça zengindir. Karvakrol oranı %81 seviyelerine kadar çıkmaktadır. Antalya ve Isparta'dan toplanan kekiklerde linalool oranı ise %91-92 seviyelerinde tespit edilmiştir (Baytop, 1991; Öğütveren vd., 1992).

O. vulgare çoğunlukla Marmara ve Ege bölgesinde yetiştirilmektedir. Aromatik ve tıbbi çay olarak değerlendirilmektedir. *Origanum* ortalama 60-65 cm boylanmaktadır. Çiçekleri beyaz renkli ve oldukça küçüktür. Bitkinin çiçeklenme dönemi genellikle temmuz-ağustos aylarıdır. Esansiyel yağ verimi %3,6-5,7 arasındadır. Karvakrol açısından oldukça zengin esansiyel yağımda aynı zamanda timol ve linalool kemotipinde mevcuttur. Esansiyel yağında bulunan önemli bileşenler β-caryophyllene, γ-terpinene, ϱ-cymene, karvakrol ve myrcene'dir. Tohumları kahverengi olup yuvarlak-oval ve çiçekleri gibi küçük olup, bin tane ağırlığı 0,2-0,3 g arasındadır.

T. vulgaris ülkemizde çok yaygın doğal yayılış göstermemektedir. İyi düzeyde antifungal ve antiseptik özelliğine sahip bir kekik türüdür. Bitki boyu 20-30 cm civarında olmaktadır. Yaprak rengi yeşil-gri, çiçek rengi ise lila ve beyaz olmaktadır. Esansiyel yağı %1,09-2,67 civarlarında olup bunun %40-74'ünü timol oluşturmaktadır. ϱ-cymene, γ-terpinene, karvakrol, β-caryophyllene ve α-terpinen içeriğindeki diğer önemli bileşenlerdir (Galambosi vd., 2010).

Kekiğin dezenfektan etkisi oldukça önemli seviyededir. Bu alanda çok fazla araştırma bulunmamakla birlikte bu tür çalışmaların daha da genişletilerek devam ettirilmesi önem arz etmektedir. Kimyasal dezenfektanlar yerine doğal ürünlerin kullanılması insan sağlığı açısından büyük bir öneme sahiptir. Çalışmanın yapıldığı Çanakkale-Marmara Bölgesi'nde kekik üretiminin yanında üretilen kekiğin işlenmesi ve değerlendirilmesi de öncelikli konular arasındadır. Yapılan birçok çalışmada kekik yağı üzerinde durulmuştur. Tüm bu bilgiler doğrultusunda bu çalışmada ise üç farklı kekik bitkisinden (*Origanum onites, Origanum vulgare* ve *Thymus vulgaris*) elde edilen esansiyel yağın dezenfektan etkilerinin belirlenmesi amaçlanmıştır.

MATERYAL VE YÖNTEM

Bitki ve Esansiyel Yağ Örnekleri

Araştırmada kullanılan kekik bitkileri (*O. onites, O. vulgare* ve *T. vulgaris*), 2021 yılında Çanakkale Onsekiz Mart Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümü üretim arazisinden toplanmıştır. Her bitkiden 500 g yaş örnek alınarak bu numuneler küçük parçalara ayrılmış ve esansiyel yağlar, su distilasyon yöntemi ile Clevenger aparatı kullanılarak elde edilmiştir. Bitki materyali saf su ile 1/10 oranında cam balon içerisinde konularak 2 saat süreyle kaynatılmıştır. Oluşan su buharı ile sürüklenen uçucu yağ molekülleri, soğutucu eşanjörde yoğunlaşarak cam boruda altta su fazı, üstte esansiyel yağ fazı olacak şekilde iki faz elde edilmiştir. Elde edilen esansiyel yağ miktarı volumetrik olarak ifade edilmiştir. Elde edilen esansiyel yağların bozulmaması için üzerine azot gazı konularak kapaklı amberli şişelerde uygulamanın yapılacağı zamana kadar −20°C'de muhafaza edilmiştir (Gültepe vd., 2019).

Bakteri İzolatları

Çalışmada G(+) bakteri grubundan *S. aureus*, G(–) bakteri grubundan ise *P. aeruginosa*, *E. cloacae*, *S. typhimurium* bakteri izolatları kullanılmıştır.

Antimikrobiyal Aktivite Testi

Kekik esansiyel yağlarının antimikrobiyal aktivitesini belirlemek için Klinik Laboratuvar Standartları Enstitüsü'nün (CLSI: Clinical and Laboratory Standards Institute) standart disk difüzyon yöntemi kullanılmıştır (CLSI, 2006). Bu yöntemde,

bakteri türleri ilk önce kanlı agar plaklarında bir gece 37°C'de inkübe edilmiş ve çoğalması sağlanmıştır. Bakterilerin McFarland 0,5 ($1x10^8$ hücre/mL) standart yoğunluğunda %0,9 NaCl solüsyonu içerisinde süspansiyonları hazırlanmıştır. Elde edilen bakteri süspansiyonları eküvyon yardımı ile Mueller Hinton Agar (MHA) besi yerlerine yayılmıştır. Bu 6 mm çapındaki steril standart boş antibiyotik disklerine 10 µL esansiyel yağ emdirilerek, bakteri inokülasyonu yapılmış petri plaklarına yerleştirilmiştir. Seçilen 4 bakterinin duyarlılık özelliğine göre CLSI'dan seçilen standart antibiyotik diskleri de aynı petrilere pozitif kontrol olarak konulmuştur. Kontrol için aynı petri kutusuna sterilite için boş antibiyotik diski de konulmuştur. Ele alınan 4 bakteri 37°C'de, normal şartlar altında 24 saat inkübe edilmiş ve sonunda disklerin çevresinde üreme olmayan alan mm olarak ölçülerek inhibisyon çapları elde edilmiştir. Her bir uygulama 4 tekerrür olarak gerçekleştirilmiştir.

BULGULAR VE TARTIŞMA

Denemeye alınan 3 kekik türüne ait esansiyel yağlarının disk difüzyon testine göre antimikrobiyal aktivite sonuçları Tablo 1'de verilmiştir. Çalışmanın sonuçlarına göre test edilen bakterilere karşı esansiyel yağlardan, *O. onites* en güçlü antimikrobiyal aktivite göstermiş ve bunu *O. vulgare* takip etmiştir. Denemeye alınan kekikler içinde en zayıf antimikrobiyal etkiyi *T. vulgaris* göstermiştir. Özellikle *S. aureus* (42 mm) ve *S. typhimurium* (39 mm) bakterileri üzerinde *T. vulgaris* esansiyel yağı en düşük aktiviteyi göstermiştir. Sadece *P. aeruginosa* bakterisine karşı 19 mm inhibisyon çapı *O. vulgare* esansiyel yağı en yüksek bir aktiviteye sahip olmuştur. Bu aktiviteyi 22 mm inhibisyon ile *O. vulgare* esansiyel yağı ve 25 mm inhibisyon ile de *T. vulgaris* esansiyel yağı takip etmiştir. *P. aeruginosa* bakterisinde antibiyotik meropenem (MEM) uygulamasında da elde edilen değer her üç kekikten de inhibisyonu yüksek gözlenmiştir.

Tıbbi ve aromatik bitkilerden elde edilen esansiyel yağlar; gıda sektöründe hazır yiyecek ürünlerine belirli oranlarda ilave edildiklerinde antimikrobiyal etki göstererek bu yiyeceklerin depolanma süresini arttırmaktadır (Farag, 1989). Kekik esansiyel yağları bakteri ve küflere karşı antimikrobiyal etki gösteren yağlardan ilk sıralarda yer almaktadır (Nychas, 1995).

Baydar vd. (2004) yılında yaptıkları bir araştırmalarında *Origanum onites* bitkisinin denemeye alınan bakteriler üzerinde etkili olduğunu tespit etmişlerdir. Aridoğan vd. (2002) ise *O. onites* esansiyel yağının güçlü bir antimikrobiyal etki gösterdiğini bularak diğer araştırmalarla paralellik oluşmuştur. Yine Evrendilek (2015) yaptığı bir çalışmada; 14 farklı bitkiden elde edilen esansiyel yağların içinde en yüksek antimikrobiyal aktiviteyi *O.onites* bitkisinden elde edilen esansiyel yağdan elde etmiştir. *Laurus nobilis*, *Salvia officinalis*, *Rosmarinus officinalis*, *O.vulgare*, *Coriandrum sativum* esansiyel yağlarının antimikrobiyal etkileri karşılaştırıldığında en etkili sonuçların kekik esansiyel yağı ile tespit edildiği bildirilmiştir (Baratta, 1998). Yapılan bu çalışmada elde edilen bulgular diğer araştırmacıların çalışmaları ile örtüşmektedir.

SONUÇ

Bu araştırmada; elde edilen bulgulara bakıldığında 3 kekik türünün esansiyel yağı, test edilen bütün bakteriler üzerinde antimikrobiyal etki gösterirken, en fazla antimikrobiyal aktivite *O. onites* esansiyel yağında görülmüştür. Bunu sırasıyla *O. vulgare* ve *T. vulgaris* esansiyel yağları izlemiştir. Araştırmaya konu

Table 1. Antimicrobial activity results of *O. onites, O. vulgare and T. vulgaris* essential oils
Tablo 1. *O. onites, O. vulgare ve T. vulgaris esansiyel yağlarının antimikrobiyal aktivite sonuçları*

Bakteriler	*T. vulgaris*	*O. onites*	*O. vulgare*	Antibiyotik	(-) Kontrol
S. aureus	38	42	40	35 (P)	-
S. typhimurium	35	39	37	19 (AMP)	-
P. aeruginosa	19	25	22	29 (MEM)	-
E. cloacae	35	36	34	31 (MEM)	-

Not: P: Penisilin G (10 ünite), MEM: Meropenem (10 µg), AMP: Ampisilin (10 µg).

olan bakterilere karşı en iyi antimikrobiyal etkiyi *O. onites* esansiyel yağı *P. aeruginosa* bakterisi ile gösterirken, bu 3 kekik türü arasında içerisinde en düşük antimikrobiyal etkiyi *T. vulgaris* esansiyel yağı *S. aureus* bakterisine karşı göstermiştir. Çalışmada test edilen kekik türlerinden elde edilen esansiyel yağların antimikrobiyal aktivitesi, kullanılan penisilin G (10 ünite), meropenem (10 µg) ve ampisilin (10 µg) antibiyotiklerinden yüksek olmuştur.

Çalışmadan elde edilen sonuçlar ışığında kekik esansiyel yağlarının, günümüzde hijyen ve temizlikten kaynaklanan birçok rahatsızlık için çözüm olabilecek potansiyele sahip olduğu ve ayrıca hem gıda hem de sağlık sektöründe bu yönüyle değerlendirilmesinin insan ve çevre sağlığı açısından büyük öneme sahip olduğu düşünülmektedir.

TEŞEKKÜR

Bu çalışma ilk yazarın yüksek lisans tezinden üretilmiştir.

Etik Standartlara Uyum

Yazarların Katkısı

Yazarlar çalışmaya eşit katkıda bulunmuştur. Her iki yazar da makalenin son halini onaylamıştır.

Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını beyan etmektedir.

Etik Onay

Yazarlar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

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Length-Weight and Length-Length Relationships of the *Scorpaena* Species (Actinopteri: Scorpaenidae) in Izmir Bay (Aegean Sea of Turkey)

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ABSTRACT

In this study, 173 specimens of *Scorpaena porcus* (n=50), *Scorpaena elongata* (n=20), *Scorpaena scrofa* (n=101), *Scorpaena notata* (n=2) were obtained from commercial fishermen in the Aegean Sea between 2017 and 2019. The length-weight relationships were determined for *S. porcus*, *S. scrofa* and *S. elongata* as $W=0.0119TL^{3.182}$, $W=0.0176TL^{3.004}$ and $W=0.0656TL^{2.579}$, respectively. Negative allometry was found for *S. scrofa* and *S. elongate*, whereas positive allometry was present for *S. porcus.* However, with less than 5 individuals *S. notata* showed maximum, minimum, and mean total length and weight values. *S. notata* (2 individuals) had a mean total length and weight of 15.7-16.6 cm and 72.31-93.26 g. The results also demonstrated that the length-length relationships were strongly correlated for all *Scorpaena* species ($r^2>0.980$, $P<0.05$).

INTRODUCTION

Aquatic biologists and fisheries managers have frequently used length-weight relationships (LWRs) to evaluate fish stocks, the ecology of fisheries and the population dynamics in aquatic ecosystems, as well as in aquatic environments that are semi-controlled (Ricker, 1968). Length-weight relationships help appraise the general health, reproduction history, life cycle and condition of fish species (Pauly, 1993). They can be helpful in comparing local and interregional morphologies in both populations and species. In addition, length-weight models can be used to assess the ecological health and productivity levels of aquatic ecosystems (Deekae & Abowei, 2010). Models such as these serve to assess the health and growth patterns of fish (Muchlisin et al., 2010; Ndiaye et al., 2015). There are 231 species of Scorpaenidae worldwide (Fricke et al., 2022), while there are eight species found off the Turkish coasts (Karataş et al., 2021).

It is often possible in fisheries studies to measure fish length more easily and quickly than to measure mass. Having a knowledge of the length-weight relationship facilitates the determination of the mass if only the length is known. When working in the field, tail flukes are often cut; this can make it difficult to obtain accurate measurements of total length.

Knowing the length enables the researcher to work out total length.

The length-weight relationships of the different *Scorpaena* fish populations have been indicated in previous studies in the seas around Turkey (Koca, 2002; Karakulak et al., 2006; Özaydın & Taşkavak, 2006; Ismen et al., 2007; Demirhan & Can, 2007; Alpaslan et al., 2007; Ak et al., 2009; Keskin & Gaygusuz, 2010; Akalın et al., 2011; Bok et al., 2011; Kasapoğlu & Düzgünleş, 2013; Bilge et al., 2014; Deval et al., 2014; Altın et al., 2015) and other regions (Jardas & Pallaoro, 1992; Petrakis & Stergiou, 1995; Dulčić & Kraljevic, 1996; Stergiou & Moutopoulos, 2001; Moutopoulos & Stergiou, 2002; Mendes et al., 2004; Ferreira et al., 2008; Crećhriou et al., 2013; Moutopoulos et al., 2013; Dimitriadis & Konstantinidou, 2018; Meiners-Mandujano et al., 2018; Miled-Fathali et al., 2019).

Nevertheless, the length-weight parameters of the same species can differ in the population as a result of fishing, reproductive activities and feeding etc. It is thus necessary to be aware of the length-weight relationships of fish caught in a specific place during a specific period of time.

The aim of the current study was to determine the length-weight and length-length relationships of *Scorpaena* species caught in Izmir Bay in 2017 and 2019.

MATERIAL AND METHODS

In this study, 173 specimens of *S. porcus* (n=50), *S. elongata* (n=20), *S. scrofa* (n=101), *S. notata* (n=2) were obtained from commercial fishermen in the Aegean Sea between 2017 and 2019. Total length (TL) and standard length (SL) of each specimen was measured using a 0.1 cm class interval. The total weight (W) of each individual was measured to the nearest 0.01 g. The total length of all specimens was employed to work out the length-weight relationship (LWR). This was calculated by log transformed data log (Eq. 1):

$$W = \log a + b \log L \quad (1)$$

where, W is the total weight (g), L is the total length (cm), a is the intercept and b is the slope or allometric coefficient (Ricker, 1979). The statistical significance level of r^2 was predicted using linear regressions on the transformed equation. An allometric coefficient (b) larger or smaller than 3.0 shows an allometric growth (Bagenal & Tesch, 1978). Value b is > 3, which can be said to show a positive allometric growth. However, b<3 demonstrated a negative allometric growth or isometric growth when it was equal to 3.0. Moreover, the SL vs TL relationships were calculated using linear regressions. Length-length relationship (LLR) was measured as Eq. (2) to standardize the length values used in other studies.

$$TL = a + bSL \quad (2)$$

Covariance analysis was conducted to test for probable significant differences in both slope and intercept. Statistical analyses were evaluated at a significance level of P<0.05

RESULTS

The study examined 173 scorpaenid species of fish with 101 *Scorpaena scrofa*, 50 *Scorpaena porcus*, 20 *Scorpaena elongata* and 2 *Scorpaena notata*.

Table 1. Descriptive statistics and estimated parameters of length-weight relationships for four *Scorpaena* species in Izmir Bay (Aegean Sea) from 2017 to 2019 (N: number of individuals, *a*: intercept, *b*: slope, r^2: coefficient of determination)

Species	N	TL range (cm)	W range (g)	*a*	*B*	95% C.I. of *b*	r^2	Growth type
S. scrofa	101	17.3-33.1	95.37-708.91	0.0176	3.004	2.892-3.116	0.963	-allometry
S. porcus	50	12.6-28.4	33.76-516.03	0.0119	3.182	3.042-3.322	0.972	+allometry
S. elongata	20	19.7-28.3	134.57-358.68	0.0656	2.579	2.347-2.811	0.958	-allometry
S. notata	2	15.7-16.6	72.31-93.26	-	-	-	-	-

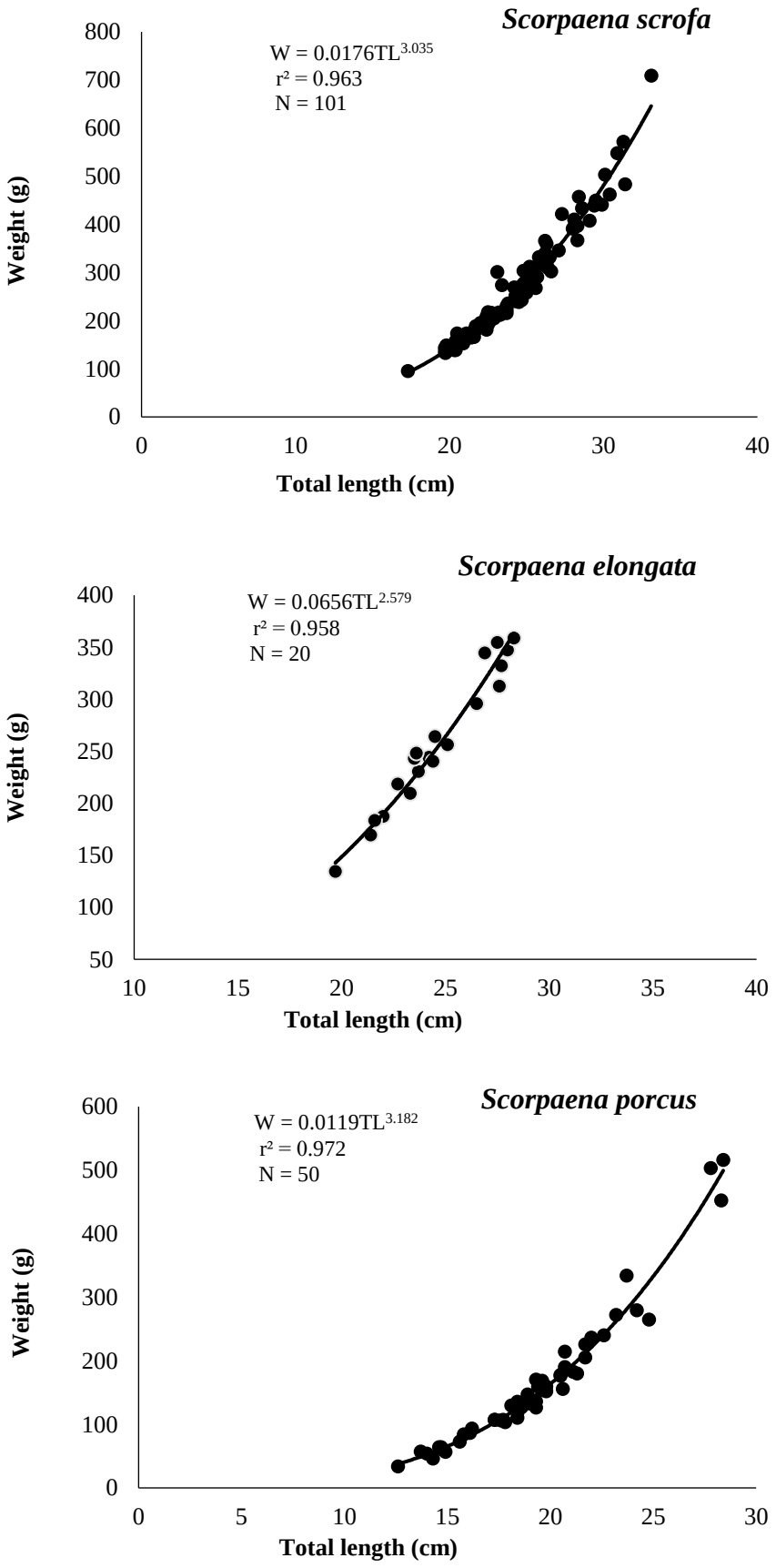

Figure 1. Length-weight relationships for three Scorpaena species from Izmir Bay (Central Aegean Sea, Turkey).

Table 2: Length-length relationships between total length (TL), and standard length (SL) of *Scorpaena* species in Izmir Bay (Aegean Sea) from 2017 to 2019 (N: number of individuals, *a*: intercept, *b*: slope, r^2: coefficient of determination)

Species	Equation	N	*a*	*b*	r^2
S. scrofa	TL=a+bSL	101	0.3354	0.7744	0.986
S. porcus	TL=a+bSL	50	0.6342	0.8171	0.989
S. elongata	TL=a+bSL	20	0.3588	0.7827	0.990

Table 3. LWRs of three Scorpaena species from different areas (N: number of individuals, a: intercept, b: slope, r^2: coefficient of determination)

Species	References	Country, Locality	N	Length range (TL, cm)	*a*	*b*	r^2
S. porcus	Jardas & Pallaoro (1992)	Croatia, Adriatic	-	5.8-30.0	0.0171	3.034	0.995
	Petrakis & Stergiou (1995)	Greece, Euboikos Gulf	100	7.0-23.5	0.0291	2.840	0.970
	Stergiou & Moutopoulos (2001)	Greece, Aegean Sea	231	11.5-40.5	0.0236	2.887	0.950
	Stergiou & Moutopoulos (2001)	Greece, Evvoikos	100	7.0-23.5	0.0290	2.840	0.970
	Stergiou & Moutopoulos (2001)	Greece, Cyclades	231	11.5-40.5	0.0236	2.887	0.951
	Koca (2002)	Turkey, Sinop Peninsula	633	12.0-25.0	0.0540	2.590	0.931
	Morey et al. (2003)	Spain, Coast of Iber	-	6.1-35.5	0.0183	3.020	0.969
	Karakulak et al. (2006)	Turkey, Gökçeada Island	255	8.0-27.3	0.0250	2.915	0.931
	Özaydin & Taskavak (2006)	Turkey, İzmir Bay	50	14.1-25.6	0.0210	3.004	0.960
	Ismen et al. (2007)	Turkey, Saroz Bay	-	10.0-22.0	0.0256	2.878	0.993
	Demirhan & Can (2007)	Turkey, Black Sea	470	4.6-17.5	0.0124	3.190	0.940
	Alpaslan et al. (2007)	Turkey, Dardanelles	-	10.5-32.0	0.0230	2.960	0.700
	Ak et al. (2009)	Turkey, Coast of Trabzon	351	5.0-34.2	0.0090	3.272	0.880
	La Mesa et al. (2010)	İtaly, Adriatic artificial reef	210	8.0-27.0	0.0202	3.030	0.950
	La Mesa et al. (2010)	İtaly, Adriatic nature reef	134	11.0-22.1	0.0257	2.940	0.950
	La Mesa et al. (2010)	İtaly, Adriatic offshore	71	13.5-28.0	0.0136	3.120	0.970
	Keskin & Gaygusuz (2010)	Turkey, Erdek Bay	45	4.9-19.0	0.0158	3.088	0.983
	Akalın et al. (2011)	Turkey, İzmir Bay	221	7.0-27.0	0.0209	2.987	0.993
	Bok et al. (2011)	Turkey, Sea of Marmara	15	17.3-21.4	0.0067	3.343	0.944
	Crec'hriou et al. (2013)	France, Coast of Catalan	111	9.5-32.0	0.0260	2.920	0.968
	Moutopoulos et al. (2013)	Greece, Korinthiakos Bay	103	10.5-31.8	0.0192	2.965	0.969
	Kasapoglu & Duzgunes (2013)	Turkey, Black Sea	136	8.5-29.2	0.0173	3.034	0.980
	Bilge et al. (2014)	Turkey, South Aegean Sea	63	7.7-26.8	0.0170	3.045	0.986
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	70	8.6-23.6	0.0295	2.830	0.980
	This study	Turkey, İzmir Bay	50	12.6-28.4	0.0119	3.182	0.972
S. scrofa	Dulčić & Kraljevic (1996)	Croatia, Eastern Adriatic	125	19.7-53.6	0.0156	3.298	0.960
	Stergiou & Moutopoulos (2001)	Greece, Cyclades	37	10.7-32.2	0.0169	2.999	0.980
	Moutopoulos & Stergiou (2002)	Greece, Aegean Sea	37	10.7-32.2	0.0169	2.999	0.980
	Mendes et al. (2004)	Portugal, from Nazaré to St André	22	14.3-42.8	0.0121	3.124	0.933
	Karakulak et al. (2006)	Turkey, Gökçeada Island	15	12.3-39.1	0.0180	3.005	0.985
	Özaydin & Taskavak (2006)	Turkey, İzmir Bay	129	8.2-30.1	0.0291	2.796	0.990
	Ferreira et al. (2008)	Madeira islands, Atlantic	12	20.0-46.0	0.0153	3.039	0.974
	Crec'hriou et al. (2013)	France, Coast of Catalan	32	14.0-49.0	0.0260	2.890	0.993
	Moutopoulos et al. (2013)	Greece, Korinthiakos Bay	53	11.7-36.8	0.0169	3.002	0.981
	Bilge et al. (2014)	Turkey, Southern Aegean Sea	74	9.6-42.9	0.0217	2.964	0.996
	Altın et al. (2015)	Turkey, Gökçeada Island	16	6.3-13.2	0.0120	3.135	0.983
	Dimitriadis & Konstantinidou (2018)	Greece, Zakintos Island	335	10.5-39.7	0.0260	2.867	0.980
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	61	11.3-38.3	0.0205	2.947	0.950
	This study	Turkey, İzmir Bay	50	17.3-33.1	0.0176	3.004	0.963
S. elongata	Deval et al. (2014)	Turkey, Antalya Bay	114	5.6-42.1	0.0230	2.880	0.996
	Meiners-Mandujano et al. (2018)	Morocco	45	18.6-41.2	0.0148	3.017	0.971
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	22	14.2-50.0	0.0127	3.077	0.990
	This study	Turkey, İzmir Bay	20	19.7-28.3	0.0656	2.579	0.958

All the specimens of *Scorpaena scrofa* examined showed length group values of 28-94 cm with 17.3-33.1 cm length. The mean total length and weight values of the species were 22.32±0.32 cm and 269.93±11.21 g, respectively. The total length-weight relationship was found to be $W=0.0176TL^{3.004}$ (r^2=0.963) with a negative allometric growth. 50 individuals of *S. porcus* species exhibited minimum maximum length range of 12.6-28.4 cm Its mean total length and weight values were 19.29±0.52 cm and 164.88±15.10 g, respectively. The total length and weight relationship was $W=0.0119TL^{3.182}$ (r^2=0.972) with a positive growth. 20 individuals of *S. elongata* had a minimum maximum length range of 19.7-28.3 cm. Its mean total length and weight values were 24.61±0.56 cm and 258.73±14.87 g, respectively. Total length weight relationship was $W=0.0656TL^{2.579}$ (r^2=0.958) with a positive allometric growth. Nevertheless, with fewer than five individuals *S. notata* showed minimum, maximum and mean total length and weight values. *S. notata* (two individuals) had mean total length and weight of 15.7-16.6 cm and 72.31-93.26 g, respectively (Table 1, Figure 1). Of the LLRs shown in Table 2, all were highly significant ($P<0.05$), and all coefficient of determination values were larger than 0.980.

DISCUSSION

The current study examined 173 individuals from three *Scorpaena* species. Previous studies on the length-weight relationship for the three species examined in the current study are presented in Table 3.

The *b* values in LWRs lie between 2.5 and 3.5 (Froese, 2006) or from 2 to 4 (Tesch, 1971). In the current study, the *b* values of the fish species studied fell within these ranges, as expected. The *b* value for *S. porcus* ranged from 2.590 to 3.190 in other areas, while the value ranged from 2.796 to 3.135 for *S. scrofa*. The *b* value for *S.elongata* was determined to be 2.579. Although this value is different from those in the studies of Meiners-Mandujano et al. (2018) and Miled-Fathali et al. (2019), it is similar to Deval et al. (2014) (Table 3).

Length-weight relationships may vary in different seasons, and they are influenced by factors such as temperature, size, maturity, food availability and salinity. Differences in *b* values can be put down to one or a mixture of these factors, including the number of specimens studied, the effects of the region and/or season, and differences in the ranges of lengths of the specimens; the length of time in which the sample was collected can also be added to these (Moutopoulos & Stergiou, 2002). Furthermore, the extent of sexual maturity, fullness or emptiness of the gut, diet, sampling techniques, and the number of specimens and period of sampling can also have an effect on its value (Wootton, 2003; Eagderi et al., 2020).

CONCLUSION

To conclude, this study has given new information regarding LWRs and LLRs for three *Scorpaena* species from Izmir Bay (the Central Aegean Sea of Turkey). It has provided additional data concerning these previously reported species, and will thus be of use in future biological studies.

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Compliance with Ethical Standards

Authors' Contributions

Conceptualization: BB, BT. Data collection and analysis: BT. Conducting the laboratory experiments: BT, OH. Writing: BB, BT.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

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

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Calculation of Residual Stress in Ships by the Method of the Fresnel Approximation

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ABSTRACT

Predictive maintenance techniques are developed to help determine the condition of in-service equipment in order to predict when maintenance should be performed. There is a need for cost-performance effective approaches and methods for predictive maintenance that can make non-destructive on-site measurements to predict residual stress-induced critical faults in large metal structures, such as ships. In this study, an optical method based on the calculation of the non-destructive surface magnetic permeability coefficient is proposed for monitoring the residual stress distribution in AISI4040 and DUPLEX materials. In our proposed new method for determining theoretically the residual stress at the joint site of large plates in ships, the Lorentz-Drude model and the Fresnel approximation were used. Our results show that the new optical technique proposed in this study is sufficient and thriving for the determination of residual stresses in large metal structures.

INTRODUCTION

Ships are massive metal structures built with the assembly of many large metal plates. The joint sites of metal plates can be subjected to enormous stress due to waves, propulsion forces, steering forces, changing loading conditions and handling, during in duty period. Cyclic load deformations or micro-fractures occur due to the strain and stress at the joints, which leads to fatigue in the metal structure, i.e., ships (Leggatt et al., 1996; Totten, 2002; Kozak & Gorski, 2011; Fricke, 2017). Residual stress is among the primary factors affecting the mechanical properties of materials, such as strength, plasticity, and surface integrity (Guo et al., 2021). The related literature features these factors affecting fatigue have been discussed from various perspectives (e.g., on material, structure, and environment) (Cui, 2002; Kozak & Gorski, 2011). If the stress at the junctions of the metal plates exceeds the threshold value determined by the Young's Modulus of the metal, the metal fatigue process accelerates. Although there are various techniques and methods for the measurement of residual stress in the literature, most of these techniques are complex and inapplicable in-situ (Song et al., 2017; Gan et al., 2018; Moharrami & Sadri, 2018).

These methods are divided into three main groups – i.e., non-destructive, semi-destructive, and totally destructive. Non-destructive methods incorporate X-ray and neutron diffraction, ultrasonics, and electromagnetism. Among the semi-destructive methods are hole drilling, trepanning, and deep hole drilling. Totally destructive methods include cutting, slicing, and block removal and layering (Leggatt et al., 1996; Ghaedamini et al., 2018; Magnier et al., 2018; Moharrami & Sadri, 2018; Vourna et al., 2018). Also, conventional residual stress measurement techniques are compared in the sense of applicability and cost in Table 1 (Kurashkin et al., 2019; Dive & Lakade, 2021; Abdulkhadar et al., 2021; Grigorev & Nosov, 2022; Sepsi et al., 2022).

A new innovative technique being non-complex and effective is needed due to the costly methods and the difficulties in applying these measurement techniques to the overall structure (Nelson, 2010; Huang et al., 2013; Yoshida et al., 2016). In this study, a new method based on optical principles is proposed to detect the stress and strain around the junction of metal plates in situ. The Lorentz-Drude model, which establishes a relationship between the refractive index and the dielectric coefficient of the conductors, is known as the most useful model for determining the optical properties of metals. According to the Lorentz-Drude model, any externally induced change, such as strain or stress, in the plasma frequency of a conductor causes a differential change in the actual refractive index of the metal (Drude, 1900; Hecht, 2002). Also, we calculated the rate of reflection as a function of stress by solving Fresnel's equations for laser radiation with S- and P-polarization at different angles of incidence for AISI4140 and DUPLEX metals. Our theoretical results showed that the proposed method based on an optical method is suitable to determine the stress or strain rate around the junction of metal plates.

Table 1. Comparison of conventional residual stress measurements techniques

Parameter	**Destructive and Semi-Destructive Methods**					
	Mechanical Methods				***Chemical Methods***	
	Hole Drilling	*Slitting*	*Ring Core*	*Counter*	*Stripping*	*Qualitative Measurements*
Cost	Mid	High	High	High	Mid	Low
Applicability	Low	Mid	Low	Mid	Low	Low
Preliminary	High	High	High	High	Mid	High
Reliability	High	High	High	Mid	Mid	Low
In-situ App.	Low	Low	Low	Low	Low	Low
Maintenance Cost	High	High	High	High	Mid	Mid

Parameter	**Non-Destructive Methods**						
	Diffraction Methods		***Ultrasonic Methods***	***Magnetic Methods***		***Optic Methods***	
	Neutron Ray	*X-Ray*	*Ultra-sound*	*Magnetic Strain*	*Magneto Mechanic*	*Raman Spect.*	*Fresnel Approx.*
Cost	High	High	Mid	High	High	Mid	Low
Applicability	Low	Low	Mid	Mid	Low	Low	High
Preliminary	High	High	Mid	High	High	High	Low
Reliability	High	High	Mid	Low	Mid	Low	Mid
In-situ App.	Mid	Mid	Mid	Low	Low	Low	High
Maintenance Cost	High	Mid	Mid	Mid	High	Mid	Low

MATERIAL AND METHODS

The dielectric and optical properties of metals change due to mechanical effects, such as stress or strain (Hristoforou et al., 2018; Vourna et al., 2018). Thanks to these properties, the mechanical state of steel can be determined by measuring the dielectric and optical properties of metal structures. These properties are affected differently by applied stress that causes elastic or residual stress (plastic deformation). Thus, these two effects can be distinguished from each other using optical methods (Qiu et al., 2018). Although the Drude model is quite simple, it is considered to be the first realistic model to describe the electrical conductivity, thermal conductivity, and optical properties of metals (Drude, 1900). The optical properties of metals can be identified more realistically using the Lorentz-Drude model. This is because the Lorentz-Drude model includes free and bound electrons (Drude term) and harmonically bound particles (Lorentz oscillator). Rakić (1995) and Johnson & Christy (1972) reorganized the Lorentz-Drude model for different plasma frequencies and binding energy states and validated their model experimentally. Experimental studies related to the optical properties of metals have shown that it is more convenient to describe the optical transmittance of metals by adding the Lorentz oscillation terms to the Drude model (Vial et al., 2005; Umeda et al., 2009). The free movement of electrons within the metal atoms causes a change in the electric potential distribution in the metal and leads to the re-arrangements of the electrons under external pressure. This restructuring in the electric potential within the metal creates small changes in the dielectric coefficient of that particular metal material. The expression defining the relationship between the electric field and polarization of the dielectric displacement of the metal medium is as follows (Eq. 1):

$$D = \varepsilon_0 E + P = \varepsilon_r \varepsilon_0 E \quad (1)$$

In the Drude model, only the intraband transitions are considered since the electrical permeability of metal is characterized by free electrons (Eq. 2) (Ehrenreich & Philipp, 1962). However, the interband transitions, which correspond to the transitions between the valence and conduction bands, play an important role in determining the dielectric function. By using the model, the real refractive indices of metals can be accurately calculated in the presence of an external electromagnetic field (Eq. 3). The Lorentz-Drude model is a combination of the terms of the Drude model and Lorentz oscillator terms, including both transitions Lorentz-Drude model (Markovic & Rakic, 1990; Rakić, 1995);

$$\varepsilon_R = \varepsilon_{intraband} + \varepsilon_{interband} \quad (2)$$

$$\varepsilon_R = \varepsilon_\infty - \frac{\Omega_p^2}{(\omega^2 + i\omega\Gamma_0)} + \sum_{j=1}^{m} \frac{f_j \omega_p^2}{\left((\omega_j^2 - \omega^2) + i\omega\Gamma_j\right)} \quad (3)$$

For conductive media such as metals, the refractive index consists of a real and an imaginary component.

$$\tilde{n} = \sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{1 + i\left(\frac{\sigma}{\varepsilon_0 \omega}\right)} = n_r + i\kappa \quad (4)$$

Here, σ refers to the conductivity, ω to the plasma frequency of the metal, and ε_0 to the electrical susceptibility coefficient of the free space (Eq. 4). If the refractive index is complex;

$$\varepsilon_{med} = \varepsilon_0 \tilde{n}^2 = \varepsilon_0 (n + i\kappa)^2 \quad (5)$$

Here, n refers to the real refractive index and κ to the absorption coefficient of conductive medium (Eq. 5).

$$n = \sqrt{\frac{1}{2\varepsilon_0}(|\varepsilon| + \varepsilon_R)}\ \kappa = \sqrt{\frac{1}{2\varepsilon_0}(|\varepsilon| - \varepsilon_R)} \quad (6)$$

If the conductivity is high, κ will be small since it will be $\sigma/\varepsilon_0\omega >> 1$ and the surface will exhibit high reflectivity. The expression of dielectric function for metals is as follows:

$$\varepsilon(\omega) = \varepsilon_0 \left(1 - \frac{\omega_p^2}{\omega^2 + i2\omega\Gamma}\right) \quad (7)$$

Here, ω_p refers to the plasma frequency of the metal, and ω to the frequency of the external field (Eq. 7). Since electrons are considered free for metals in the Drude model, the plasma frequency will be large, and the imaginary part of the dielectric coefficient will move to zero exempt from the vicinity of Brewster's Angle. The following is the familiar expression between the dielectric constants and the real index of refraction:

$$n = \frac{c}{v} = c\sqrt{\mu\varepsilon_r} = \sqrt{\frac{\mu_r\varepsilon_r}{\mu_0\varepsilon_0}} \quad (8)$$

Here, c refers to the speed of light, v to the speed of light in the conductive medium, μ to the magnetic susceptibility (permeability) of the material, and ε to the electrical susceptibility (permittivity) of the material. The change between the interband transitions under pressure or strain causes a change in electrical susceptibility (permittivity). This appears as a change in the real refractive index of the material (Jiles, 1988). When the electromagnetic wave comes to an interface, the transmission and reflection rates depend on the real and imaginary refractive indices on both sides of the interface. The equations, whose refractive indices determine the behavior of light at the interfaces of different optical media, were derived by the French physicist Augustin-Jean Fresnel and named the Fresnel equations (Eqs. 9, 10) (Hecht, 2002; Pedrotti et al., 2017). Fresnel's equations can be derived by solving Maxwell's equations, assuming an ideal planar surface. The reflection formula for a random polarization can be expressed from two basic solutions when the oscillation (polarization) of the EM Wave is parallel (S-polarization) or perpendicular (P-polarization) to the surface. Fresnel's equations are used to determine the amplitude of the reflected beam according to the polarization of the incident light and the angle of incidence (Pedrotti et al., 2017). According to the S-polarization (parallel) and P-polarization (perpendicular) of the incident light, the reflection ratio is defined, respectively;

$$R_S = \frac{E_R}{E_i} = \frac{\cos\theta_i - \sqrt{\tilde{n}^2 - \sin^2\theta_i}}{\cos\theta_i + \sqrt{\tilde{n}^2 - \sin^2\theta_i}} \quad (9)$$

$$R_P = \frac{E_R}{E_i} = \frac{-\tilde{n}^2\cos\theta_i + \sqrt{\tilde{n}^2 - \sin^2\theta_i}}{\tilde{n}^2\cos\theta_i + \sqrt{\tilde{n}^2 - \sin^2\theta_i}} \quad (10)$$

Here, θ_i refers to the angle of incidence of the light, E_R to the amplitude of the reflected EM wave, E_i to the amplitude of the incident EM wave, and $\tilde{n} = n + i\kappa$ to the complex refractive index. When Eq. 4 is substituted for Eqs. 9 and 10, the Fresnel equations of both polarizations for metal surface with the complex refractive index;

$$R_S = \frac{E_r}{E_i} = \frac{\cos\theta_i - \sqrt{(n^2 - \kappa^2 - \sin^2\theta_i) + i(2n\kappa)}}{\cos\theta_i + \sqrt{(n^2 - \kappa^2 - \sin^2\theta_i) + i(2n\kappa)}} \quad (11)$$

$$R_P = \frac{E_r}{E_i} = \frac{-[(n^2 - \kappa^2) + i(2n\kappa)]\cos\theta_i + \sqrt{(n^2 - \kappa^2 - \sin^2\theta_i) + i(2n\kappa)}}{[(n^2 - \kappa^2) + i(2n\kappa)]\cos\theta_i + \sqrt{(n^2 - \kappa^2 - \sin^2\theta_i) + i(2n\kappa)}} \quad (12)$$

The reflectance at the interface of metals is a function of the angle of incidence and the complex refractive index. Changes in the angle of incidence and complex refractive index cause a change in the amplitude of the EM wave reflected from the metal. In the case of an incoming EM wave at the Brewster angle, the absorption at the surface has a maximum value and partial reflection occurs. Metal surfaces generally exhibit high reflectivity. On these surfaces, the absorption at the angles of incidence other than the Brewster angle will be quite low. In this case, the contribution of the value κ in Eqs. 11 and 12 to the function can be ignored. Therefore, the complex refractive index was operationalized as the constant in the calculations. Eq. 8 was used to calculate the refractive index caused by strain or stress.

RESULTS AND DISCUSSION

Lattice distortions, caused by stress or strain in metal structures during production or their service cycles, result in the rearrangement of both the metal grains and the electric-magnetic fields within the metal (Iordache et al., 2003; Perevertov, 2007). Magnetization within the metal structure involves the nucleation and movement of the magnetic walls; thus, the microstructure in steel is strongly correlated with the changes in grain size, stress state, and deformation (Shea, 2005; Jiménez et al., 2017). In their study on the non-destructive testing of metal structures, Hristoforou et al. (2018) experimentally measure the surface magnetic susceptibility of AISI4140 and DUPLEX metal under pressure. They experimentally show that magnetic susceptibility changes as a function of pressure between -300 MPa and +300 MPa. 300 MPa corresponds to 3059 Kilogram-force/Square Centimeter (kg/cm²), this value corresponds to the load values that can occur on ships due to loading and waves (Asmael et al., 2020).

$$\mu(P) = a_0 + a_1P + a_2P^2 \quad (13)$$

In this article, firstly, the experimental data found by Hristoforou et al. (2018) were fit to a 2nd-order polynomial (Eq. 13) and calculated the magnetic

susceptibility as a function of pressure. The experimental data and calculated values for the magnetic susceptibility are shown in Figure 1. Moreover, the iteration coefficients determined for AISI4140 and DUPLEX are presented in Table 2. The correlation coefficient (R^2) for both materials is about 1 which is the ideal value for an iteration.

The refractive index is mainly dependent on temperature, pressure (or intensity of material), and frequency of incident light. The square of the refractive index was found to be proportional to the product of the intensity and the average polarizability (Malitson, 1965; Tan, 1999; Tan & Arndt, 2001). The density and molecular arrangement of solid materials partially increase under pressure; as a result of these effects, the refractive index also increases depending on the pressure. The pressure-dependent values of the refractive index were calculated with Eq. 8 by operationalizing the data in Eq. 13 and Table 3. It can be seen that the refractive index of both AISI4140 and DUPLEX material increases with pressure as expected.

Table 2. Coefficients of Eq. 13 fitted to experimental data for AISI 4040 and DUPLEX

	a_0	$a_1(\frac{1}{MPa})$	$a_2(\frac{1}{MPa^2})$	R^2
AISI4140	801.09	1.35	9.49x10-4	0.99
DUPLEX	457.11	0.39	1.53x10-4	0.92

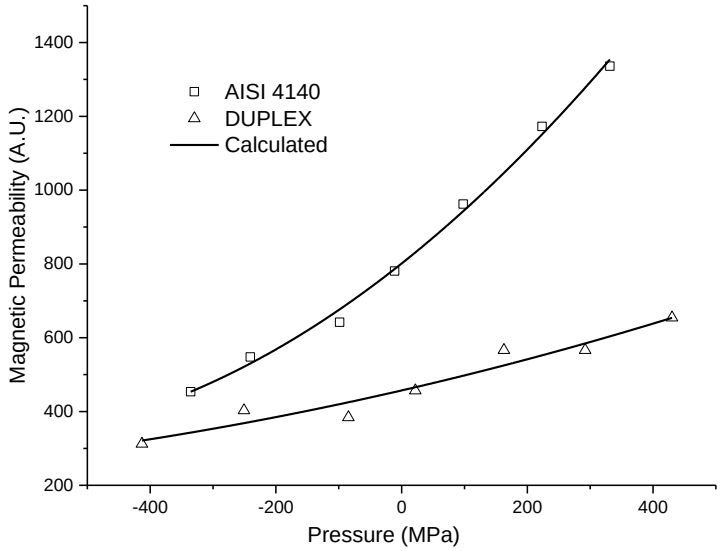

Figure 1. Experimental and calculated values of pressure-dependent permeability

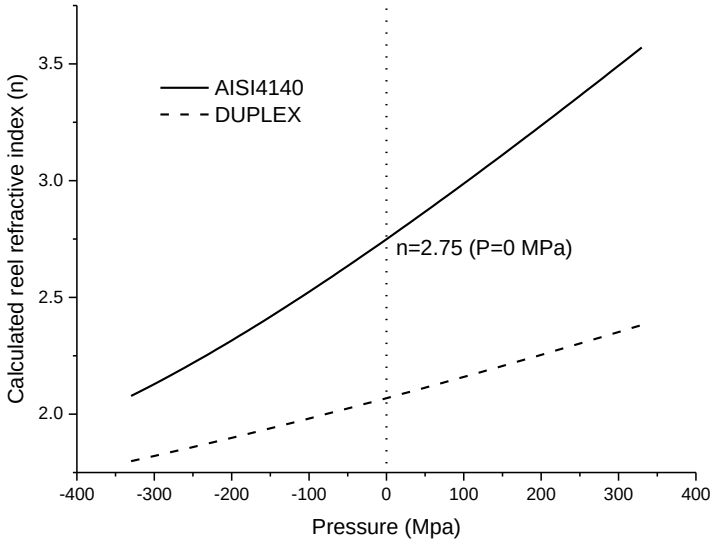

Figure 2. The calculated reel refractive index for AISI 4040 and DUPLEX as a function of pressure

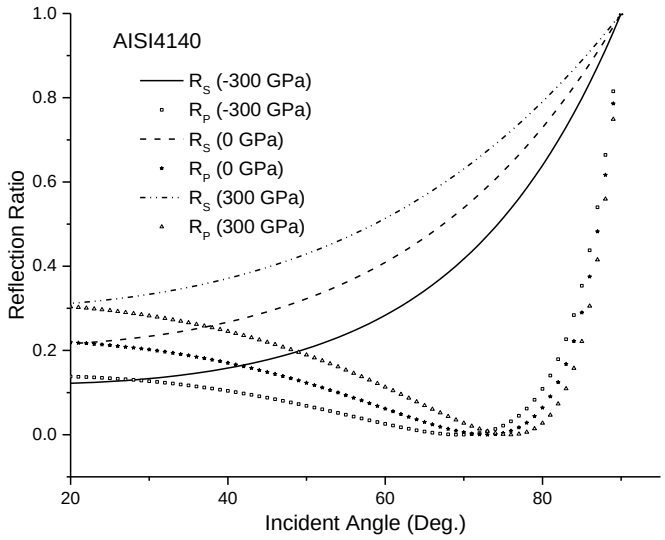

Figure 3. Reflection ratio for AISI4140 material depending on the angle of incident light with S- and P- polarization

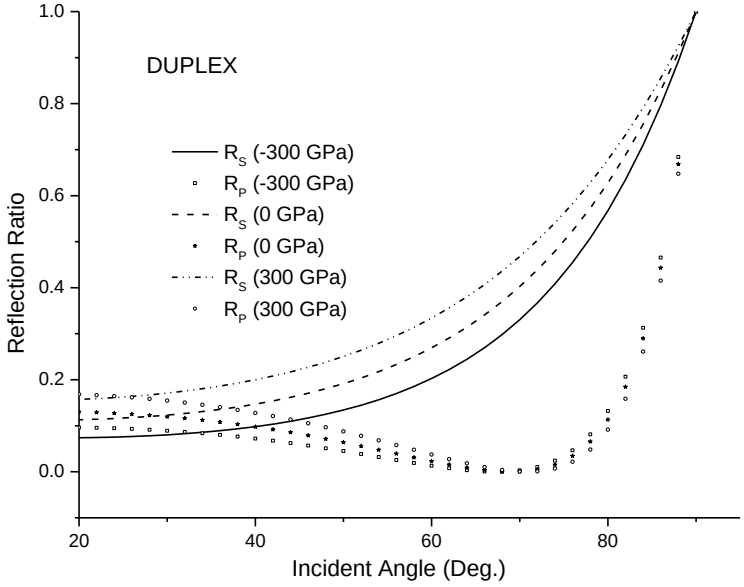

Figure 4. Reflection ratio for DUPLEX material as a function of the angle of incident light with S- and P- polarization

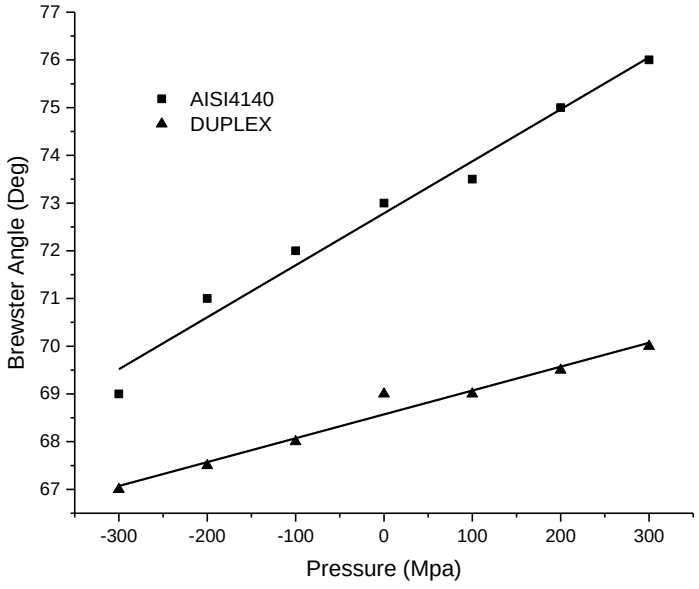

Figure 5. Brewster angle as a function of pressure for AISI4140 and DUPLEX material

Table 3. Reel refractive indices of AISI4140 and DUPLEX material at various pressure

Pressure	Refractive Index (n)	
(MPa)	AISI 4140	DUPLEX
-300	2.128	1.821
-200	2.315	1.898
-100	2.524	1.981
0	2.749	2.068
100	2.987	2.159
200	3.236	2.254
300	3.492	2.352

Table 4. Pressure-dependent Brewster angle values for AISI4140 and DUPLEX material

Pressure	Brewster Angle (Degree)	
(MPa)	AISI 4140	DUPLEX
-300	69	67
-200	71	67.5
-100	72	68
0	73	69
100	73.5	69
200	75	69.5
300	76	70

The reflection ratios for AISI4140 and DUPLEX materials were calculated as a function of pressure for the single-wavelength laser light coming in S- and P-polarization with Eqs. 12 and 13. Figures 3 and 4 show the calculated reflection ratios for these materials. The calculated values were normalized to 1 in order to get a better resolution. It was observed that the reflection ratio of the light with S- and P- polarization increased when the pressure was increased for a constant angle of incidence in both materials. This behavior can be attributed to the behavior of the refractive index. The refractive index of AISI 4140 material varies more predominantly depending on the applied pressure compared to DUPLEX material, as shown in Figure 1. Therefore, the dependence of the reflection ratios on the angle of incidence for both S- and P- polarization was determined to get higher as the pressure increased (Figures 3 and 4). One can see from Figures 3 and 4 that the Brewster angle shifts slowly with the pressure increasing for both metals.

It is known that metals are a function of the angle of incidence reflectivity for a P-polarized laser beam and they have a minimum value for a given wavelength and refractive index at the Brewster angle. Absorption at the Brewster angle is maximum, and this angle can be much bigger than the normal angle of incidence (Hüttner, 1995). Brewster's angle is an important parameter in applications of lasers for determining linearly polarized light by reflections at the mirror like metal surface. The Brewster angle is strongly dependent on the photon energy and is not easy to measure experimentally, but it provides important information about the angle of incidence to be measured. The Brewster angle values were calculated for both materials from the minimization of Eq. 13 (Figure 5, Table 4).

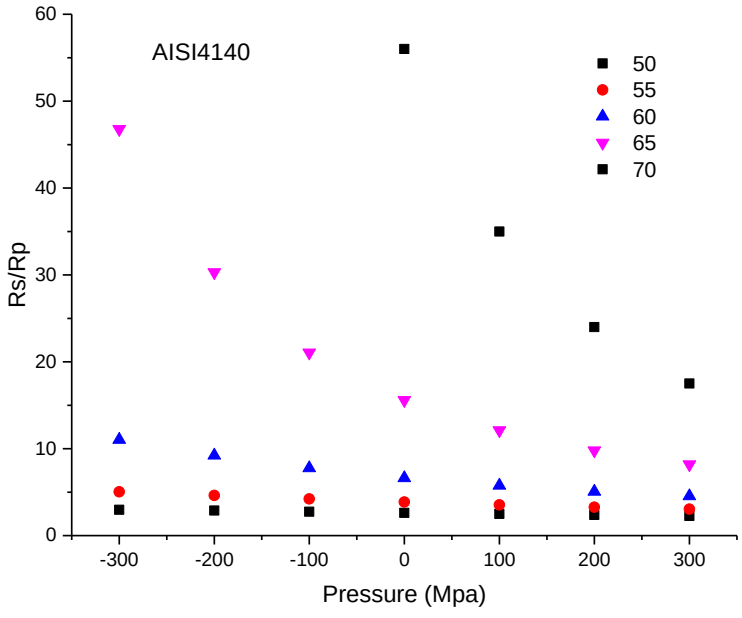

Figure 6. Rs/Rp ratio for AISI4140 material at different angles of incidence depending on pressure

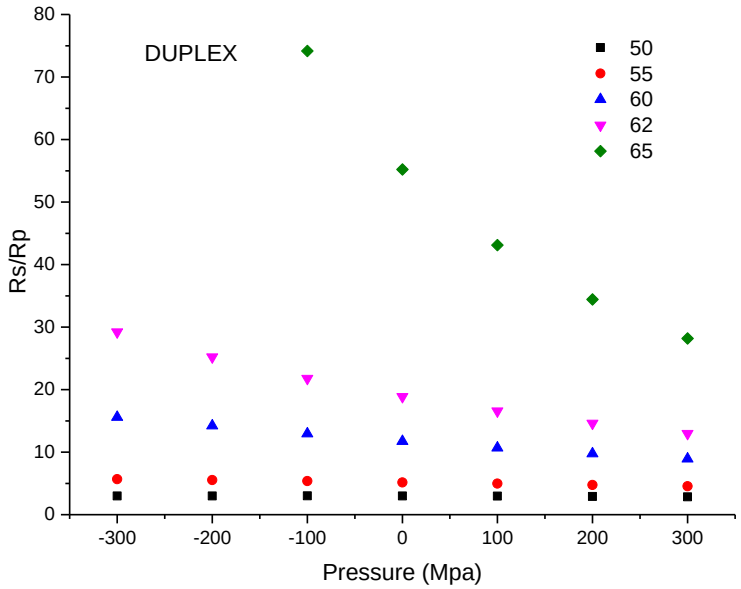

Figure 7. Rs/Rp ratio for DUPLEX material at different angles of incidence depending on pressure

Table 5. Rs/Rp ratios for AISI4140 and DUPLEX at different angles of incidence depending on pressure

Angle of Incidence (Degree)	Rs/Rp					
	AISI4140			*DUPLEX*		
	-300 Mpa	*0 MPa*	*300 MPa*	*-300 MPa*	*0 MPa*	*300 MPa*
50	2.97	2.62	2.26	2.99	2.99	2.85
52.5	3.79	3.13	2.60	3.99	3.84	3.54
55	5.03	3.86	3.04	5.68	5.16	4.55
57.5	7.13	4.93	3.65	8.79	7.42	6.15
60	11.04	6.63	4.54	15.59	11.73	8.93
62.5	19.76	9.60	5.89	35.49	21.73	14.44
65	46.78	15.58	8.18	151.47	55.22	28.19
67.5	239.83	31.06	12.55	22518	370.32	82.72
70	2399.42	99.43	23	-	-	-

The Brewster angle variation concerning the pressure of AISI4140 is differentially greater than that of DUPLEX, and this behavior is attributed to the change in the refractive index under pressure, and also in the reflection ratios. The Brewster angle for AISI4140 material was observed to change substantially at pressures ranging from -300 MPa to +300 MPa and to be linearly dependent. This shows that stress or strain values can be determined from Brewster's point of view in structures with high load density – e.g., ships – using this parameter.

It is difficult to determine the Brewster angle in experimental measurements (Hüttner, 1995). Therefore, it would be a much more accurate approach to look at the reflection rate of the incident laser light with S- and P- polarization. Rs/Rp ratios for the different angles of incidence under the Brewster angle for both materials were calculated with Eqs. 12 and 13 as a function of pressure (Figures 6 and 7, Table 5). As expected, it was observed as regards both materials that this ratio became larger as it got closer to the Brewster angle. In order to determine strain or stress

by analyzing the light reflection with S- and P-polarization in AISI4140 and DUPLEX materials, the incidence angles of 65° and 62°, respectively, were determined to be the most suitable values.

CONCLUSION

Structures (e.g., ships) formed with the assembly of large metal parts are exposed to high stress and strain throughout their service cycles. If the stress occurring during loading is above the value determined as the design parameter, it will cause temporary or permanent deformations in the structure. There is a need for on-site measurement methods for real-time predictive maintenance in order for the structure to complete its optimum life cycle and to reduce the cost of troubleshooting.

In this study, considering the change in the refractive index resulting from the rearrangement of the electronic structure of AISI4140 and DUPLEX materials under pressure, the pressure-dependent derivation of Fresnel's equations was performed, and the reflection rates were calculated for the pressure-dependent refractive index and laser light incident with the Brewster angle and S- and P- polarization. The results show that the method proposed herein can be used to measure residual stresses in metal structures by adopting a non-destructive and relatively simple optical method.

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Compliance with Ethical Standards

Authors' Contributions

Both authors have contributed equally to the paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

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

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The Effect of Using Wheat Protein as a Protein Source on Some Blood Parameters in Juvenile Sea Bass (*Dicentrarchus labrax*) Feeds

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ABSTRACT

In this study, wheat protein was substituted for fish meal at different rates (25%, 50%, 75%, 100%) in sea bass (*Dicentrarchus labrax*) fish feed and the effects on some blood parameters were investigated. The initial weight of 450 sea bass fish used in the study was calculated as 2.33 ± 0.2 g. Sea bass fry, 30 in each aquarium, were fed with experimental feeds for 60 days in triplicates. At the end of the experiment, hematological and biochemical blood parameters were analyzed. As a result, it was found that the use of wheat protein at a high rate had statistically significant effects on blood parameters.

Levrek (*Dicentrarchus labrax*) Yavru Yemlerinde Protein Kaynağı Olarak Buğday Proteini Kullanımının Bazı Kan Parametreleri Üzerine Etkisi

MAKALE BİLGİSİ

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Anahtar Kelimeler:
Levrek buğday proteini
Kan biyokimyası

ÖZET

Bu çalışmada yavru levrek balığı (*Dicentrarchus labrax*) yemlerinde farklı oranlarda (%25, %50, %75, %100) balık ununa ikame buğday proteini kullanılmasının bazı kan parametreleri üzerine etkisi araştırılmıştır. Çalışmada kullanılan toplam 450 adet levrek balığının başlangıç ağırlığı 2,33 ± 0,2 g olarak hesaplanmıştır. Levrek yavruları 60 gün süresince hazırlanan deneysel yemlerle her bir akvaryumda 30 adet olacak şekilde üç tekerrürlü kurgulanmış sistemde beslenmişlerdir. Deneme sonunda kan numunelerinde hematolojik ve biyokimyasal kan parametreleri analiz edilmiştir. Bulgular neticesinde yüksek oranda buğday proteini kullanımının kan parametreleri üzerinde önemli etkiler yaptığı istatistiksel olarak belirlenmiştir.

GİRİŞ

İnsanlar açısından çok değerli besin kaynağı olan balık stoklarının gün geçtikçe azalması, beraberinde birçok sorun getirmektedir. Bu nedenle insanların besin ve protein ihtiyacının karşılanması için denizlerde ve iç sularda çeşitli su ürünleri üretim tesisleri kurulmaktadır. Ancak kurulan tesislerde balık üretim maliyetleri oldukça yüksektir. Bir balık çiftliğinde işletme giderlerinin yaklaşık %50'sini yem maliyeti oluşturmaktadır (Gültepe, 2020). Bu nedenle dünya genelinde maliyeti düşük alternatif yem kaynaklarının kullanılmasına yönelim artmıştır Su ürünleri yetiştiriciliğinde maliyetlerin azaltılması ve üretimin artırılabilmesi için yem üretiminin sürdürülebilir olması gerekmekte bu da sürekliliği olan ve ucuz hammaddelere ihtiyacı açığa çıkarmaktadır. Balık yem katkı maddelerinden sürekliliği olan ve maliyeti düşük bir ham madde de buğdaydır. Cowey (1992), balık yetiştiriciliğinde maliyetin %40 ile %60 arasını yem giderlerinin oluşturduğunu belirtmiştir. Balık yetiştiriciliğinde yem formülasyonu balığın yaşam koşullarına, gelişim evrelerine ve fizyolojik durumuna göre yapılmalı ve ayrıca hazırlanan yem formülasyonu yemin fiziksel, kimyasal ve biyolojik kalitesini arttıracak özellikte olmalıdır.

MATERYAL VE YÖNTEM

Deneme Yeri ve Sistemi

Bu araştırma, Çanakkale Onsekiz Mart Üniversitesi Deniz Bilimleri ve Teknolojisi Fakültesi Canlı Balık Yetiştirme Ünitesinde kurulan kapalı devre deniz sisteminde yapılmıştır. Bu sistemde çökeltme tankı, kaba filtrasyon, kum filtre, biyolojik filtre ve ısıtma-soğutma ünitesinden oluşmaktadır. Deneme 30 L hacmindeki fiberglas tanklarda gerçekleştirilmiştir. Toplamda 60 gün süren çalışmada günlük olarak %10-15 oranlarında su değişimi uygulanmıştır. Ayrıca otomatik zamanlayıcılar yardımıyla 12 saat aydınlık, 12 saat karanlık fotoperiyodu uygulanmıştır.

Deneme Yemleri

Yem ham maddeleri balık yemi üreten bir ticari işletmeden temin edilmiştir. Balık unu, buğday unu, mısır nişastası, balık yağı ve vitamin-mineral karışımı, nem, protein, yağ ve kül gibi besin maddesi analizleri yapılmıştır (AOAC, 1998). Balık ununa ikame protein kaynağı olarak buğday proteini ile %0 (kontrol), %25, %50, %75 ve %100 oranlarında hazırlanan deneme yemlerine ait yem formülasyonu Tablo 1'de verilmiştir.

Balıklardan Kan Örneklerinin Alınması ve Analizi

Beleme çalışması sonunda her tanktan 4 adet balık (12 balık/grup) analizlerde kullanılacak kanın örneklenmesi için tam şansa dayalı yöntem ile seçilmiştir. Balıklar, doğal bir ürün olan ve yaygın olarak kullanılan karanfil yağı ile bayıltılmış (Mylonas vd., 2005), kana mukoza karışmaması için alkolle anüs yüzgecinin hemen arka kısmı iyice temizlendikten sonra en kısa süre içerisinde, 5 ml'lik plastik enjektörle kaudal venadan girilerek balığa zarar vermeden, kan alınmıştır (Val vd., 1998).

Biyokimyasal analizler için alınan kan 4000 rpm devirde 10 dakika santrifüj edilip (Bricknell vd., 1999) kan serumu ayrıldıktan sonra analizleri kit (Bioanalytic) kullanılarak spektrofotometrede yapılmıştır. Denemede glikoz (GLİ), toplam protein (TPROT), trigliserit (TRİ), kolesterol (KOL) AST ve ALT ve ALP biyokimyasal parametreler belirlenmiştir (Bulut vd., 2010).

Toplam eritrosit (RBC) ve lökosit (WBC) sayıları, hematokrit (Hct) değerleri, hemoglobin (Hb) içeriği konvansiyonel metotla belirlenmiştir. Eritrosit indeksleri; ortalama hücresel hemoglobin (MCH), ortalama hücresel hacim (MCV) ve ortalama hücresel hemoglobin konsantrasyonu (MCHC) formülerle hesaplanmıştır (Gültepe vd., 2012).

İstatistiksel Değerlendirmeler

Deneme sonunda elde edilen veriler SPSS istatistik programının tek yönlü varyans analizi (ANOVA) testi ile analiz edilmiş ve Tukey, Scheffe ve Duncan çoklu karşılaştırma testleri ile karşılaştırmalar yapılmıştır. Ortalamalar arasındaki farklılıklar 0.05 önem düzeyinde test edilmiştir.

Table 1. The feed formulation used in the experiment
Tablo 1. *Denemede kullanılan yem formülasyonu*

Yem İçeriği	Kontrol	BUP 25%	BUP 50%	BUP 75%	BUP 100%
Balık unu (g/kg)	60	45	30	15	0
Buğday proteini (g/kg)	0	15	30	45	60
Mısır nişastası (g/kg)	11	10,5	10	9,5	9
Buğday unu (g/kg)	15	15	15	15	15
Vitamin (g/kg)	4	4	4	4	4
Balık yağı (g/kg)	10	10,5	11	11,5	12

% (g/kg)	100	100	100	100	100

Not: BUP: Balık unu proteini; Hamsi balık unu: Koptur Balıkçılık. Trabzon. Türkiye. Hamsi balık yağı: Agromarin Yem San. ve Tic. A.Ş. İzmir. Türkiye. Vitamin karışımı: Vitamin A, 18000 IU kg^{-1}yem; Vitamin D_3, 2500 IU kg^{-1} yem; Vitamin E, 250 mg kg^{-1} yem Vitamin K_3, 12 mg kg^{-1} yem; Vitamin B_1, 25 mg kg^{-1} yem; Vitamin B_2, 50 mg kg^{-1} yem; Vitamin B_3, 250 mg kg^{-1} yem; Vitamin B_6, 20 mg kg^{-1} yem; Vitamin B_{12}, 0,06 mg kg^{-1} yem; Vitamin C, 220 mg kg^{-1} yem; Folik asit, 10 mg kg^{-1} yem; Kalsiyum d–pantothenate. 50 mg kg^{-1} yem; Biyotin, 1 mg kg^{-1} yem; İnositol, 210 mg kg^{-1} yem; Kolin Klorid, 2000 mg kg^{-1} yem.

Table 2. Changes in hematological and biochemical blood parameters of sea bass (Dicentrarchus labrax) fed different experimental feeds

Tablo 2. *Farklı deneysel yemlerle beslenen Yavru levrek (Dicentrarchus labrax) balıklarının hematolojik ve biyokimyasal kan parametrelerindeki değişimler*

	Kontrol	**25**	**50**	**75**	**100**
RBC ($x10^4 uI^{-1}$)	67,79±7,1^a	73,2±7^a	68,06±5,86^a	57,32±7,39^b	46,27±7,94^b
Hb (g dl^{-1})	6,37±0,22^b	7,44±0,11^a	7,20±0,18a	6,46±0,01^b	5,44±0,02^c
Hct (%)	19.18±1,03^b	21,09±0,92^a	22,59±0,51^a	20,10±0,21^b	18,98±1,02^c
MCH	90,95±9,36^c	98,88±12,37^b	105,27±21,84^a	86,57±9,05^c	98,67±20,36^b
MCHC (g dl^{-1})	32,38±2,52^b	33,06±2^a	33±2,64^a	33,4±1,44^a	33,95±2,24^a
MCV	245,28±38,12^b	268,25±38,97^b	307,73±22,93^a	305,6±22,3^a	312,2±58,02^a
WBC(%)	20,44±0,49^a	20,52±0,49^a	21,36±0,37^a	19,53±0,35^b	20,48±0,38^a
Lym(%)	68,34±1,87^b	70,93±0,73^a	73,01±1,81^a	67,24±2,13^b	70,30±1,90^a
Neutrofil(%)	22,23±2,35^a	20,57±1,97^b	20,25±1,79^b	22,48±1,4^a	22,26±0,70^a
AST (Ul^{-1})	273,16±37,99^a	260,61±23,54^a	201,86±58,46^c	244,63±100^b	248,76±98,60^b
ALT (Ul^{-1})	368,86±159,63^b	427,96±105,10^a	416,08±184,45^a	338,90±11,45^c	338,84±122,47^c
ALP (Ul^{-1})	66,33±15,65^b	54,43±8,10^c	56,01±8,63^c	70,15±9,54^a	65,45±5,45^b
GLC (mg dl^{-1})	262,3±63^a	182,66±51,11^c	237,97±60,53^b	260,96±92,6^b	286,66±94,85^a
CHOL (mg dl^{-1})	49,43±6,51^a	45,11±5,05^a	37,5±8,07b	49,75±9,85^a	49,81±7,6^a
Tprot (mg dl^{-1})	1,39±0,006^a	1,23±0,01^b	1,30±0,02^a	1,31±0,02^a	1,31±0,006^a
Trig (mg dl^{-1})	95,48±14,10^b	133,93±11,63^b	131,23±7,37^b	136,31±9,88^a	139,40±18,45^a

Not: Aynı satırda farklı üstel harfler içeren gruplar istatistiksel açıdan diğer gruplardan farklıdır(P< 0,05).

BULGULAR VE TARTIŞMA

Araştırma sonunda deneme yemleriyle beslenen yavru levrek balıklarında elde edilen bazı hematolojik ve biyokimyasal kan parametreleri Tablo 2'de gösterilmiştir.

Bugüne kadar karnivor balık yemlerinde kullanılan protein kaynaklarının ikame oranı büyüme performansı temel alınarak belirlenmeye çalışılmıştır. Ancak, günümüzde balık yemlerinde kullanılan bu alternatif kaynakların balık sağlığına ve büyümesine olan etkilerinin araştırılması daha da önemli hale gelmiştir. Bundan dolayı hematolojik ve serum biyokimyasal kan parametrelerinin yorumlanması balıkların sağlığı ve gelişimi hakkında çok önemli bilgiler vermektedir. Aynı zamanda kan parametreleri, balık sağlığı ve refah durumunu, terapötik tedavilerin etkilerini, beslenmenin yanı sıra çevre yönetimini izlemek için önemlidir (Gültepe vd., 2017; Gültepe & Gültepe, 2020). Balıkların hematolojik parametreleri, bir dizi faktörden etkilenebilir: türler, boyut, yaş, fizyolojik durum, çevresel koşullar ve diyet rejimi (kalite ve beslenme miktarı, diyet içerikleri, protein kaynakları, vitaminler, probiyotikler) (Barnhart, 1969; Lim vd., 2000; Brunt & Austin, 2005; Osuigwe vd., 2005, Gültepe vd., 2015).

Hematolojik parametrelerden kırmızı kan hücre sayısı (RBC), hematokrit (HCT), hemoglobin (Hb) ve eritrosit indeksleri balıkların stres veya hastalık durumlarının tespitinde kullanılan önemli parametrelerdendir (Campbell, 2004).

Bu çalışmada yavru levrek yemlerine farklı oranlarda (%25, %50, %75, %100) buğday proteini ilavesinin hematolojik parametrelerden eritrosit seviyelerinde bazı değişimler tespit edilmiştir. Rasyondaki buğday unu proteini miktarı arttıkça eritrosit seviyesinde önemli değişimler gözlenmiştir (p<0,05). Buğday unu miktarı arttıkça eritrosit seviyesi düşmüştür. İdealinin %50 buğday proteini kullanılan yem olduğu görülmüştür. Fazla miktarda (%75 ve %100) yeme buğday proteini katılmasının balığın sağlığı açısından zararlı olabilme olasılığı bulunmaktadır. Hemoglobin seviyeleri incelendiğinde kontrol grubuna göre gruplar arasında önemli değişimler gözlenmiştir (p<0,05). Yeme katılan buğday proteini miktarı arttıkça hemoglobin seviyesinde de önemli bir azalma görülmüştür (p<0,05). Aynı

şekilde benzer sonuçlar hematokrit içinde geçerli olup hematokrit seviyesinde önemli farklılık görülmüştür ($p<0,05$). Yemdeki buğday proteini arttıkça levrek yavrularının hematolojik parametrelerinde önemli bir değişim gözlenmiştir. Bu değişim yem içindeki buğday proteini arttıkça hematolojik parametrelerde azalma gözlenmiştir. Benzer bir araştırmada alabalık yavruları ile yapılan bir araştırmada (Akrami vd., 2007; Sheikholeslami vd., 2007; Hoseinifar vd., 2011) yeme farklı oranlarda oligofruktoz ilave etmişler ve sonucunda hematolojik parametrelerde bir değişim gözlemişlerdir. Yemlere katılan bitkisel kaynaklı hammaddelerin oranları arttıkça balıkların kan değerlerinde önemli değişimler gözlenmektedir. Balık unu yerine %40-100 oranlarında buğday glüteni, mısır glüteni ve soya unu içeren yemler ile beslenen alabalıkların hematolojik parametrelerinde önemli değişimler gözlenmiştir (Jalali vd., 2013). Yapılan çalışmada da buğday proteini ikame oranı değiştikçe sonuçlar daha farklı çıkmıştır($p<0,05$). Bu çalışma ile benzer olarak yüksek oranda bitkisel (%50) içerikli yemler ile beslenen gökkuşağı alabalıklarının HCT oranı ve Hb değeri önemli oranda azalmıştır. Yapılan bütün çalışmalara bakıldığında bitkisel kaynaklı hammaddelerin balık yemlerinde yüksek oranda kullanılması ile balık kan parametrelerinde önemli değişimler meydana getirmiştir. Yemdeki buğday unu proteininin yavru levrek balıklarında RBC, WBC, Hb, Hct, MCV, MHC, MCHC Lym ve oranlarını önemli ölçüde etkilediği görülmüştür (Tablo 2). Yemdeki oran arttıkça hematolojik parametrelerde bir düşüş gözlenmiştir. Bu düşüşün sebebi farklı immünolojik araştırmalar ile belirlenebilir. Ayrıca bu olaya birçok çevresel faktörler (Goel vd., 1981; Azizoğlu & Cengizler 1996) etki etmiş olabilmektedir. Kan parametreleri türler arasında farklılık gösterebileceği gibi aynı tür balıklar arasında da su kalitesi, örnekleme metodu ve beslenmeye bağlı olarak farklılık gösterebilmektedir (Gallaugher & Farrell, 1998). Araştırmada kapalı devre sistem kullanılmış olup çevresel faktörler kontrol altında tutulmuştur. Su kalite parametrelerinde herhangi bir değişim olmamıştır.

Balıklarda AST, GOT, GPT, LDH ve ALP karaciğer enzimleri olup karaciğer ile ilgili sorunların teşhisinde değerlendirilmektedir (Campbell, 2004; Hart vd., 2010). Ayrıca çoklu enzimlerin değerlendirilmesi, doku hasarının endikasyonları için değerli bir araç olarak kabul edilir, mikrobiyolojik ve histopatolojik teknikleri tamamlayabilir (Racicot vd., 1975). Bu çalışmada, serum, AST, ALT ve ALP seviyeleri yeme katılan farklı oranlardaki buğday unu proteini ile bu enzim seviyelerinde istatistiksel olarak önemli bir değişim gözlenmiştir (Tablo 2). Yemdeki buğday proteini oranı arttıkça enzim değerlerinde istatistiksel olarak değişimler gözlenmiştir. Benzer olarak yemde bitkisel içerikli hammadde ilavesi arttıkça mercan balıklarının serum enzim değerlerinde de artış görülmüştür (Linn vd., 2014). GPT değerleri bitkisel kaynaklı yemler ile beslenen balıklarda etkilenmezken, ALT ve AST değerleri değişmiştir. Balıkların gelişimi için katkı miktarının belirli seviyelerde olması (%25-50) balığın sağlığı açısından oldukça önemlidir.

Bilindiği gibi serum glikoz spesifik olmayan bir stres indikatörü olarak balık çalışmalarında kullanılmaktadır. Özellikle balıkların ellenmesinde, hastalıklarda, oksijen azlığında, taşınmasında ve yoğun stoklamada artış göstermektedir. Artan glikoz miktarı kaslarda; kortizon ve karaciğerde, adrenalin ve stres hormonlarını tetiklemektedir. Bu çalışmada farklı oranlarda buğday unu proteini ilavesi ile artış gösteren serum glikoz seviyelerinin direkt olarak stres ile ilişkilendirmek çok doğru olmayacaktır. Çünkü stres etkisi dışında glikoz yemin kompozisyonuna göre de değişebilmektedir (Page vd., 1999). Çalışmamızla benzer olarak %25, %50, %75 ve %100 oranlarında buğday unu proteini ile beslenen yavru levrek balıklarının serum glikoz seviyeleri önemli oranda artmıştır yine başka bir çalışmada levrek (*Dicentrarchus labrax*) balığı yemlerinde kullanılan sarımsak ve zencefil yağı karışımının serum glikoz seviyesini düşürdüğü belirtilmiştir (Yılmaz & Ergün, 2012). Buradan da anlaşılacağı üzere yeme katılan hangi bitkisel kaynaklı hammadde olursa olsun serum glikoz oranlarında değişim göstermektedir. Balıklarda serumda toplam protein, miktarlarındaki değişimler bağışıklık sisteminin durumunun değerlendirilmesinde kullanılan indikatörlerdir. Bu nedenle toplam protein miktarının artması ya da değişmemesi beklenmektedir. Mevcut çalışmada yavru levrek balığı yemlerinde %25,%50, %75 ve %100 oranlarında buğday proteini kullanımı serum toplam protein miktarını çok az bir miktar arttırmıştır. Ayrıca Baba ve ark., (2016) yeme eklenen yulaf ekstraktının sazan balıklarının serum toplam protein miktarını arttırdığını belirtmişlerdir. Serum toplam kolesterol ve trigliserit değerleri yüksek tansiyon, kalp rahatsızlıkları, diyabet ve kan yağlarının oranlarında meydana gelebilecek metabolik bozuklukların belirlenmesinde kullanılan indikatörlerdir (Bruss, 1997). Çalışmamızda da yeme katılan buğday unu proteini miktarı arttıkça serum kolesterol ve trigliserit oranlarında artış meydana gelmiştir. Kontrol grubu ve %25-50'lik grupta diğerlerine göre değerler daha stabil kalmıştır (Tablo 2).

Çalışmadan elde edilen sonuçlar balık ununa ikame buğday unu kullanımı arttıkça balıkların fizyolojik olarak etkilenme oranının arttığını göstermiştir. Bu artış özellikle balıkların kan parametrelerinde kendini göstermiştir. Elde edilen verilere göre kontrol grubu ile kıyaslandığında en uygun sonuçları %25 ikame buğday proteini kullanılan grupta olduğu gözlenmiştir. Bu nedenle bu konuda yapılacak olan çalışmalarda %25'ten daha düşük oranlarda

buğday proteini kullanımı ile ilgili detaylı çalışmalara ihtiyaç olduğu düşünülmektedir. Ancak bu oranların balık kan parametrelerine nasıl bir etki edeceği araştırılmalıdır. Kan parametreleri balıkların sağlık indeksleri olup dışarıdan yapılan herhangi bir müdahalenin etkisi direkt olarak kanlardan tespit edilebilir.

Buğday ham maddesinin kolay bulunabilir olması, düşük maliyetli yem ile daha uzun sürede porsiyonluk boya ulaşan balık yetiştiriciliği bazı ticari işletmeler açısından cazip gözükebilir. Fakat balıkların yavru dönemlerinde ihtiyaç duydukları proteini doku-organ gelişimi, metabolizma reaksiyonlarında ve bu dönemde sürekli olan fizyolojik aşamalarda kullandıklarını gözden kaçırmamak gerekir. Bu nedenle maliyetinin düşük olması sebebi ile özellikle büyütme yemi içeriğinde kullanılması daha doğru olacağı kanaati oluşmuştur. Ancak büyütme yemlerinde kullanılması durumunda da balıkların immünolojik durumu takip edilip bunun sonucuna göre değerlendirme yapılması tavsiye edilmektedir.

SONUÇ

İnsan beslenmesinde balık etinin çok nemli bir yeri vardır. Bu besinin sağlıklı şartlarda ve besin içeriğinin zengin olması gerekir. Bu araştırma sonucuna göre farklı oranlarda ve içerikteki bitkisel kaynaklı ham madde kullanımı ile sağlıklı bireyler ve et kalitesi elde edilmiştir. Hayvansal kaynaklı yem katkı maddelerinin ekonomik olmayışı bizi bitkisel kaynaklı hammaddelere yönlendirdi ve araştırma sonucunda sağlıklı bir üretim elde etmiş olduk. Et kalitesi ve sağlıklı birey elde ettiğimizi ise bu balıkların kan biyokimyası ve hematolojisi parametrelerinin belirlenmesi ile tespit edilmiştir.

TEŞEKKÜR

Bu çalışma ilk yazarın doktora tezinin bir kısmından üretilmiştir.

Etik Standartlar İle Uyum

Yazarların Katkısı

Yazarlar bu makaleye eşit katkıda bulunmuştur.

Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını deklare etmektedir.

Etik Onay

Yazarlar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

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The Nesting Activity of Sea Turtles (*Chelonia mydas* and *Caretta caretta*): Results of 2017 Monitoring Study on Kumluca Beach

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ABSTRACT

The aim of this study is to evaluate the sea turtles (*Caretta caretta* and *Chelonia mydas*) monitoring results of Kumluca beach in 2017 and to compare these results with those of previous years. In addition, it identified problems faced by loggerhead turtles on Kumluca beach and propose solutions. The study area covers 14 km of Kumluca nesting beach. Field studies were carried out daily between June and September 2017. A total of 1306 tracks for *C. caretta* was recorded, and 715 of them resulted in the nest on Kumluca beach. However, only a single nest of *C. mydas* was recorded in the 2017 nesting season. Also, it was found that nesting success is 54.74 and nest density is 51.07 nests/km for *C. caretta.* The mean distance from the sea of the nests is 21.75±7.71 m (range=6-66 m). The most density occurred between 15 and 30 m from the sea. Mean hatch success for all nests was 65.4% while no hatching activities were observed in 248 (34.6%) nests. A total of 36 *C. caretta* was tagged. The mean curved carapace length (CCL) and curved carapace width (CCW) were 74.7±3.9 cm (range=64-84) and 67.4±3.5 cm (range=61-77), respectively. The mean head length (HL) and head circumference (HC) were 26.6±2.6 cm (range=20-30) and 49.1±3.8 cm (range=42-61), respectively. Also, a total of 116 nests were lost due to storms and anthropological effects. The problems frequently encountered in the Kumluca spawning area mainly, vehicle use, sand removal, artificial light sources, animal entry and solid wastes on the beach. In addition, solution suggestions for these problems are presented.

INTRODUCTION

Five species of sea turtles (*Dermochelys coriacea, Lepidochelys kempii, Eretmochelys imbricata, Caretta caretta* and *Chelonia mydas*) occur in the Mediterranean, only two of them (*C. caretta* and *C. mydas*) regularly nesting on the Mediterranean (Margaritoulis, 2005; Başkale et al., 2013; Casale et al., 2018). Both species (*C. caretta* and *C. mydas*) are protected under the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Plant), Barcelona Convention (1975) and Bern Agreement (1979) (European Wildlife and Plant Species). In addition, *C. caretta* is listed as vulnerable (VU) globally (Casale & Tucker, 2015), while the green sea turtle (*C. mydas*) is listed endangered (EN) (Seminoff, 2004) according to the International Union for Conservation of Nature (IUCN). It is also considered as LC (least concern) for *C. caretta*, in the Mediterranean subpopulation (Casale, 2015).

Turkey has the second most important stock based on the nest numbers of the loggerhead turtle in the Mediterranean (Margaritoulis et al., 2003). An average of 8179 loggerhead turtle nests per year were recorded in the whole Mediterranean of the most recent 5-year period, and 2822 of them were reported to be on the coast of Turkey (Casale et al., 2018). The important studies that play a key role in the conservation of sea turtles have been carried out on sex ratio, genetics, predation, nest conservation and morphology (Kılıç & Candan, 2014; Sönmez, 2018).

The first study on Kumluca beach was carried out in 1979 (Geldiay et al., 1982). Subsequently, studies were carried out in different years by different researchers as 1988 (Baran et al., 1992), 1990 (Baran et al., 1992), 1994 (Yerli & Demirayak, 1996) and 1998 (Yerli et al., 1997). In recent studies, it has been reported that Kumluca beach is among the first-degree nesting beaches for the loggerhead turtle (Canbolat, 2004). It was determined 875 nests on Kumluca beach, and the nest density was reported as 39.8 nests/km (Canbolat, 2007). Up-to-date data on the nesting beach is needed due to the reasons such as the fact that the latest monitoring study on the Kumluca beach was carried out in 2007, as well as the demands due to the high tourism potential of the area, the environmental factors that threaten the life of sea turtles, and the pressures due to human activities.

The aim of this study is (i) to evaluate the sea turtles (*Caretta caretta* and *Chelonia mydas*) monitoring results of Kumluca beach in 2017, (ii) to compare these results with those of previous years, and (iii) to identify and solve the problems that threaten the population.

MATERIAL AND METHODS

Kumluca nesting beach covers a 21 km sandy beach from the borders of Mavikent Town at the eastern end to the borders of Beykonak Town, Kumluca District, Hasyurt Town, Sahilkent Town and Finike District to the west. Our study covers an area of 14 km protected by the General Directorate of Nature Conservation and National Parks and defined as the "Sea Turtle Nesting Area" (Figure 1). The study area is divided into 3 sub-regions, namely 1st, 2nd and 3rd sub-regions The area from the starting point up to 3900 m (Hasyurt location) is called the 1st Region (westernmost), the area between the two breakwaters is called the 2nd Region, and the region from 5900 m to 14000 m is called the 3rd Region (Easternmost).

Figure 1. Kumluca Beach nesting area

This study was carried out between 1 June and 20 September and the beach was monitored by three people from night to morning (9 PM to 9 AM). All sea turtle emergences were followed, and they were recorded whether they were nested or not. The geographic position of the nest was recorded and marked with GPS (±4). After this, the distance from the sea (DFS) of each nest was measured with a flexible tape meter (±1cm). Each nest was excavated 7 days after the last hatchling emerged. During the excavation of the nests, the nesting depth was measured.

The carapace measurements (such as curved carapace length (CCL) and curved carapace width (CCW)) of female individuals after the nesting activity, were carried out using millimeter-intermittent caliper. In addition, the head length and the head width were taken from the longest and the widest part of the head. Then, female individuals were tagged and released safely into the sea.

The detected nests were followed daily during the incubation period, and their threats, if any, were recorded. The surroundings of the slots were cleaned using mops until the control opening. Thus, offspring tracks, and directions and the predator tracks were recorded daily.

The nest density of the beach was calculated according to the average number of nests per km of the entire beach length, and the success rate of hatchlings reaching the sea was calculated according to the formula (Equation 1) (Yalçın-Özdilek et al., 2005, 2006; Ozdilek et al., 2006).

$$Success\ Rate = \frac{Number\ of\ hatchlings\ reaching\ the\ sea}{Number\ of\ empty\ eggshells} \times 100 \quad (1)$$

RESULTS

In total, 1306 loggerhead turtle emergences were recorded, with 715 (54.7%) resulting in nesting during the 2017 nesting seasons. In addition, only one *C. mydas* nest was recorded. During the 2017 nesting season, a total of 591 non-nesting emergences (NNE) occurred for *C. caretta*. The highest number of NNE was observed in July (Figure 2).

Nest density for *C. caretta* on Kumluca beach of 14 km was determined as 51.07 nests/km. The last nest emergence was recorded on 8 August, but the most intense nesting activity occurred in June and July with 49.93% and 49.09%, respectively. The highest density of the nests has been detected in the 3rd Region (Easternmost) with a total number of 312 nests (43.6%). The distribution of *C. caretta* nests by regions and months is shown in Figure 3.

The results of this study showed that the distance from the sea (DFS) was 6-66 m (average 21.75±7.71 m). Density is observed between 15 and 30 m (Figure 4).

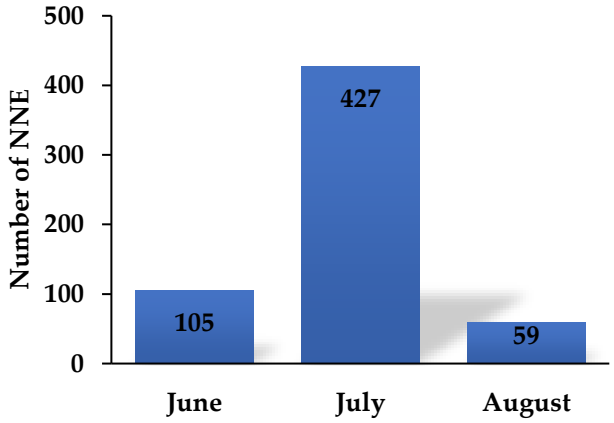

Figure 2. Distribution of the number of non-nesting emergence (NNE) by months

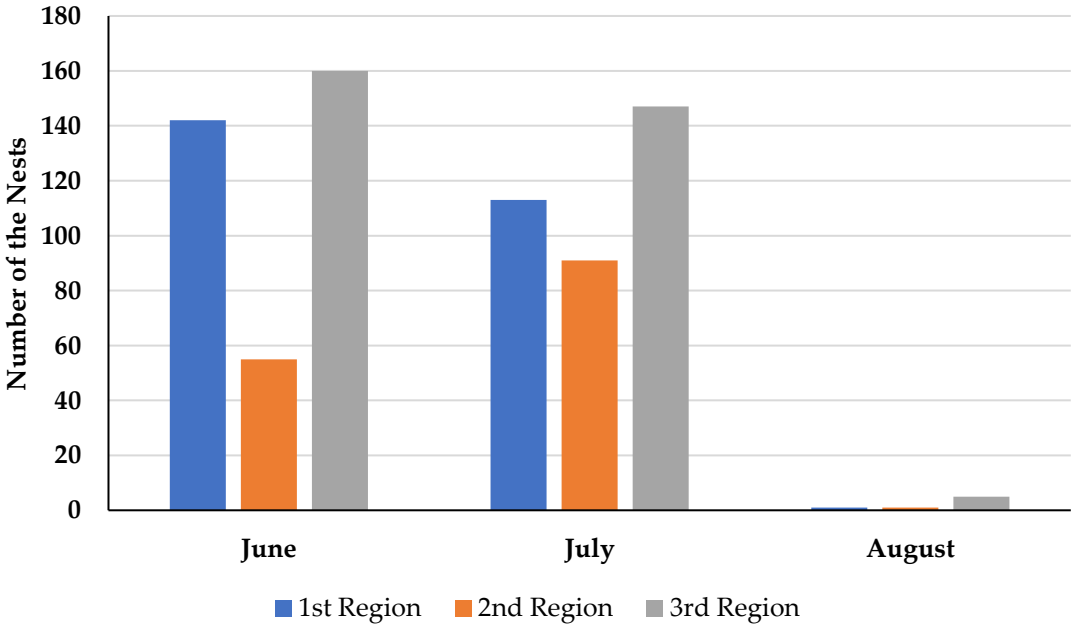

Figure 3. The distribution of *Caretta caretta* nests by regions and months

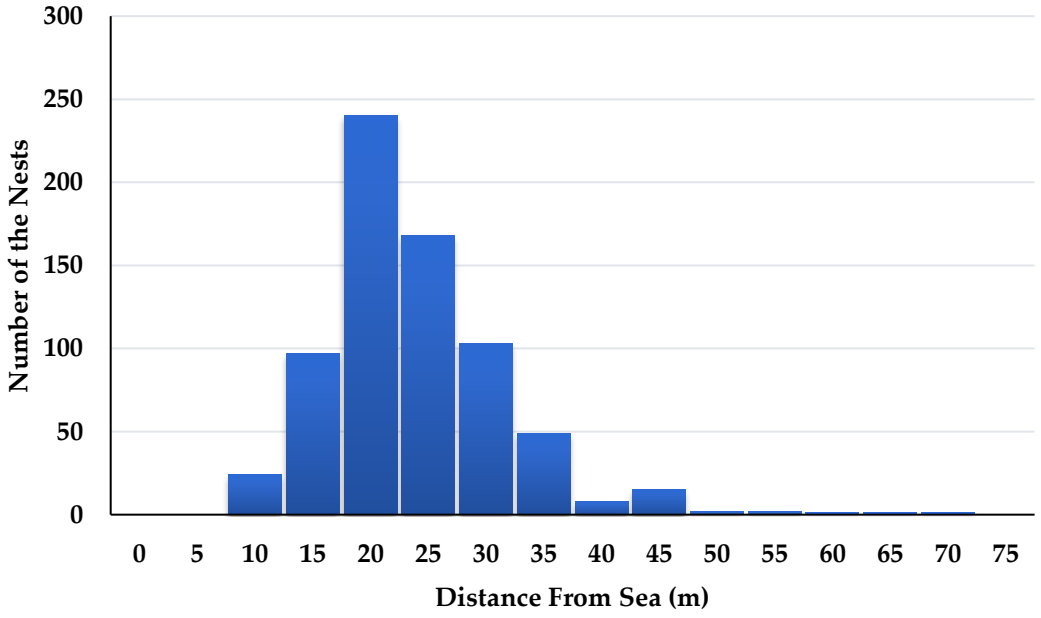

Figure 4. Distribution of nests according to the distance from sea (DFS)

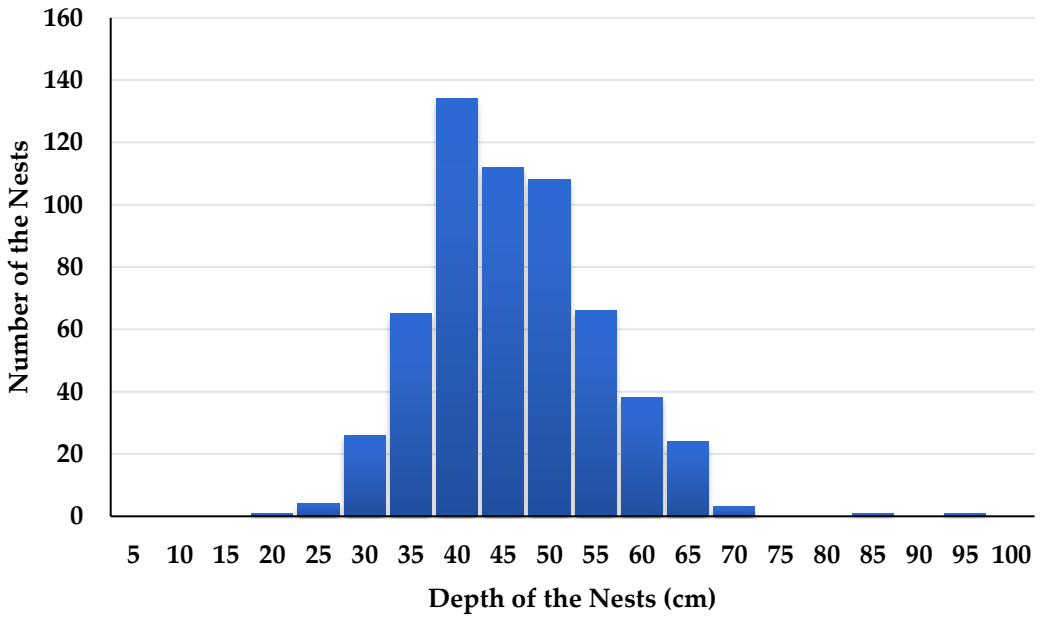

Figure 5. The nest depths of the *Caretta caretta* nests in Kumluca beach of 2017 season

Table 1. Measurements of marked female *Caretta caretta* individuals

Measurement Axis	N	Min.	Max.	Mean	SD
Curved Carapace Length (CCL)	36	64	84	74.78	3.90
Curved Carapace Width (CCW)	36	61	77	67.47	3.53
Head Length (HL)	36	20	30	26.69	2.69
Head Circumference (HC)	36	42	61	49.14	3.89

Note: N=Number, Min.=Minimum, Max.=Maximum, SD=Standard deviation

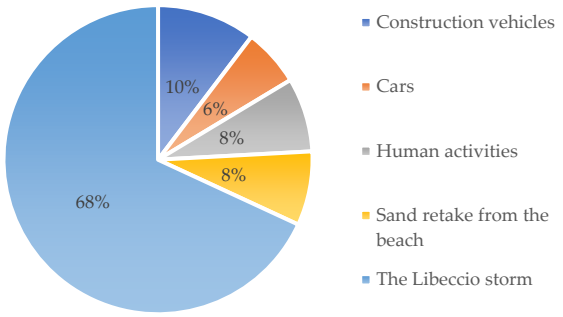

Figure 6. The reasons of the disappearance of the nests on the Kumluca beach in 2017

The nesting depths are found between 40 and 50 cm (Figure 5). The nesting depth of a detected single *C. mydas* nest was measured as 91 cm. The maximum, minimum and average depths of *C. caretta* nests were determined as 83 cm, 16 cm, and 43.88±9.11 cm, respectively.

Although the majority of *C. caretta* nests completed their incubation period successfully, it was determined that a significant number of nests were predated, lost, or deteriorated. The results obtained from this study indicate that 64.2% of the nests successfully completed their incubation period. Of the total 715 slots, 116 (16.2%) were lost, 30 (4.1%) predated and 130 (18.1%) were completely destroyed. The effects caused by losing are given in Figure 6.

The most important source of predation was dogs. In the predated nests, the success rate of hatchling after the predation was found as 26%, while the rate of the dead embryos was determined as 73%. A total of 46488 eggs were laid on Kumluca beach and 26546 of these eggs successfully hatched in the 2017 nesting season.

A total of 110 eggs were determined in the single *C. mydas* nest, 53 of these eggs hatched and all these hatchlings reached the sea. The success rate of reaching the sea for *C. caretta* hatchlings was calculated as 84.29% (22367 offspring) at Kumluca beach in the 2017 season. Besides, it was determined that 4179 hatchlings could not reach the sea due to, predation in/out of the nest, jamming in the nest, sun effect, reverse orientation, artificial light source, solid wastes on the beach and deep ruts created by vehicles entering the beach.

In total, 36 loggerhead turtles were tagged and measured for morphological dimensions. The resulting descriptive statistics are shown in Table 1. The mean CCL and CCW were 74.7±3.9 cm (range=64-84) and 67.4±3.5 cm (range=61-77), respectively. The mean HL and HC were 26.6±2.6 cm (range=20-30) and 49.1±3.8 cm (range=42-61), respectively.

DISCUSSION

Kumluca beach is one of the most important nesting beaches in Turkey in terms of nest density (Canbolat, 2007). Despite this, very few studies have investigated the nesting areas of sea turtles on the Kumluca beach. The studies were carried out at very long intervals (Canbolat, 2007). The first study conducted on the Kumluca beach reported that they identified 295 nests (Geldiay et al., 1982). Then, other studies were carried out in 1988 (Baran & Kasparek, 1989), 1990 (Baran, 1990), 1994 (Yerli & Demirayak, 1996) and 1998 (Yerli & Canbolat, 1998). It was reported that there had been detected between 35 and 305 nests in these studies (Figure 7). According to Canbolat (2004), It has been determined that the nest density on Kumluca beach is 11.2 nests/km. In another study, Canbolat (2007) reported that 875 nests were found on Kumluca beach, and the nest density was reported as 39.8 nests/km. Nesting beaches were classified based on the number of nests and indicated that a beach with an average number of nests between 100–300 nests a year is high nesting activity (Casale et al., 2018). An average of 8179 loggerhead turtle nests per year are recorded in the entire Mediterranean in the most recent 5 years, and 2822 of them were reported to be on the coast of Turkey (Casale et al., 2018). Our results showed that Kumluca beach, with its 715 slots, provides approximately 25% of the *C. caretta* nests on the Mediterranean coasts of Turkey. Hence, Kumluca beach is a very important nesting beach. In our study, the nest density was recorded as 51.7 nests/km, the second highest value in the previous studies. In addition, we determined that 48.1% of the hatchling sea turtles reached the sea. Similarly, Canbolat (2007) reported that 49.2% of hatchlings reached the sea.

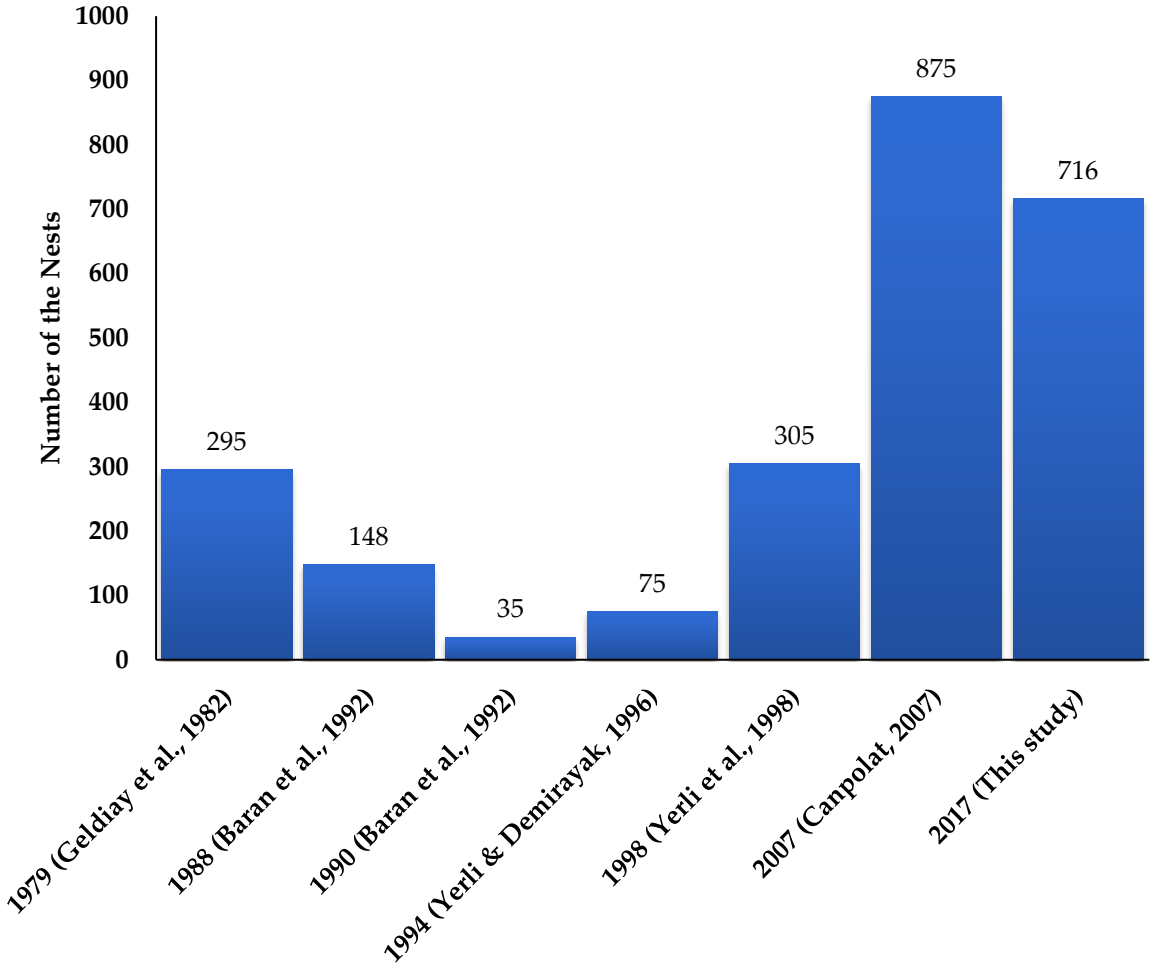

Figure 7. Comparison of the number of sea turtle nests detected on the Kumluca coast in 2017 with the previous studies (revised from Canbolat, 2007)

Coastal areas support nesting habitat for marine turtles that is critical for the survival of their populations (Fuentes et al., 2016, Altın et al., 2021). The problems frequently faced in the Kumluca nesting area mainly, vehicle use, sand removal, artificial light, an animal entry such as dogs and solid wastes on the beach. Sun loungers and umbrellas are placed on the beach in the first 30 meters from the sea, by the two big touristic facilities in the region. In these areas, sea turtle nests are concentrated and any structures or permanent sunbeds, umbrellas or closed areas should be prohibited. In this respect, it should be reminded that the fixed structures must be moved, and the sun loungers and umbrellas must be removed at night in consultation with the owners of hotels.

It has been determined that the problems caused by artificial light are generally caused by the recreation areas, streets, and road lights. In this regard, warnings should be done for artificial light and the light in the above-mentioned places should be controlled. In the Hasyurt location, in front of the hotel located, in the 2nd region, and in the 3rd region, which is heavily used by the local people, nesting should be done above and below the nest. In particular, the owners or managers of recreation areas, cafes and restaurants in these regions should be contacted and requested to take measures within the legal framework. In addition, it is necessary to inform the local people, especially the administrative superiors of public institutions situated in Kumluca and Finike. To prevent vehicles from entering the beach, all roads leading to the beach should be closed and deterrent measures should be taken for off-road vehicles entering the beach.

A large part of the 3rd region is in front of the nature park. Hence, human influence is significantly less in this region. However, in the summer of 2017, two large southwestern storms were experienced in this area. These storms were especially effective in this region

and intense flooding has occurred. The possibility of flooding should be considered in the management studies to be carried out in the following years and the nests should be kept away at a distance of at least 25 m from the sea. Nests closer than this distance must be replaced. Furthermore, a total of 3 dead *C. caretta* were found during the field surveys and the main cause of the death of 2 adult individuals was reported due to be fishing activities.

CONCLUSION

As a result, Kumluca beach is one of the most significant nesting beaches in both Turkey and the Mediterranean for *Caretta caretta*. Kumluca coast is a crucial nesting area because of it is not exposed to intense anthropological influence. Tourism has the potential to create negative effects on the environment. Kumluca beach has not developed much in terms of tourism, so it is effective in protecting this beach from the human effects. However, Kumluca has development potential in terms of migration and tourism. In this respect, continuous monitoring and protection studies of the region are vital. Considering the potential of the beach in future studies, carrying out more comprehensive biological studies will reveal more productive results.

Compliance with Ethical Standards

Authors' Contributions

All authors have contributed equally to this paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

This study was carried out within the framework of the protocol signed between Çanakkale Onsekiz Mart University Sea Turtles Application and Research Center (DEKUM) and the General Directorate of Nature Conservation and National Parks (DKMP).

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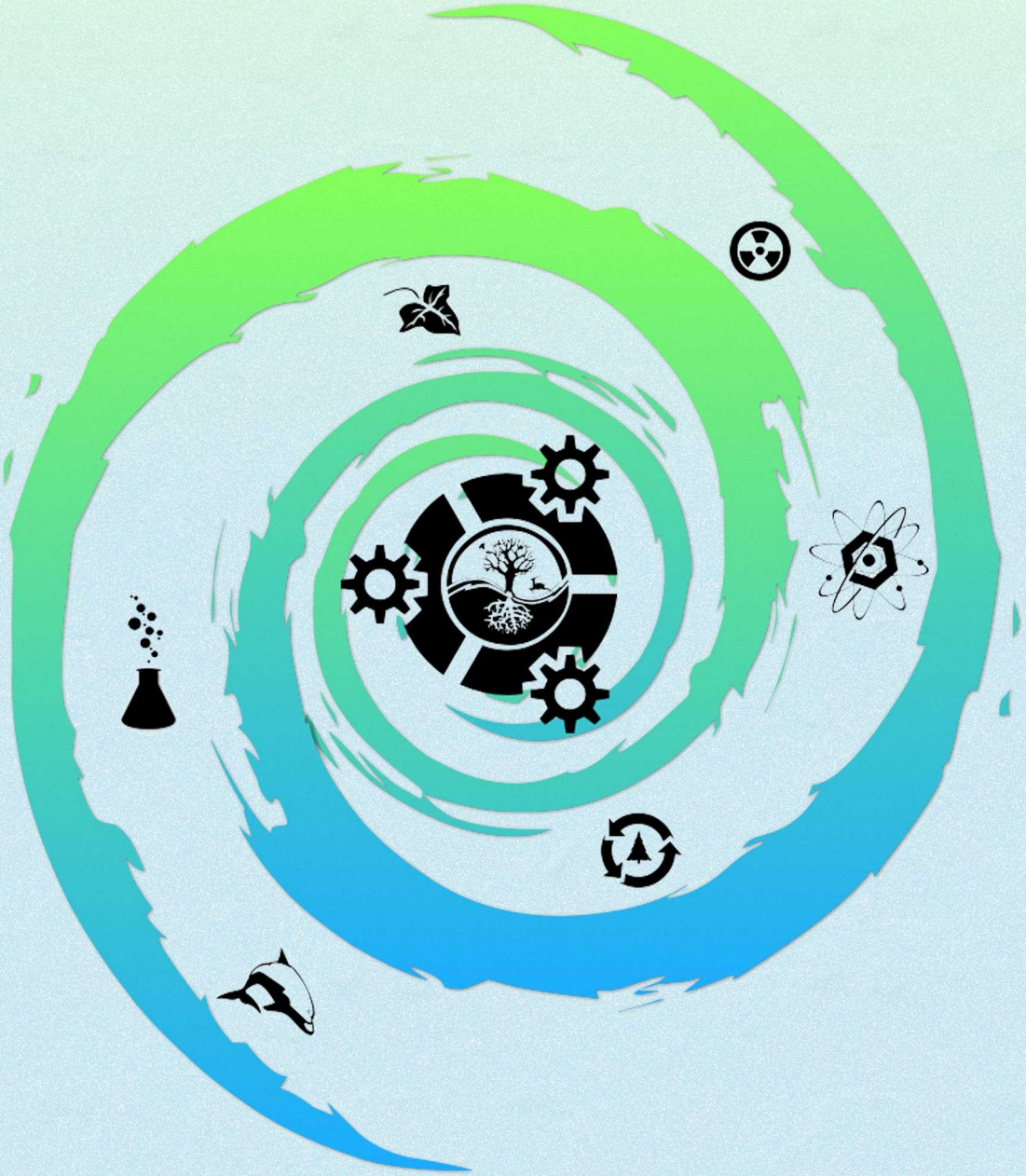

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