CUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCE

MSc THESIS

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SOME POPULATION DYNAMICAL PARAMETERS OF BOGUE (*Boops boops* (L. 1758)) IN MERSİN BAY AND İSKENDERUN BAY, (THE NORTHEASTERN LEVANTINE COAST OF TURKEY)

DEPARTMENT OF BASIC SCIENCES IN FISHERIES

ADANA-2021

ABSTRACT

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SOME POPULATION DYNAMICAL PARAMETERS OF BOGUE (*Boops boops* (L. 1758)) IN MERSİN BAY AND İSKENDERUN BAY, (THE NORTHEASTERN LEVANTINE COAST OF TURKEY)

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Year: 2021, Page: 64
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Bogue, *Boops boops* (Linnaeus 1758), is one of the important commercial species in marine fisheries of Turkey. This study was performed to document feeding, growth, mortality, and exploitation rate of bogue population in Mersin Bay and Iskenderun Bay, the Eastern Mediterranean Sea. Between September 2019 and August 2020, a total of 967 specimens were collected from commercial fishers operating in the area. Total length (TL) ranged from 11.1 to 28.4 cm, and total weight (TW) ranged from 12.1 to 281 g. The exponential coefficient of the TL–W relationship (LWR) was significantly different between sexes ($p<0.05$). The LWR for juveniles, males, females, and combined sexes were estimated as $W=0.011TL^{2.90}$ ($R^2=0.947$), $W=0.004TL^{3.29}$ ($R^2=0.912$), $W=0.002TL^{3.52}$ ($R^2=0.947$), $W=0.003TL^{3.38}$ ($R^2=0.941$), respectively. The growth profile was found to be positive allometric, except for juveniles. The von Bertalanffy growth parameters were calculated as L_∞ = 32.991 cm, k= 0.181 years^{-1} and t_0= -1.928 years for combined sexes. The growth performance index was Ø =5.286. The total mortality, natural mortality and fishing mortality rates were estimated as Z=1.402, M=0.520 and F=0.882, respectively. The exploitation ratio was E=0.629, indicating that bogue stock inhabits Mersin Bay and Iskenderun Bay was overexploited. Therefore, the fishing pressure should be reduced to sustain its population. Stomach content of 190 specimens were examined 46 of which (24 %) were found containing undigested food. The diet composition consisted of larval and juvenile fish, copepods, shrimps, and squids. Larval and juvenile stages of invasive *Bregmaceros nectabanus* were the most dominant prey item occurring in the 95 % of the examined specimens with full stomachs. This provided a good example of how an invasive species became an important food item for a native species and can restructure the marine food web.

Keywords: Exploitation rate, Diet, Feeding, Length-weight Relationship, Sparidae, von-Bertalanffy growth parameters

ÖZ

YÜKSEK LİSANS TEZİ

TÜRKİYENİN KUZEYDOĞU LEVANT KIYISINDA YER ALAN İSKENDERUN VE MERSİN KÖRFEZİ'NDEKİ KUPESLERİN ((*Boops boops* (L. 1758)) BAZI POPÜLASYON DİNAMİĞİ PARAMETRELERİNİN BELİRLENMESİ

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ÇUKUROVA ÜNİVERSİTESİ
FEN BILIMLERI ENSTITÜSÜ
SU ÜRÜNLERI TEMEL BİLİMLERİ ANABİLİM DALI

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Kupes, *Boops boops* (Linnaeus 1758), Türkiye deniz balıkçılığının en önemli ekonomik türlerinden biridir. Bu çalışma, Doğu Akdeniz'de Mersin Körfezi ve İskenderun Körfezi'ndeki kupes popülasyonunun büyüme ve beslenme özellikleri ile ölüm ve sömürülme oranlarını tespit etmek amacıyla gerçekleştirilmiştir. Bu kapsamda, Eylül 2019 ile Ağustos 2020 tarihleri arasında bölgede faaliyet gösteren ticari balıkçılardan toplam 967 adet örnek toplanmıştır. Toplam boy (TL) 11.1 ile 28.4 cm arasında ve toplam ağırlık (W) 12.1 ile 281.0 g arasında değişmiştir. Dişi ve erkekler için hesaplanan boy-ağırlık ilişkilerinin (LWR) üstel katsayıları arasındaki fark istatistiksel açıdan önemli bulunmuştur. ($p<0.05$). Juvenil, dişi, erkek ve toplam örneklem için LWR, $W=0.011TL^{2.90}$ ($R^2=0.947$), $W=0.002TL^{3.52}$ ($R^2=0.947$), $W=0.004TL^{3.29}$ ($R^2=0,912$ ve $W=0.003TL^{3.38}$ ($R^2=0.941$) olarak tahmin edilmiştir. Juvenil bireyler dışında büyümenin pozitif allometrik özellikte olduğu tespit edilmiştir. Tüm örneklem için von Bertalanffy büyüme parametreleri, $L_\infty=32.991$ cm, $k=0.181$ yıl^{-1} ve $t_0=-1.928$ yıl, büyüme performansı indeksi ise $Ø$ =5.286 olarak hesaplanmıştır. Toplam, doğal nedenlerle gerçekleşen ve balıkçılık nedeniyle gerçekleşen ölüm oranları sırasıyla $Z=1.402$ yıl^{-1}, $M=0.520$ yıl^{-1} ve $F=0.882$ yıl^{-1} olarak belirlenmiştir. Sömürülme oranı $E=0.629$ olup, bu değer çalışma alanında yaşayan kupes stokunun aşırı avcılık baskısı altında olduğunu göstermektedir. Bu nedenle, mevcut stok durumunun iyileştirilmesi ve korunabilmesi için balıkçılık baskısının azaltılması gerektiği önerilmektedir. Çalışma kapsamında toplam 190 bireyin mide içeriği incelenmiş, bunlardan 46'sının (%24) midesinde sindirilmemiş besin maddesi bulunmuştur. Besin kompozisyonunun balık larva ve juvenilleri ile kopepodlar, karidesler ve kalamarlardan oluştuğu gözlenmiştir. Yabancı yayılımcı bir tür olan *Bregmaceros nectabanus*'un larval ve jüvenil evreleri, dolu midelerin yaklaşık %95'inde gözlenmiş ve en baskın besin unsurunu oluşturmuştur. Bu durum, istilacı bir türün yerli bir tür için nasıl önemli bir besin maddesi haline geldiğine ve denizel besin ağını yeniden yapılandırabileceğine dair iyi bir örnek oluşturmaktadır.

Anahtar Kelimeler: Sömürülme Oranı, Besin, Besleme, Boy-ağırlık ilişkisi, Sparidae, von-Bertalanffy büyüme parametreleri

EXTENDED ABSTRACT

Bogue, *Boops boops* (Linnaeus 1758), is a commercial fish species commonly found across all seas of Turkey. It's a sparid fish listed within the top landed marine species of Turkish fishers with an annual average landing of 1934 tones. It is mainly targeted by purse seiners, however, gillnets, and trammel nets also catch bogue. Despite its commercial importance, little is known on the population dynamics of bogue in the Northeastern Mediterranean. Therefore, this study was performed to investigate feeding, growth, mortality, and exploitation of bogue population in Mersin Bay and Iskenderun Bay.

Between September 2019 and August 2020, a total of 967 bogue specimens were collected from commercial fishers operating in the area. The samples were carried to the laboratory in cold storage. After morphometric measurements were taken and recorded, the sex was determined by macroscopical investigation if gonads were ripe or under a stereomicroscope, otherwise. The gonadal weight and the gut weight were scaled using a digital balance to the nearest 0.01g. Sagittal otoliths were extracted for age reading. For feeding and diet content analyzes, 190 specimens were preserved in 4% formaldehyde and their stomach content were extracted, measured, scaled, and identified to the lowest possible taxa. In context of the study, length-length, and length-weight relationships, von-Bertalanffy growth parameters, the growth performance index, the total, natural and fishery mortality rates, and the exploitation rate of bogue population distributed in the Northeastern Levantine Basin of the Mediterranean Sea were calculated. Regarding the stomach content, the abundance, biomass, frequency of occurrence, and index of relative importance of each diet group were calculated. The correlation between prey and predator size were calculated.

Among the samples, 448 (46.3%) individuals were males, 466 individuals (48.2%) were females, and 53 (5.5%) individuals were identified as juveniles. The

female to male ratio (F: M) was calculated as 1:1.04 which was not statistically significantly different from 1:1 based on a Chi square test (X^2 = 0.354, df=1, p=0.552). Total length (TL) for juvenile fishes ranged between 11.1 and 15.6 cm with an average value of 13.4 ±1.19 cm (±standard deviation). The average TL for males, females and overall specimens were found as 16.9 ±2.41, 17.3 ±2.55, 15.9 ±2.05 cm, respectively. The total weight (TW) for juveniles ranged between 12.1 and 32.2 gr with an average value of 21.2 ±5.62 gr. The average W for males, females and overall specimens were found as 47.3 ±26.1, 53.8 ±37.1 and 40.8 ±22.9 gr, respectively.

The length-weight relationship (LWR) for juveniles, males, females, and overall specimens were estimated as $W=0.011TL^{2.90}$ (R^2=0.947), $W=0.004TL^{3.29}$ (R^2=0.912), $W=0.002TL^{3.52}$ (R^2=0.947), $W=0.003TL^{3.38}$ (R^2=0.941), respectively. The exponential coefficient of the LWR was significantly different between sexes ($p<0.05$). The growth type was found to be positive allometric except for juveniles.

The age of bogue was determined between 1 and 6 years. First and second age groups were found as the most dominant ones constituting 31.9% and 40.6% of the specimens. The von Bertalanffy growth parameters were calculated as follows: L_∞ = 37.362 cm, k = 0.136 year^{-1}, t_0 = -2.436 years for females, L_∞= 29.453 cm, k= 0.237 year^{-1}, t_0 = -1.626 years for males, and L_∞= 32.991 cm, k =0.181 years^{-1}, t_0 = -1.928 years for overall specimens. The growth performance indices for females, males and overall specimens were estimated as Ø = 5.250, Ø = 5.237, and Ø = 5.286, respectively. The longevity of bogue in Mersin Bay and Iskenderun Bay was estimated as 14.6 years.

The total, natural and fishing mortality rates were estimated as Z=1.402 year^{-1}, M=0.520 year^{-1} and F=0.882 year^{-1}, respectively. The exploitation ratio was E=0.629, indicating that the population of bogue in Mersin Bay and Iskenderun Bay was overexploited.

The total length-body width relationships were BW = 0.355+0.066TL (R^2 =0.282), BW = 1.053+0.171 TL (R^2 =0.792), BW = -1.259+0.184TL (R^2 =0.832), BW = 1.132+0.176TL (R^2 =0.825) for juveniles, males, females, and overall sexes respectively. Significant differences were observed between the regression parameters of sexes.

Total length-body circumference (BC) relationships were calculated as BC = 1.683+0.388TL (R^2 =0.609), BC = -1.801+0.650TL (R^2 =0.826), BC = -2.305+0.682TL (R^2 =0.844), and BC = -2.016+0.664TL (R^2 =0.849) for juveniles, males, females, and overall specimens, respectively. Significant differences were observed between the slope of TL-BC regressions among sexes, however no statistically significant difference was found among the intercept values.

The total length - fork length (FL) relationship parameters for overall specimens were as follows; FL = 0.057+0.906TL (R^2=0.979). Neither intercept, nor slope of TL- FL regression was found significantly different between sexes.

The total length-standard length (SL) relationship parameters for juveniles, males, females, and overall specimens were calculated as SL = -1.929 + 0.962TL (R^2=0.948), SL = -0.444 + 0.852TL (R^2 = 0.971), SL = -0.306 + 0.844TL (R^2=0.968), SL = -0.406 + 0.849TL (R^2=0.972), respectively. The slope of TL-SL regression was statistically significantly different among sexes, whereas there was not significant difference between intercepts.

In context of the study, 190 specimens were examined for diet composition, stomach of 144 of which (76 %) contained digested and 46 (24 %) contained undigested food. The diet composition consisted of larval and juvenile fish, copepods, shrimps, and squids. Larval and juvenile stages of invasive *Bregmaceros nectabanus* were the most dominant prey item occurring in the 95 % of the investigated specimens with full stomachs. There was a positive correlation between prey size and predator size (r=0.55, and p<0.001).

Larval and juvenile stages of *Bregmaceros nectabanus* was the most important prey item for bogue population inhabit in Mersin Bay and Iskenderun Bay. *Bregmaceros nectabanus* is an alien invasive small pelagic fish recently introduced to the Mediterranean probably via the Suez Canal. In such a short time, this species looks like become an important part of the food web of the Eastern Mediterranean. However, further investigation is required to better understand its effects on the Mediterranean ecosystem.

In the present study the stock of bogue in Mersin Bay and Iskenderun Bay was found overexploited (E=0.63), similar with the different regions of Mediterranean Sea. Moreover, young fish were dominant in the study as another indicator for overexploitation. The similar observations were reported from different areas of the Mediterranean. Therefore, a better management strategy is required to protect bogue stocks and its recovery to a sustainable level. For this purpose, further measures can be taken to reduce the fishing pressure on the stock. For example, a temporal ban or increase of mesh size for its fishing nets may be off help in reducing fishing effort and stock recovery.

GENİŞLETİLMİŞ ÖZET

Kupes, *Boops boops* (Linnaeus 1758), Türkiye'nin tüm denizlerinde yaygın olarak bulunan ekonomik öneme sahip bir balık türü olup, yıllık ortalama 1934 ton ile Türkiye balıkçılarının en çok avladığı deniz balıklarından birini oluşturmaktadır. Kupes gırgır balıkçılığının temel hedef türlerinden biri olmakla birlikte, sade ve fanyalı uzatma ağlarıyla da yakalanmaktadır. Ticari önemine rağmen, Kuzeydoğu Akdeniz'deki kupes popülasyonunun dinamikleri üzerine az sayıda çalışma bulunmaktadır. Bu nedenle, bu çalışma Mersin ve İskenderun Körfezi'ndeki kupes popülasyonunun beslenme ve büyüme özelliklerini incelemek ve ölüm ve sömürülme oranlarını belirlemek amacıyla gerçekleştirilmiştir.

Çalışma kapsamında, Eylül 2019 ile Ağustos 2020 tarihleri arasında bölgede faaliyet gösteren ticari balıkçılardan toplam 967 kupes numunesi toplanmıştır. Numuneler buzluklar içerisinde laboratuvara taşınmış, morfometrik ölçümler alınıp kaydedildikten sonra, gonadların olgun olup olmamasına bağlı olarak makroskopik veya stereomikroskop altında mikroskobik inceleme ile cinsiyet tayini gerçekleştirilmiştir. Ardından dijital terazi kullanılarak 0.01 g hassasiyetle gonad ağırlığı ve bağırsak ağırlığı tartılmıştır. Yaşın belirlenmesi amacıyla sagital otolitler kullanılmıştır. Besleme özellikleri ve besin kompozisyonunun incelenmesi için toplam 190 adet numune %4'lük formaldehit ile sabitlenmiş, bu örneklerin mide içeriği çıkarılarak ölçülmüş, tartılmış ve mümkün olan en düşük taksonomik seviyede tanımlanmıştır. Çalışma kapsamında, Kuzeydoğu Levant Havzası'nda dağılış gösteren kupes popülasyonunun boy-boy ve boy-ağırlık ilişkilerinin yanı sıra von-Bertalanffy büyüme parametreleri ve büyüme performansı indeksi ile toplam, doğal nedenlerle gerçekleşen ve balıkçılık nedeniyle gerçekleşen ölüm oranlarına ek olarak sömürülme oranları da hesaplanmıştır. Mide içeriği ile ilgili olarak, besin gruplarının bolluğu, biyokütlesi, bulunma sıklığı ve göreceli önem indeksi hesaplanmış; av ile avcı boyutu arasındaki ilişki incelenmiştir.

İncelenen balıklardan 448'i (%46.3) erkek, 466'sı (%48.2) dişi ve 53'ü (%5.5) juvenildir. Dişi-erkek oranı (K:E) 1:1.04 olarak hesaplanmış ve Chi-kare testi sonucunda bu oranın 1:1'den istatistiksel olarak önemli ölçüde farklı olmadığı belirlenmiştir (X^2= 0.354, df=1, p=0.552). Juvenil bireylerde toplam boy (TL) 11.1 ile 15.6 cm arasında değişmekte olup, ortalama boy 13.4 ±1.19 cm'dir. Erkekler, dişiler ve tüm örnekler için ortalama boy değerleri sırasıyla 16.9 ±2.41, 17.3 ±2.55, 15.9 ±2.05 cm olarak bulunmuştur. Juveniller için toplam ağırlık değerleri 12.1 ile 32.2 gr arasında değişmekte olup, ortalama değer 21.2 ±5.62 gr'dır. Erkekler ve dişiler için ortalama ağırlık değerleri sırasıyla 47.3 ±26.1, 53.8 ±37.1 ve 40.8 ±22.9 gr olarak bulunmuştur.

Juveniller, erkekler, dişiler ve tüm örnekler için boy-ağırlık ilişkisi eşitlikleri şu şekilde bulunmuştur; $W=0.011TL^{2.90}$ (R^2=0.947), $W=0.004TL^{3.29}$ (R^2=0.912), $W=0.002TL^{3.52}$ (R^2=0.947) ve $W=0.003TL^{3.38}$ (R^2=0.941). Boy ağırlık ilişkisinin allometrik katsayısının eşeyler arasındaki değişimi istatistiksel açıdan önemli bulunmuştur ($p<0.05$). Ayrıca juveniller hariç büyüme profilinin pozitif allometrik özellikte olduğu görülmüştür.

Çalışma kapsamında kupes balıklarına ait yaş değerleri 1 ile 6 yıl arasında değişmiş olup, örneklerin %31.9'unu ve %40.6'sını sırasıyla birinci ve ikinci yaş grupları oluşturmuştur. Von Bertalanffy büyüme parametreleri dişiler için L_∞ = 37.362 cm, k = 0.136 yıl^{-1}, t_0 = -2.436 yıl, erkekler için L_∞= 29.453 cm, k= 0.237 yıl^{-1}, t_0 = -1.626 yıl ve tüm örnekler için L_∞= 32.991 cm, k =0.181 yıl^{-1}, t_0 = -1.928 yıl olarak hesaplanmıştır. Dişi, erkek ve tüm örneklem için büyüme performans indeksi değerleri sırasıyla Ø = 5.250, Ø = 5.237 ve Ø = 5.286 olarak belirlenmiştir. Mersin ve İskenderun körfezinde dağılış gösteren kupes balıklarının toplam ömrünün 14.6 yıl olduğu tahmin edilmiştir.

Toplam ölümler ile doğal nedenler ve balıkçılık nedeniyle gerçekleşen ölümlerin üssi katsayıları sırasıyla Z=1.402 yıl^{-1}, M=0.520 yıl^{-1} ve F=0.882 yıl^{-1} olarak tahmin edilmiştir. Sömürülme oranı E=0.629 olarak hesaplanmış olup, bu değer Mersin ve İskenderun Körfezi’ndeki kupes popülasyonunun aşırı avlandığını göstermektedir.

Toplam boy-vücut genişliği (BW) ilişkileri sırasıyla juveniller, erkekler, dişiler ve tüm örneklem için BW = 0.355+0.066TL (R^2 =0.282), BW = 1.053+0.171 TL (R^2 =0.792), BW = -1.259+0.184TL (R^2 =0.832), BW = 1.132+0.176TL (R^2 =0.825) olarak tahmin edilmiştir. Eşeylerin toplam boy-vücut genişliği ilişki parametreleri arasında istatistiksel açıdan önemli farklılıklar gözlenmiştir.

Toplam boy-vücut çevresi (BC) ilişkileri sırasıyla juveniller, erkekler, dişiler ve tüm örneklem için BC = 1.683+0.388TL (R^2 =0.609), BC =-1.801+0.650TL (R^2 =0.826), BC = -2.305+0.682TL (R^2 =0.844) ve BC = -2.016+0.664TL (R^2 =0.849) olarak hesaplanmıştır. Eşeylere ait eğim değerleri arasında önemli farklılıklar gözlenmiş olsa da sabit terimler arasında istatistiksel olarak anlamlı bir fark bulunamamıştır.

Tüm örnekler için toplam boy - çatal boy (FL) regresyon eşitliği FL = 0.057+0.906TL (R^2=0.979) olarak hesaplanmış, ne eğim ne de sabit terimin eşeyler arasındaki değişimi istatistiksel açıdan önemli bulunmamıştır.

Sırasıyla, juveniller, erkekler, dişiler ve tüm örnekler için toplam boy-standart boy (SL) ilişkileri SL = -1.929 + 0.962TL (R^2=0.948), SL = -0.444 + 0.852TL (R^2 = 0.971), SL = -0.306 + 0.844TL (R^2=0.968), SL = -0.406 + 0.849TL (R^2=0.972) olarak hesaplanmıştır. Toplam boy-standart boy (SL) ilişkisinin b değerleri arasında eşeyler arasında istatistiksel olarak önemli farklılıklar gözlenirken, sabit terimler arasında anlamlı bir fark bulunamamıştır.

Beslenme ile ilgili olarak, çalışma kapsamında 144'ü (%76) sindirilmiş besin ve 46'sı (%24) sindirilmemiş besin olmak üzere incelenen tüm örneklerin midelerinde besin bulunduğu tespit edilmiştir. Kupesin İskenderun ve Mersin Körfezi'ndeki temel besinini larval ve juvenil balıklar, kopepodlar, karidesler ve kalamarlar oluşturmaktadır. Dolu mideye sahip bireylerin yaklaşık %95'inde yabancı-yayılımcı *Bregmaceros nectabanus*'un larval ve jüvenil evreleri ile karşılaşılmış olup, bu tür kupesin en önemli besin unsurunu oluşturmaktadır. Av boyutu ile avcı boyutu arasında pozitif bir korelasyon tespit edilmiştir ($r=0.55$, $p<0.001$).

Çalışma kapsamında tespit edilen büyüme performansı değerlerinin daha önce yapılan çalışmalar içerisinde üst sıralarda olduğu görülmüş, bu bağlamda İskenderun ve Mersin Körfez'lerinin türün büyümesi için ideal bir ortam oluşturduğu sonucuna varılmıştır. Kupes stoklarının büyüme performansları arasındaki farklılıklar, sıcaklık gibi çevresel koşulların farklılıkları ile açıklanabilir. Ayrıca, farklı popülasyonların yaş kompozisyonları arasındaki farklılıklar da büyüme performansını etkileyebilmektedir. Bu bağlamda, aşırı avcılık, bir balık stokunun ortalama yaş ve boy değerlerini düşürmek suretiyle de büyüme performansı değerlerini etkileyebilmektedir.

Gerek bu çalışmada gerekse Akdeniz'in farklı bölgelerinde gerçekleştirilen çalışmalarda kupes stoklarının aşırı sömürüldüğü görülmektedir. Bu durumun bir başka göstergesi olarak, Akdeniz'in çeşitli bölgelerinde bulunan kupes popülasyonlarında genç balıkların baskın durumda olduğu ortaya konmuştur. Bu nedenle, stok büyüklüğünü sürdürülebilir bir düzeye çıkarmak ve kupes stoklarını korumak için daha iyi bir yönetim stratejisinin uygulanması ve stok üzerindeki av baskısının azaltılması gerekmektedir. Bu bağlamda, kupes balıkçılığında av gücünü azaltacak yönde önlemlerin alınması, örneğin, kupes avcılığı için zamansal yasakların konması yada ilk yakalama boyunun sınırlandırılması faydalı olabilecek uygulamalar arasındadır. Çalışma kapsamında İskenderun ve Mersin Körfezi'nde yaşayan kupes popülasyonu için en önemli besin unsurunun *Bregmaceros nectabanus*'un larval ve juvenil evreleri olduğu görülmüştür. Bu tür yakın zamanda Süveyş Kanalı yoluyla Akdeniz'e giren yabancı yaylımcı bir küçük pelajik balık olup, kısa süre içinde Doğu Akdeniz'in besin ağının önemli bir parçası haline gelmiştir. Bununla birlikte, bu türün Akdeniz ekosistemi üzerindeki etkilerini daha iyi anlamak için daha fazla araştırmaya ihtiyaç vardır.

ACKNOWLEDGEMENTS

First and foremost, I am grateful to Allah for this remarkable achievement of accomplishing my master study from one of the most prestigious universities in Turkey. I would like to express many thanks to many people for their assistance with this thesis. I am sincerely thankful to my parents and other family members; in fact, their care, love, and prayers is what make me move forward and achieve my goals successfully.

I would like to express my deepest appreciations to my mentor Assoc. Prof. Dr. Sinan Mavruk for his guidance and endless support throughout my study. Special thanks to Prof. Dr. Dursun Avşar for his advice and commitments throughout entire Journey. Thanks to Assoc. Prof. Dr. Hacer Yeldan for her assistance in age reading.

I owe many thanks to many people including Cukurova University management, academic personal of my department and lecturers as well, thanks to them for their facilitation and support to my study. This also reminds my colleagues and friends who assisted me in fisheries laboratory thanks to all of them.

Finally, I would like to express my sincere gratitude to the Republic of Turkey and Turkish people for permitting me gaining lifetime experience in this great Country, thanks for the scholarship and for the support to international students in general.

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LIST OF ABBREVIATIONS

%F	: Frequency of occurrence
%N	: Proportional Abundance
%W	: Occurrence in weight
+A	: positive allometric growth
a	: Intercept of regression
-A	: Negative allometric growth
b	: Slope of regression
B	: Bhattacharya Method
BC	: Body circumference length
BW	: Body width
CI	: Confidence interval
E	: Exploitation rate
F	: Fishing mortality
FAO	: Food and Agriculture Organization of United Nations
FL	: Fork length
I	: Isometric growth
IRI	: Index of relative importance
J	: Juvenile
k	: Growth coefficient
L_∞	: Asymptotic length,
L_t	: Total length at age t
M	: Natural mortality
O	: Otolith
Ø	: Growth Performance Index
sd	: Standard deviation
SL	: Standard length

T_{max}	: Maximum recorded age
t_0	: Theoretical age of fish at zero length
TL	: Total length
TÜİK	: Turkish Statistical Institute
VBGF	: von Bertalanffy growth function
Z	: Total mortality

1. INTRODUCTION

Marine fisheries play an important role in total fisheries production of Turkey (Ünal and Göncüoğlu, 2012), which is estimated to be 836524 tons in 2019 (*TURKSTAT Institutional* 2019). The marine landings in Turkey are mainly dominated by small pelagic fishes particularly anchovy, sprat, Atlantic bonito, pilchards, mackerels, scads, blue fish, bluefin tuna, whiting and bogue (*TURKSTAT Institutional* 2020).

Bogue, *Boops boops* (Linnaeus, 1758), is an indigenous marine fish which belongs to family Sparidae (Bilecenoglu et al., 2014). The species occurs in the eastern Atlantic from Norwegian coast to Angolan Sea where it's occasional (Haedrich, 1986). It is also commonly distributed in the Mediterranean Sea, the Aegean Sea, the Marmara Sea, and the Black Sea (*TURKSTAT Institutional* 2020). Bogue is a semi-pelagic fish which inhabits inshore waters above sandy, muddy to rocky habitats. Although it inhabits up to 350 m, it usually occurs between 0 and 100 m migrating to surface during night (Bauchot and Hureau, 1986; Froes and Pauly, 2019). It is an omnivorous fish which feeds on phyto and zooplanktonic organisms, and primarily crustaceans (Froese and Pauly, 2019). Although it is documented as protogynous hermaphrodite (Haedrich, 1986a), some researchers argue that the protogynous hermaphroditism can only be found in some specimens (Monteiro et al., 2006; Bottari et al., 2014).

Bogue is captured across all seas in Turkey throughout the year and sold in local fish markets. It is mainly targeted by purse seiners, gillnets and trammel nets (FAO-GFCM 2020; Haedrich, 1986). Hence, it does not only provide a livelihood for fishers in Turkey, but also an important food fish for the Turkish people (FAO, 2008; *TURKSTAT Institutional*, 2020). Bogue is the only Sparid fish among the top landed species list of Turkish fisheries based on the fishery landing statistics (*TURKSTAT Institutional* 2020). According to Turkish Statistical Institute, the highest annual quantities of bogue catch were recorded in 2017, 2018 and 2019 with a total catch of 3175, 3559, 2865 tons per year, respectively.

The General Fisheries Commission for the Mediterranean Sea (GFCM) reports annual bogue landings of Turkey since 1970. Based on these data, the Aegean Sea provides the largest capture quantity over all seas in Turkey with an average of 1488.5 tons per year, followed by the Levant Sea with 288.9 tons and the Marmara Sea with 70.2 tons per year, respectively. Lesser catch amounts (126.6 tons per year) were reported from the Black Sea (FAO-GFCM 2020). The historical landing records from these seas revealed that the annual landings have increased between 1970 and 2018. The initial catches were 236 tons in 1970. Nevertheless, a great increase has been reported in 1975, approximately 1277 tons. From 1975 to 1992, the catches were fluctuating from one thousand tons and lesser. In 1993 and 1994 a dramatic increase has been observed again with landings of 2174 and 1842 tons per year, respectively.

As the landing records show, the Levant Sea is the second largest producer of bogue from all seas of Turkey. Based on these records, the catch of bogue in Levant Sea was 14 tons per year in 1970. In 1973, 1974 and 1975 no catches were reported in Levant Sea, however, from 1976 and 1981 the catch was fluctuating between 26 and 175 tons per year. In 1995, the maximum catch was recorded with 1452 tons and then catch declined to 98 tons in 1998. In general, the catch reports of bogue in Levant Sea have been increasing from 1999 to 2018 with approximate catch amount of 228 tons in 2018 (FAO-GFCM, 2020).

Although there are some studies on fisheries and biological characteristics of bogue such as age and growth by (El-Okda, 2008), length-weight and length-length relationships by (Kara and Bayhan, 2008), bio-ecological characteristics by (Bilge, 2008), reproductive biology by (Bottari et al., 2014), feeding habits by (El-Maremie and El-Mor, 2015); there is no study in Iskenderun Bay and only single study were found in Mersin Bay, northeastern Mediterranean. Besides, the available studies on feeding and relatively less comprehensive compared other aspects. Therefore, the aim of this study is to enhance the understanding on the population dynamics of bogue (*Boops boops*) in Mersin Bay and Iskenderun Bay of northeastern Mediterranean. The results of this study is expected to provide new data for future stock assessment and fisheries management of the species. In this framework, the objectives of this study are as follows:

a) To assesses length-weight and length-length relationships,
b) to examine age and growth based on sagittal otolith readings,
c) to determine von Bertalanffy Growth parameters,
d) to determine mortality and exploitation rates and
e) to analyze the feeding and diet content of bogue.

2. LITERATURE REVIEW

There are some studies on the biological characteristics of bogue, and these were mainly concerned on its growth, age, and fisheries status of the species. On the other hand, very few studies were conducted regarding its feeding biology and reproduction.

2.1. The Range of Size and Age

A recent study conducted by Ceyhan et al. (2018) in Izmir coast of the Aegean Sea has found that the bogue reaches a maximum length of 40.2 cm and maximum weight of 986 g, which is the largest individual reported from the region. A study performed by Andsoy (2015) in Edremit bay of Aegean Sea reveals that the total length and weight values of bogue were between 7.7-23.9 and 3.52-154.4 g, respectively. According to a study conducted in Izmir Bay of Aegean Sea by Kara and Bayhan (2015), the total length and total weight vary between 11.3 and 27.9 cm, and 12.2 and 261.7 g, respectively. In the same study Kara and Bayhan (2015) also reported that the average length and weight values are 19.6 cm and 82.7 g, respectively. Further, Bilge (2008) have determined that the total length and weight of bogue ranged from 9.5 to 27.1 cm and from 7.79 to 267.76 g in Izmir Bay and from 9.3 to 28.1 cm and from 7.74 to 237.55 g in Edremit Bay, respectively. A study about the bogue population in Algerian coast (Dahel et al., 2019) has reported that the total length and weight of bogue ranged between 10.1 and 30.9 cm, and 13.47 and 268.14 g, respectively. In another study performed in Strait of Sicily, the total length ranges between 12.8 and 32.5 cm for females, and between 12.2 and 40.0 cm for males and the average total length were 16.0 and 18.0 cm for females and males, respectively (Cannizzaro et al., 2001). According to a study performed by Massaro and Pajuelo (2018) in central and eastern Atlantic Ocean, the minimum and maximum size of bogue ranges between 4 and 34.5 cm in total length. The maximum length of bogue was reported as 40.0 cm in a study performed in Portuguese coast (Gordo, 1996). A study conducted in Algarve, southern coast of Portugal by Monteiro et al (2006), the total length of bogue is found between 7.4 and 30.5 cm.

The age of bogue has ranged between 0 and 9 years in a study performed in Izmir and Edremit Bay, Aegean Sea (Bilge, 2008). A study conducted in Izmir Bay, by Kara and Bayhan (2015), the age of bogue has varied from 1 to 5 years. A study on age and growth of bogue in Egypt also states that the ages ranged between 1 and 4 years (El-Okda, 2008). A recent study in Alexandria of Egypt revealed that the longevity as 4 years, and the study presents the most abundant age groups are 1+ and 2+ years constituting 85% of the catch (Azab et al., 2019). Nevertheless, the longevity of bogue has been estimated to reach 5 years in a study performed in Algerian coast of the Western Mediterranean Sea (Dahel et al., 2019). Another study in the Bay of Bou-Ismail of Algerian coast in the Western Mediterranean Sea reveals that the age groups of bogue are from 1 to 5 years (Rachid et al., 2014). Additionally, a study done by Massaro and Pajuelo (2018). in Canary Island, central Atlantic, reveals that the age classes of female bogue ranged between 0 and 4 years and of males between 0 and 5 years. A report in Algarve in the Southern coast of Portugal by Monteiro et al. (2006), the age groups of bogue are found between 1 and 3 years.

The longevity of bogue is estimated as 20 years in Alexandria coast of Egypt by (El-Okda, 2008). Another study in Alexandria coast of Egypt indicated that the maximum theoretical age is 17.81 years (Allam, 2003). The lifespan of bogue is estimated as 16.6 years in central Adriatic Sea by Alegria-Hernandez (1989). On the other hand, the longevity of bogue is found to be 13.9 years by Monteiro et al., (2006) in Algarve southern coast of Portugal.

2.2. Length-Weight Relationships

In Babadıllimanı Bight of Mersin, length weight relationship parameters are estimated as a= 0.009, b= 2.978, r^2= 0.964 for males, a=0.008, b=3.046, r^2= 3.046 for females and a = 0.008, b= 3.03, r^2 = 0.945 for overall specimens (Manaşirli et al., 2006). In Edremit Bay of Aegean Sea, the length weight relationships of bogue are described as $W = 0.004L^{3.295}$, $W = 0.004L^{3.304}$, and $W = 0.004L^{3.299}$ for males, females, and combined sexes (Andsoy, 2015) indicating positive allometric growth in both sexes. In Izmir Bay of Aegean Sea, the length weight relationship parameters for males, females, hermaphrodites, and combined specimens are calculated as $W=0.002L^{3.522}$, $W= 0.004L^{3.272}$, $w= 0.003L^{3.350}$, $W=0.003L^{3.429}$, respectively with high correlation of (r^2=0.990) (Kara and Bayhan, 2008). The length weight relationship of bogue is assessed by Kara and Bayhan (2015) in a study performed in Izmir Bay of Aegean Sea and the parameters of combined sexes are estimated as a $W= 0.003L^{3.420}$ for males, $W= 0.007L^{3.128}$ for females and $0.003L^{3.237}$ for combined and high correlation of (r^2=0.956) and the growth is positive allometric. A report on age and growth of bogue in Egypt reveals the length and weight relationships of combined sexes as $W = 0.0254L^{2.660}$ and r^2= 0.989 and the growth is negative allometric (El-Okda, 2008). In Alexandria Egypt, (Mehanna, 2014) describes the length weight relationship parameters of overall specimens are explained as $W= 0.006 L^{3.153}$, r^2 = 0.985 and b indicates that the growth is positive allometric of both sexes. In Algerian coast the length-weight relationship parameters is defined as a=0.016 and b=2.815 for combined sexes showing a negative allometric growth (Dahel et al., 2019). Another study conducted in the Bay of Bou-Ismail of Algerian coast in Western Mediterranean Sea shows that the length weight relationship is $W=0.016L^{2.798}$ which also indicates negative allometric growth for combined sexes (Rachid et al., 2014).

2.3. von Bertalanffy Growth Parameters

Bilge (2008) reports that the von Bertalanffy growth parameters of combined sexes of bogue as, L_t=32.08 [1-$e^{-0.122(t+3.204)}$] for Izmir Bay and L_t=31.54 [1-$e^{-0.129\ (t+3.107)}$] for Edremit Bay. A study performed in Izmir Bay, the von Bertalanffy growth parameters are described as L_∞ = 29.87 cm, k= 0.243 years^{-1}, and t_0 = - 0.98 years for males and L_∞ = 30.79 cm, k = 0.239 years^{-1} and t_0 =-0.90 years for females (Kara and Bayhan, 2015). The same study calculates the growth performance index of males and females as 2.33 and 2.36, respectively (Kara and Bayhan, 2015). Similarly, a study on age and growth of bogue in Alexandria coast of Egypt estimates the Von Bertalanffy growth parameters for combined specimens as L_∞ = 30.11 cm, k= 0.151 years^{-1}, t_0 = 1.5083 years, W_∞ = 218.0g and Ø = 2.136 (El-Okda, 2008). Another study in Alexandria coast of Egypt, the von Bertalanffy growth parameters for all specimens is estimated as L_∞ = 27.27 cm, k = 0.67 years^{-1} and t_0 = 0.33 years (Mehanna, 2014). A recent on the bogue population in Algerian coast estimates the von Bertalanffy growth parameters of both sexes as L_∞ =32.03 cm, k= 0.28 years^{-1}, t_0 = -1.13 years and Ø = 2.45 (Dahel et al., 2019). A study performed in the Bay of Bou-Ismail of Algerian coast in Western Mediterranean Sea, the von Bertalanffy growth parameters of combined specimens are estimated as L_∞= 29.66 cm, k= 0.33 year^{-1} and t_0= 0 years and W_∞=209.79 g (Rachid et al., 2014). In Strait of Sicily, the growth parameters of bogue for combined sexes are detected as L_∞=45.0 cm, k = 0.13 years^{-1} and t_0 = -1.9 years (Cannizzaro et al., 2001). According to a study performed by Massaro and Pajuelo (2018) in central and eastern Atlantic Ocean, the von Bertalanffy growth parameters of females are as follows L_∞ = 32.3 cm, k = 0.44 years^{-1} and t_0 = -0.81 years, and for males are as follows L_∞ = 35.3 cm, k = 0.38 years^{-1} and t_0 = -0.80 years. In the same study, the growth performance index is found the same in both sexes as Ø = 5.68. In Algarve (southern coast of Portugal), the von Bertalanffy growth is reported as L_∞ = 28.06 cm, k= 0.22 years^{-1}, t_0 = -1.42 years and Ø = 5.16 (Monteiro et al., 2006).

2.4. The Mortality Rates and Exploitation

In Babadıllimanı Bight of Mersin, mortality parameters are estimated as M=0.3514, F=0.9058 and Z=1.257 years^{-1}, and E=0.7205, respectively, (Manaşirli et al., 2006). A Study in Alexandria coasts of Egypt estimates the total mortality (Z), natural mortality (M), the fishing mortality (F) and the exploitation rate (E) of bogue as M= 0.671, F = 1.589 and Z = 2.26 years^{-1}, and E= 0.70, respectively (Azab et al., 2019). A study performed in the bay of Bou-Ismail of Algerian coast in Western Mediterranean Sea revealed that M = 0.36, F = 0.66, Z = 1.02 years^{-1} (Rachid et al., 2014). Moreover, mortality parameters are found as M= 0.33, F=0.71 and Z= 1.04 years^{-1}, and E= 0.68 in Algarve, Southern coast of Portugal (Monteiro et al., 2006). In Algerian coast of Western Mediterranean Sea, the mortality parameters and exploitation rate are detected as M=1.03, F=0.66 and Z=1.03 years^{-1} and E=0.640, respectively, (Dahel et al., 2019).

2.5. Reproduction and Length at First Maturity and Capture

It was also determined that the species lie eggs from January to May in Edremit and Izmir bays (Bilge, 2008), and between March and May in Saros Bay (Cengiz et al., 2019). In the strait of Sicily the spawning season of bogue were detected between February and May (Cannizzaro et al., 2001). In southern coast of Portugal, the spawning have been shown to occur from late winter to early spring between February and May (Monteiro et al., 2006). Nevertheless, in the southern Tyrrhenian Sea of central Mediterranean, the spawning period of bogue was from February to April, with a peak in March (Bottari et al., 2014).

In Eastern-Central Aegean Sea, the length at first capture for males and females of bogue is calculated as 12.96 and 9.13 cm respectively (Soykan et al., 2015). According to Mehanna (2014) the length and age at first sexual maturity is described as 14.9 cm and 1.17 years, respectively. A recent study performed in Alexandria coast of Egypt indicates that the length at first capture of bogue is 12.5

cm and the length at first maturity is 13.2 cm (Azab et al., 2019). The same study describes that the age at first capture and age at first maturity are 1.72 years and 1.86 years, respectively (Azab et al., 2019). In the Canary Islands of central and eastern Atlantic Ocean, the average length at first sexual maturity for females and males of bogue is 16.02 and 16.49 cm, respectively (Massaro and Pajuelo, 2018). A study performed in southern Tyrrhenian Sea of central Mediterranean revealed that the length at first maturity is 13.8 cm with no significant difference between females and males (Bottari et al., 2014). According to Mehanna (2014) the length and age at first sexual maturity are 14.9 cm and 1.17 years, respectively.

2.6. Food Preferences and Diet Types

A study conducted in Aegean Sea describes bogue to be an omnivorous fish which feeds on benthic organisms (Crustacea, Mollusca, Annelida, Sipuncula, plantae) and pelagic preys (*Siphonophorae*, Copepod, eggs) as food (Bilge, 2008). According to another study performed in the Aegean Sea, the gelatinous organisms such as cnidarians are also detected constituting an important part of the diet of small sized bogues (Akcinar, 2017). In accordance with this, another study performed in the Eastern Libya shows that bogue is an omnivorous fish, and its diet composition is found to contain crustacea (49.0 %), porifera (22.7%), coelenterate (10.2%), sea grasses (9.2%), mollusks (8.1%) and protozoa (0.9%) (El-Maremie and El-Mor, 2015).

3. MATERIAL AND METHOD

3.1. Study Area

The Mediterranean Sea is a semi-enclosed water body with high salinity, high temperature, and restricted water exchange with the world's oceans (Tanhua et al., 2013). It is bordered by Asia in the east, by Europe on the north and by Africa on the south. It has a connection with the Atlantic Ocean via the Gibraltar Strait and with the Red Sea via the Suez Canal. The Marmara Sea and the Black Sea are commonly regarded as the parts of the Mediterranean (Karataş and Karataş, 2017). The fish biodiversity of Mediterranean Sea accounts for around 4% of all marine species on the planet (Coll et al., 2010). The Mediterranean biota mainly originate from the Atlantic Ocean and today, it's a home to about 650 different fish species (Coll et al., 2010). This number has recently risen as a result of alien species arriving from the Atlantic Ocean via the Gibraltar Strait and from the Red Sea via the Suez Canal which was opened in 1869 (Ben Rais Lasram and Mouillot, 2009) and widened in 2015 (Sarah, 2016). With an average of one alien species introduce to the Mediterranean Sea each month (Streftaris *et al*., 2005). On top of that, climate change as well as human induced stresses, such as overfishing and environmental degradation have been identified as factors contributing to affecting the biodiversity patterns and the species composition in the Mediterranean Sea (Bianchi, 2007).

The Aegean Sea in the northwest and Levantine Sea in the southeast are the two major basins of the Eastern Mediterranean Sea (Deniz et al., 2016). With 441 species, Levant Sea has the largest fish biodiversity in Turkish marine waters after Aegean Sea (Bilecenoglu et al., 2014). Lessepsian species constitute an important portion in the catches of Levantine Sea (Gücü et al., 2010). According to Gökce (2012), the Levant Basin is home to nearly a third of Turkey's demersal vessels as well as a large number of other small-scale fisheries that use various passive gears such as trammel nets, gillnets, and demersal longlines. Based on the records of Turkish Statistical Institute (*TURKSTAT Institutional* 2014), three primary fleet segments that operate in this area are bottom trawlers, purse seiners and small-scale fishers. In this region, there are 205 trawlers, 57 purse seiners, 12 trawler-purse seiners and 1677 small scale fishing boats registered in 20 fishing ports ((*TURKSTAT Institutional* 2014).

Mersin Bay and Iskenderun Bay (Figure 3.1) are the most prominent fishing areas in Levant Basin. These Bays have a relatively large continental shelf when compared with the rest of the Eastern Mediterranean. Additionally, there are important river discharges which increases productivity of the area for fish and crustaceans (Gucu and Bingel, 1994).

Iskenderun Bay is in the northeastern corner of the Mediterranean Sea. Its maximum depth is 90 m with an average depth of 55 m. The bay is 34 km wide and 70 km long in the largest axes (Avşar, 1999 ; Mavruk and Avsar, 2008). Iskenderun Bay has rich territorial nutrient inflows, with a temperature annually ranged between 16°C and 33°C. It has a high salinity ranging between 37 and 40 psu (Polat and Piner, 2002).

Mersin Bay is also another productive area for pelagic and demersal fishery resources with its large continental shelf and high river discharges (Gucu and Bingel, 1994; Gökce, 2012). The average annual bottom and surface water temperatures of Mersin Bay are reported at 19.15°C (Ergev, 2002; Mutlu and Ergev, 2008), and 22.56 ºC (Gücü et al., 2011).

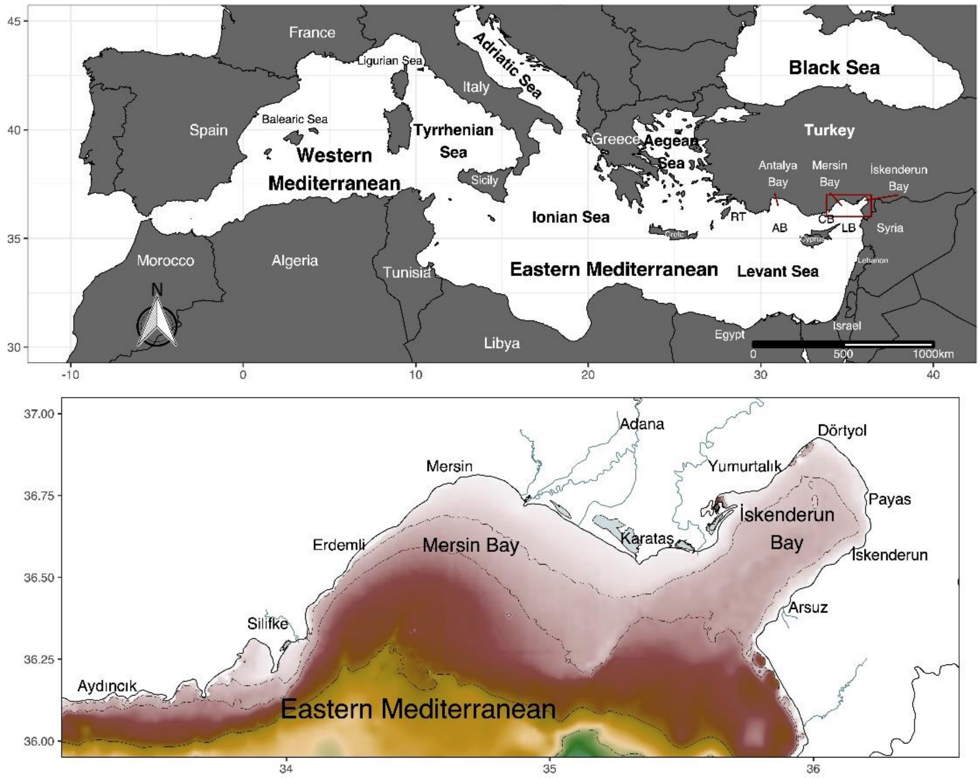

Figure 3.1. Map of Study Area

3.2. Sample Collection

A total of 967 specimens of bogue (Figure 3.2) were collected from commercial purse seiners and fish markets around the Gulf of Iskenderun and Mersin (36°30′N, 35°40′E) of northeastern Levantine Basin (northeastern Mediterranean Sea) between August 2020 and July 2021. The samples were carried to the Fisheries Laboratory of the Department of Fisheries Basic Sciences in Çukurova University in cold storage condition.

Figure 3.2. Photo of a Bogue, *Boops boops* (Linneaeus, 1758) Specimen

3.3. Laboratory Procedures

The morphometric measurements for all specimens were taken with an analog caliper to the nearest 0.1 cm. After morphometric measurements were taken, all individuals were dissected. The fish was dissected from the anus along the ventral line of the fish body. The sex was differentiated, and sexual maturity degree were determined based on macroscopical investigation. Then the gonad and gut weight were scaled using a digital balance to the nearest 0.01g. Finally, the head of all collected specimen were dissected perpendicular to opercle, and the sagittal otoliths were extracted for age readings.

To investigate the feeding and diet items, the stomach content of 190 specimens were preserved in 4% formaldehyde solution and these were examined separately. During dissection after the gut extraction, it was dissected and then the food items were extracted and identified to the lowest possible taxa. Identifications were performed with macroscopic investigation or under an Olympus SZ7 stereo microscope, if necessary. The total weight of prey items was scaled using a balance to the nearest 0.01g. Then all food items were photographed, and the total length of the prey items were measured using ImageJ software (Schindelin et al., 2012). Finally, the head of all collected specimen were dissected perpendicular to opercle, and the sagittal otoliths were extracted for age readings.

3.4. Age Determination

Age readings were performed based on sagittal otoliths which is a commonly employed method to calculate growth parameters (Mercier et al., 2011). The term otolith is often meant to describe one of the three pairs of calcareous structures in the inner ear of teleost fish. Generally sagittal otoliths are used in age readings because in most it is the largest one in Teleost fishes (Panfili et al., 2002). To investigate the age of bogue in the Gulf of Mersin and Iskenderun, a subsample of 411 specimens were investigated. The total length of specimens ranged between 11.1 and 28.5 cm. For each bogue a pair of sagittal otoliths were removed and stored in ELISA-plate holes containing glycerin for preservation. In age readings, otoliths were cleaned in pure water and placed in a black background petri dish. Olympus SZ7 stereomicroscope attached with a camera was used in age readings. The readings were performed observing the annual rings formed in the sagittal otoliths (Avşar, 2016) starting from posterior region through the anterior-posterior axis (Morales-Nin and Panfili, 2002; Panfili et al., 2002; Wright et al., 2002).

3.5. Statistical Analyses and Modeling Procedures

3.5.1. Length-Weight Relationships

Length-Weight relationship is an important life history characteristic of the fish that describes the growth performance and allometry, so it is vital for fish biology (Costa and Araújo, 2003). Length-weight relationship in fish is exponential (Keys, 1928), the equation of which is as follows:

$$W = a * TL^b$$

Where: W is the total weight of the fish in grams (g), TL is the total length in centimeters (cm), a and b are regression coefficients. The parameter “a” (intercept) and "b" (slope) were estimated by ordinary least square approximation using the natural logarithms of variables:

$$\mathrm{Ln}\,(W) = \mathrm{Ln}\,(a) + b\,\mathrm{Ln}\,(TL)$$

The coefficient of determination (r^2) was calculated to investigate the strength of relationship between the variables. The significance of regression parameters was evaluated, and the 95% confidence intervals of regression parameters were calculated to compare sexes and to test deviation from allometric growth (b=3). The b is generally between 2.5 and 3.5 and the growth is accepted to be isometric when b is equal to three (Ecoutin et al., 2005), however, the growth is considered as allometric if b is smaller or larger than three.

The linear relationships between total length versus fork length, total length versus standard length, total length versus body width and total length versus body circumference were calculated using ordinary least square method. The significance of regression parameters was evaluated, and the 95% confidence intervals of regression parameters were calculated.

3.5.2. The von Bertalanffy Growth Parameters

von Bertalanffy's growth function (von Bertalanffy, 1938) is in the center of fishery biology to fit length at age relationship in fish (Sparre and Venema, 1998). In context of this thesis, we fitted von Bertalanffy growth function (VBGF) to average length at age values. The VBGF parameters were fitted using Ford-Walford method (Ford, 1933; Walford, 1946). The parameter estimation procedures were performed with TropFishR package (Mildenberger et al., 2017) of R computational environment (R Core Team 2021). The VBGF equation was as follows:

$$L_t = L_\infty * [1-e^{(-k*(t-t0))}]$$

L_t = is total length at age t, k= is growth parameter which indicates how fast a fish approaches its asymptotical length (L_∞) and t_0 = is the theoretical age when the fish has zero length. Then the growth performance index (Ø) was calculated using Pauly and Munro (1984)'s equation:

$$Ø = \text{Ln } k + 2 \cdot \text{Ln } L_\infty$$

This equation also employed using the growth parameters reported in the literature so that the growth performance can could be compared among different areas. The longevity of bogue was estimated from to the equation given by Pauly (Pauly, 1984):

$$t_{max} = 3/k + t_0$$

Where t_{max} is the maximum age which fish can achieve.

3.5.3. Total, Natural, Fishing Mortality (F) and Exploitation (E) Rate

Total mortality was estimated from the average and minimum length of fish using the method given by Beverton and Holt (1957). The formula used to estimate the total mortality rate was as following:

$$Z = k * \frac{L_\infty - L`}{\bar{L} - L`}$$

To calculate the natural mortality (M) the empirical formula given by Pauly (Pauly, 1980) was employed using TropFishR library (Mildenberger et al., 2017):

$$\text{Ln } M = -0.0152 - 0.279 \cdot \text{Ln } L_\infty + 0.6543 \cdot \text{Ln } k + 0.463 \cdot \text{Ln } T$$

Where T was the average annual water temperature of the study area which is assumed as 23°C (Avsar et al., 2020). After total and natural mortality were estimated, the fishing mortality coefficient (F) was computed from the following equation:

$$Z = F + M$$

Then the exploitation level of the stock (E) was calculated using the formula given by Spare and Venema (1992):

$$E = F/Z$$

3.6. Feeding Indices

The proportional abundance (%N) and biomass (%W) of food items were calculated by dividing the total number or weight of each food item to the total number or weight of overall food items detected in the stomachs of investigated bogue specimens. The percentage frequency of occurrence (%FO) was calculated as the proportion of the number of bogues containing a specific food item to the total number of investigated specimens (190). The correlation between prey and predator size were calculated using Spearman Rank Correlation. Then the index of relative importance (IRI) was computed (Hacunda, 1981) to describe the importance of the various food groups using the following formula:

$$IRI = (\%N) + (\%W) * \%FO$$

Furthermore, the percentage of IRI were also calculated for easier representation. R (Version 4.0.4) language and environmental for statistical computing (R Core Team 2021) was used for all statistical analyses and data visualizations of this study. In context of the study, the average values were reported with ± standard deviations.

4. RESULTS

4.1. Sex Ratio and Length Frequency Distribution

Among the samples 448 (46.3%) individuals were males, 466 individuals (48.2%) were females, and 53 (5.5%) individuals were found as juveniles. The female to male ratio (F: M) of samples was calculated as 1:1.04 which is not statistically significantly different from 1:1 based on Chi square test ($X^2 = 0.354$, df = 1, p = 0.552).

The total length of examined fish ranged from 11.1 and 28.4 cm (Table 4.1). The minimum and maximum value of TL of juveniles were found as 11.1 and 15.6 cm, respectively with an average TL of 13.4 ±1.19 cm (standard deviation). For the males and females, the minimum and maximum length values ranged from 11.6 to 28.4 cm and from 11.8 to 27.8 cm respectively, with average values of 16.9 ±2.41 cm and 17.3 ±2.55 cm, respectively. The length frequency distribution of the samples was given in Figure 1.1.

Table 4.1. Number of Fish, the Average, Minimum, Maximum, and Standard Deviation of Total Length of Bogue Specimens by Sexes

Sex	N	Mean (cm)	Min (cm)	Max (cm)	Standard Deviation (cm)
Juvenile	53	13.4	11.1	15.6	1.19
Male	448	16.9	11.6	28.4	2.41
Female	466	17.3	11.8	27.8	2.55
Overall	967	16.9	11.1	28.4	2.58

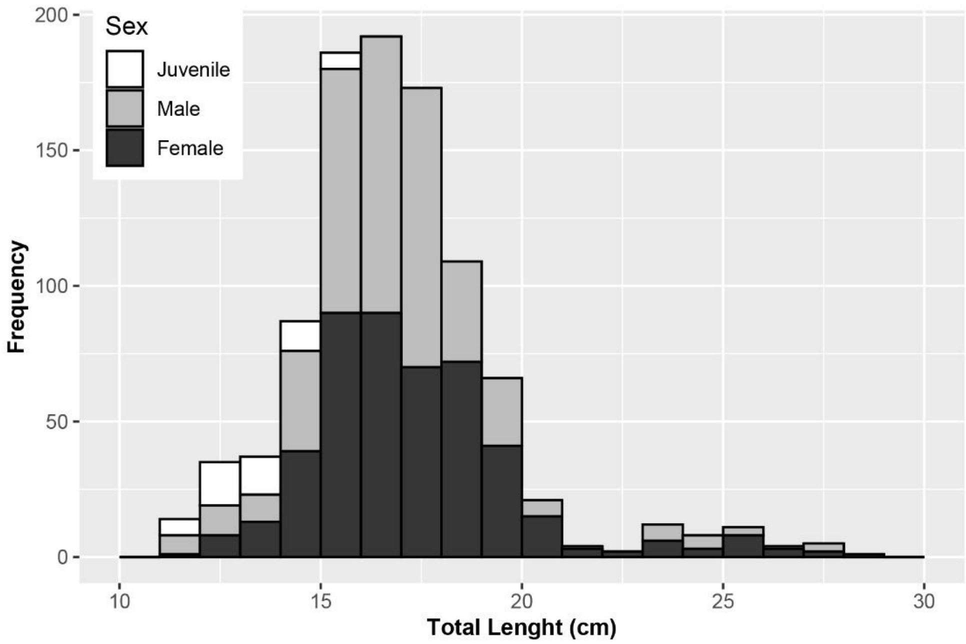

Figure 4.1. Stacked Length Frequency Distribution of Bogue in the Eastern Mediterranean Sea

4.2. Weight Frequency Distribution

Table 4.2 illustrates the descriptive statistics of the total weight of examined fish which ranged from 12.1 to 281 g. The minimum and maximum weight for bogue juveniles were determined as 12.10 and 32.30 g, respectively. The average value was 21.20 ±5.62 g. The weight of males and females were ranged from 14.10 to 210 g and from 14.80 to 281.00 g, respectively with a mean weight value of 47.30 ±26.10 g, and 53.80 ±37.10 g, respectively. Weight frequency distribution for juveniles, females, and males of bogue was given in Figure 4.2.

Table 4.2. Number of Fish, the Average, Minimum, Maximum, and Standard Deviation of Total Weight Bogue Specimens by Sexes

Sex	N	Mean (g)	Min (g)	Max (g)	Standard Deviation (gr)
Juvenile	53	21.20	12.10	32.30	5.62
Male	448	47.30	14.1	210.00	26.10
Female	466	53.80	14.80	281.00	37.10
Total	967	49.02	12.10	281.00	32.18

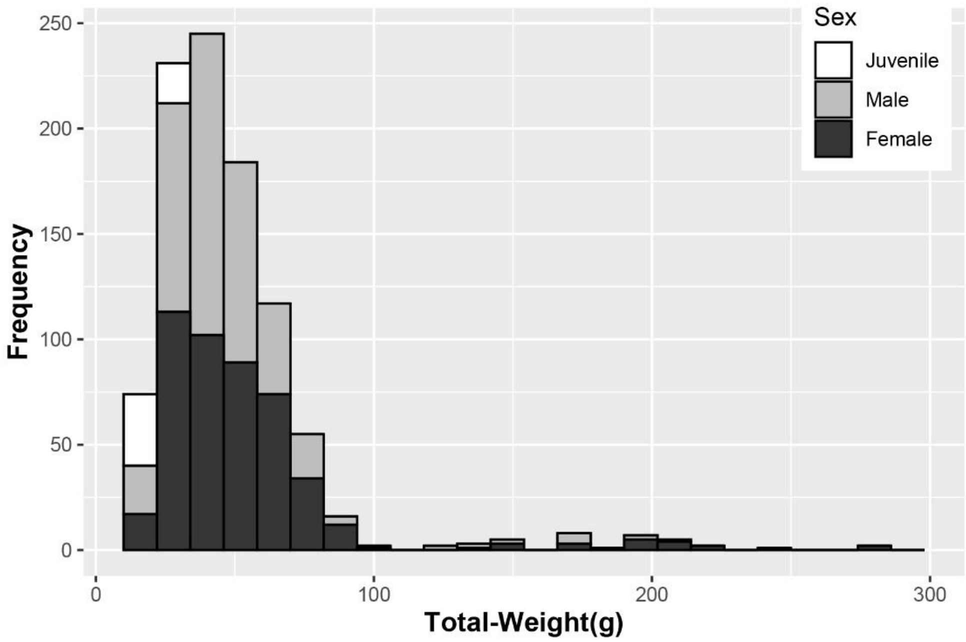

Figure 4.2. Stacked Weight Frequency Distribution of Bogue in the Eastern Mediterranean

4.3. Length - Weight Relationships

The length-weight relationship (LWR) parameters for the juveniles, males, females, and the combined sexes were described by the following exponential equations; $W=0.011TL^{2.90}$ (R^2=0.948), $W = 0.004TL^{3.29}$ (R^2=0.912), $W = 0.002TL^{3.52}$ (R^2=0.947), $W= 0.003TL^{3.38}$ (R^2=0.941), respectively. The LWR parameters and their 95% confidence intervals were given in (Table 4.3), and scatterplots were given in Figure 4.3. Except for juveniles, the exponential coefficient (b) for males, females and all combined sexes was significantly greater than three ($p<0.05$) which indicates that the growth is positive allometric in bogue population in Mersin Bay and Iskenderun Bay of the Eastern Mediterranean Sea.

Table 4.3. Length-Weight Relationship Parameters for Juveniles, Females, and Males of Bogue (the ranges in parentheses show 95% confidence interval of the parameter)

Sex	N	Parameter	Estimate (95% CI)	Std. Error	t-value	Pr(>|t|)	R^2
Juvenile	53	a	0.011	0.244	-18.35	<0.001	0.948
		b	2.896 (2.706 -3.085)	0.094	30.75	<0.001	
Male	448	a	0.004	0.137	-40.28	<0.001	0.912
		b	3.289 (3.194-3.384)	0.048	67.84	<0.001	
Female	466	a	0.002	0.110	-55.85	<0.001	0.947
		b	3.516 (3.440- 3.592)	0.039	90.90	<0.001	
Overall	967	a	0.003	0.077	-74.59	<0.001	0.941
		b	3.382 (3.328-3.435)	0.027	123.30	<0.001	

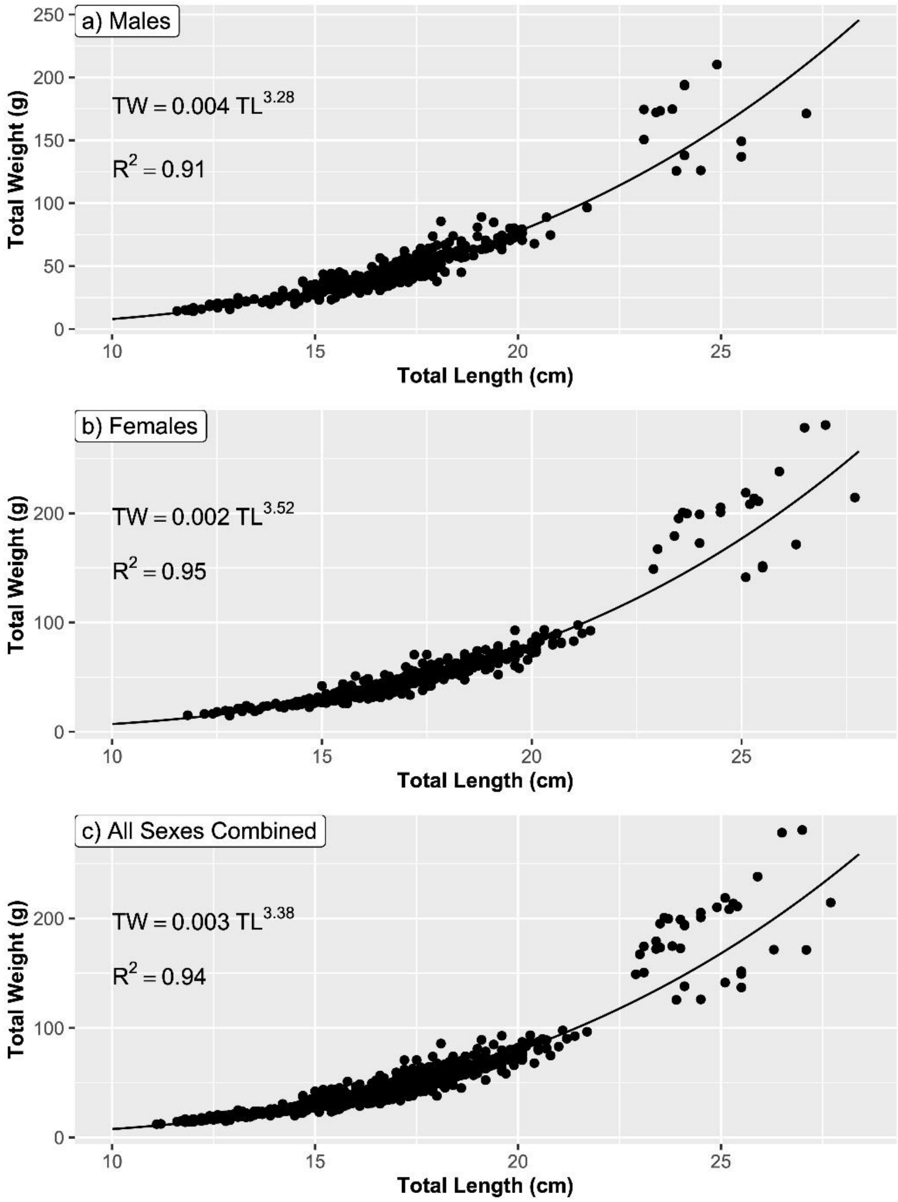

Figure 4.3. Length-Weight Relationships for Males (a), Females (b) and All Specimens of Bogue in Eastern Mediterranean

The "b" of LWR was significantly different between sexes, although there was not statistically significant difference amongst the intercepts (Table 4.4).

Table 4.4. ANOVA Table for the Comparison of Length-Weight Relationship Parameters Between Sexes of Bogue

Parameters	Df	Sum Sq	Mean sq	F value	Pr(>F)
TL	1.000	182.171	182.171	12607.485	< 0.001
Sex	1.000	0.000	0.000	0.032	0.856
Sex: TL	1.000	0.197	1.197	13.640	<0.001
Residuals	903.000	13.049	0.014		

4.4. Total Length - Body Width Relationship

The total length-body width (BW) relationship by sexes were given in Table 4.5 and Figure 4.4. The intercepts were not significantly different from zero and the slope of regressions was significant in each sex ($p<0.001$).

Table 4.5. Total Length-Body Width Relationship Parameters for Juveniles, Males, Females, and All Specimens of Bogue (the ranges in parentheses show 95% confidence intervals of the parameter)

Sex	N	Parameter	Estimate (95%CI)	Std. Error	t-value	Pr(>|t|)	R^2
Juvenile	53	a	0.355	0.191	1.855	0.069	0.282
		b	0.066 (0.037-0.095)	0.014	4.628	<0.001	
Male	448	a	-1.053	0.071	-14.86	<0.001	0.792
		b	0.171 (0.163-0.179)	0.004	41.30	<0.001	
Female	466	a	-1.259	0.067	-18.77	<0.001	0.832
		b	0.184 (0.176-0.191)	0.004	47.96	<0.001	
Overall	967	a	-1.132	0.045	-25.31	<0.001	0.825
		b	0.176 (0.171-0.181)	0.003	67.42	<0.001	

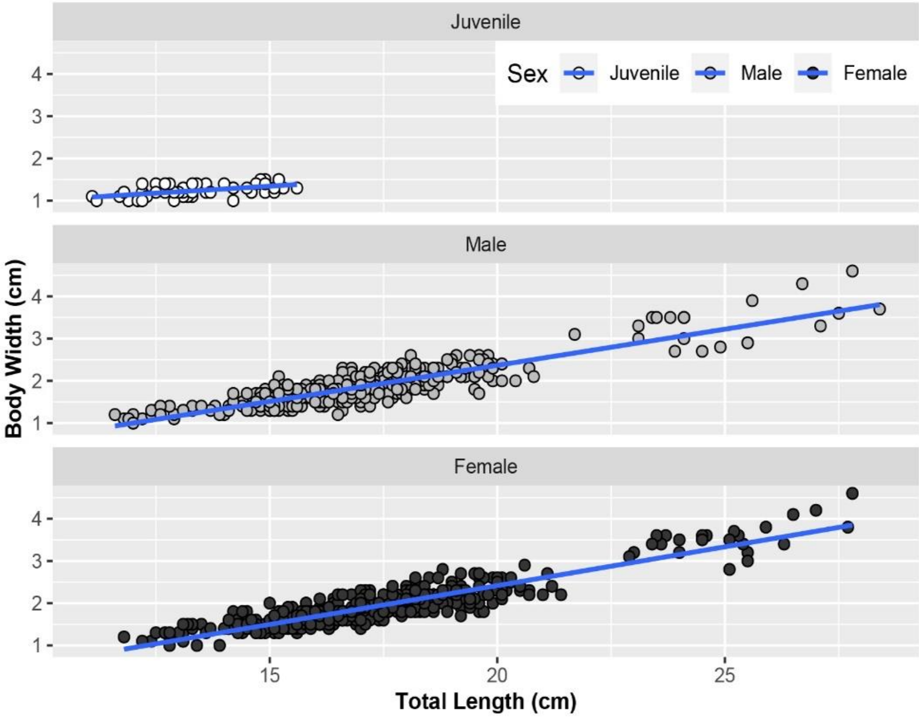

Figure 4.4. Total Length-Body Width Relationships for Males, Females, and Juveniles of Bogue in the Eastern Mediterranean

The "b" value of total length-body width relationships was significantly different among juveniles, males, and females whereas the intercepts were not found to be significantly different each other (Table 4.6).

Table 4.6. ANOVA Table for the Comparison of Total Length-Body Width Regression Parameters of Bogue

Parameters	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TL	1.000	199.749	199.749	4656.419	< 2.2e-16
Sex	2.000	0.046	0.023	0.541	0.582
TL: Sex	2.000	1.137	0.568	13.251	<0.001
Residuals	961.000	41.224	0.043		

4.5. Total Length - Body Circumference Relationship

The total length - body circumference (BC) regression parameters for juveniles, males, females, and combined sexes of bogue were given in (Table 4.7 and in Figure 4.5).

Table 4.7. Total Length-Body Circumference Regression Parameters for Juveniles, Females, Males and for All Specimen of Bogue (the ranges in parentheses show 95% confidence intervals of the parameter)

Sex	N	Parameter	Estimate (95%CI)	Std. Error	t value	Pr(>|t|)	R^2
Juvenile	53	a	1.683	0.575	2.929	<0.001	0.609
		b	0.388 (0.302-0.474)	0.043	9.055	<0.001	
Male	448	a	-1.801	0.241	-7.459	<0.001	0.826
		b	0.650 (0.622-0.678)	0.014	46.052	<0.001	
Female	466	a	-2.305	0.238	-9.681	<0.001	0.844
		b	0.682 (0.656-0.709)	0.014	50.172	<0.001	
Overall	967	a	-2.016	0.154	-13.070	<0.001	0.849
		b	0.664 (0.647-0.682)	0.009	73.700	<0.001	

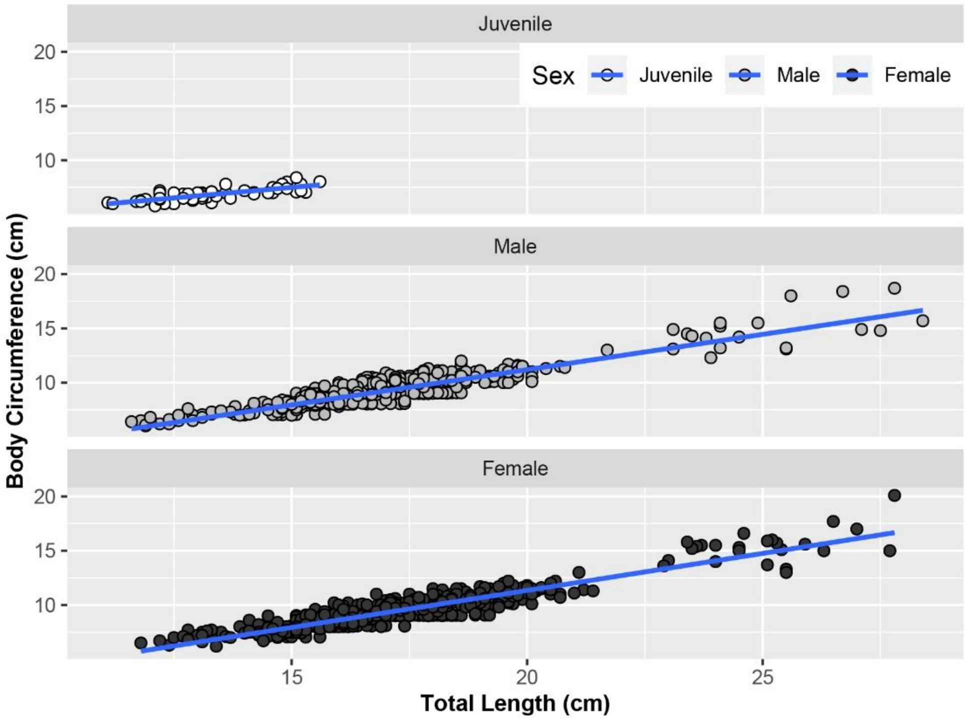

Figure 4.5. Total Length-Body Circumference Relationships for Juveniles, Males, Females, and All Specimens of Bogue in the Eastern Mediterranean

The study revealed that the slope of total length - body circumference regressions significantly different between sexes, whereas no significant difference was observed between the intercepts (Table 4.8).

Table 4.8. ANOVA Table for Comparison Between Total Length-Body Circumference Regression Parameters of Bogue

Parameters	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TL	1.000	2841.860	2841.860	5493.383	< 0.001
Sex	2.000	0.600	0.300	0.583	0.558
TL: Sex	2.000	7.130	3.570	6.895	0.001
Residuals	961.000	497.150	0.520		

4.6. Total Length - Fork Length Relationship

The total length - fork length regression parameters for juveniles, females, males, and all combined specimens were given in Table 4.9 and Figure 4.6. The intercepts were not significantly different from zero. The slope of regressions was significant in each sex ($p<0.001$).

Table 4.9. Total Length - Fork Length Regression Parameters for Juveniles, Males, Females and for All Specimen of Bogue (the ranges in parentheses show 95% confidence intervals of the parameter)

Sex	N	Parameters	Estimate (95% CI)	Std. Error	t-value	Pr(>|t|)	R^2
Juvenile	53	a	-0.702	0.459	-1.531	0.132	0.939
		b	0.969 (0.900-1.038)	0.034	28.346	<0.001	
Male	448	a	0.082	0.115	0.715	0.475	0.976
		b	0.905 (0.891-0.918)	0.007	133.51	<0.001	
Female	466	a	-0.046	0.109	-0.423	0.673	0.979
		b	0.911 (0.899-0.924)	0.006	146.71	<0.001	
Overall	967	a	0.057	0.072	0.784	0.433	0.979
		b	0.906 (0.898-0.914)	0.004	214.06	<0.001	

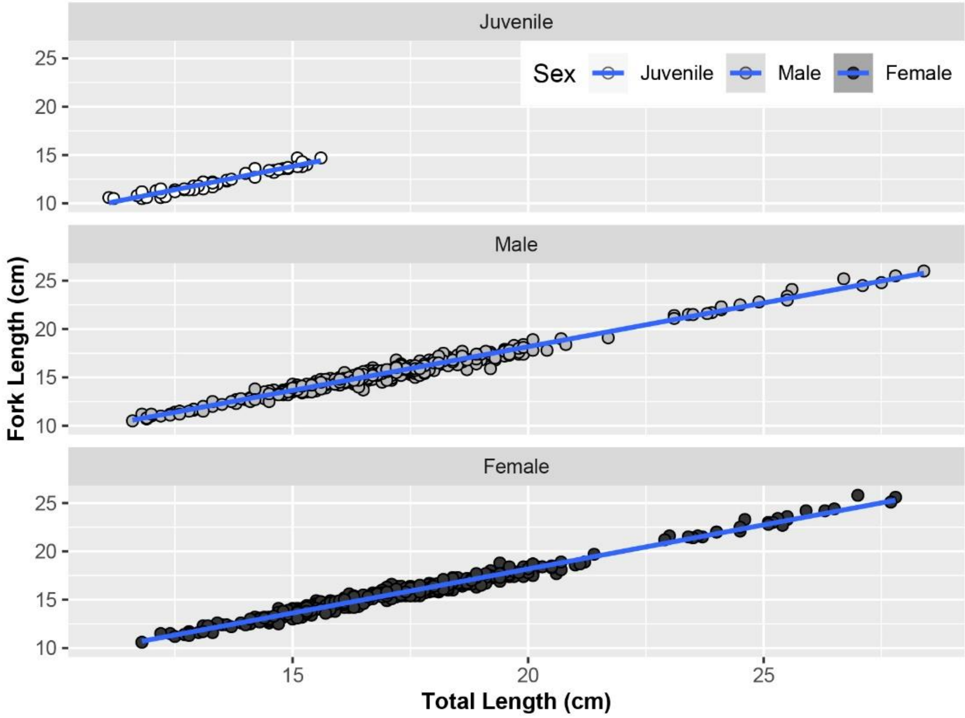

Figure 4.6. Total Length - Fork Length Relationships for Juveniles, Males, Females, and All Specimens of Bogue in the Eastern Mediterranean

No statistically significant difference was found amongst the intercept and slope values of total length - fork length regressions among sexes (Table 4.10).

Table 4.10. ANOVA Table for Comparison Between Total Length-Fork Length Relationships Regression Parameters of Bogue

Parameters	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TL	1.000	5287.200	5287.200	45949.478	<2e-16
Sex	2.000	0.400	0.200	1.919	0.147
Sex: TL	2.000	0.300	0.200	1.447	0.236
Residuals	961.000	110.600	0.100		

4.7. Total Length - Standard Length Relationship

Table 4.11, and Figure 4.7 shows the total length - standard length regression parameters for juveniles, females, males and for the overall specimens.

Table 4.11. Total Length - Standard Length Regression Parameters for Juveniles, Males, Females and For All Specimen of Bogue (the ranges in parentheses show 95% confidence intervals of the parameter)

Sex	N	Parameter	Estimate (95% CI)	Std. Error	t-value	Pr(>|t|)	R^2
Juvenile	53	a	-1.929	0.420	-4.594	<0.001	0.948
		b	0.962 (0.899-1.025)	0.031	30.735	<0.001	
Male	448	a	-0.444	0.120	-3.694	<0.001	0.971
		b	0.852 (0.838-0.866)	0.007	121.19	<0.001	
Female	466	a	-0.306	0.125	-2.439	0.015	0.968
		b	0.844 (0.829-0.858)	0.007	117.86	<0.001	
Overall	967	a	-0.406	0.079	-5.114	<0.001	0.972
		b	0.849 (0.840-0.858)	0.005	183.05	<0.001	

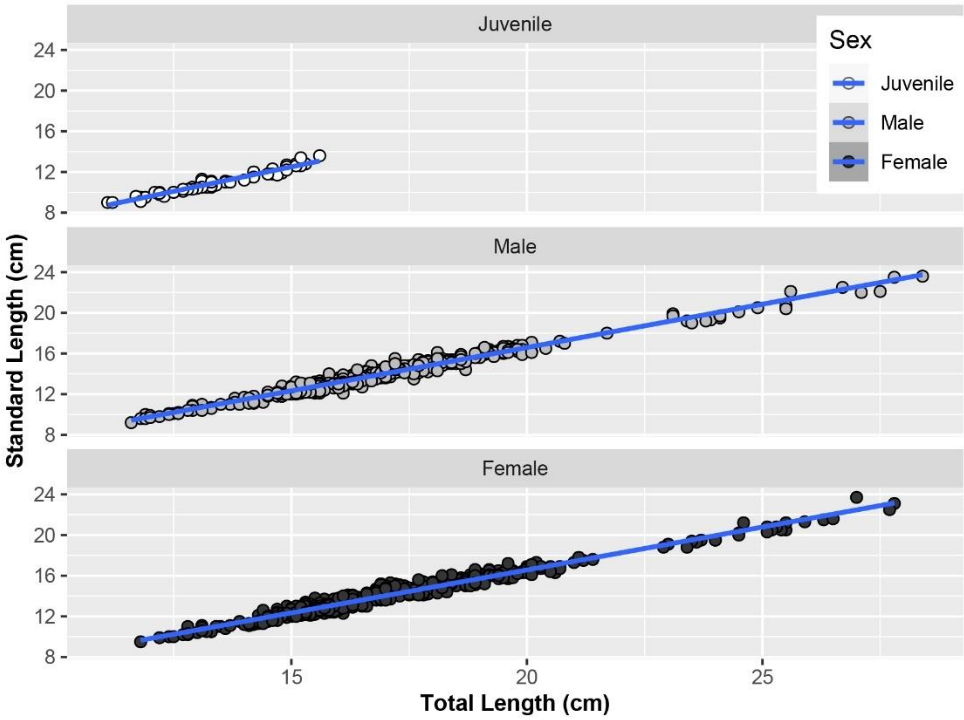

Figure 4.7. Total Length - Standard Length Relationships for Juveniles, Males, Females, and All Specimens of Bogue in the Eastern Mediterranean

The slope of total length - standard length regression was statistically significantly different among sexes (Table 4.12) whereas there was no significant difference between intercepts.

Table 4.12. ANOVA Table for Comparison Between Total Length-Standard Length Relationship Regression Parameters of Bogue

Parameters	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TL	1.000	4646.100	4646.100	33634.821	<0.001
Sex	2.000	0.000	0.000	0.067	0.936
Sex: TL	2.000	1.000	0.500	3.796	0.023
Residuals	961.000	132.700	0.100		

4.8. Age, Growth and Mortality

The age of bogue determined from sagittal otoliths were giving in (Figure 4.9 and 4.10). The ages were between 1 (11.0 cm) and 6 (26.3) years. The von Bertalanffy growth parameters were calculated as follows: L_∞= 29.453 cm, k=0.237 year^{-1}, t_0 = -1.626 years for males, L_∞ = 37.362 cm, k = 0.136 year^{-1}, t_0 = -2.436 years for females and L_∞= 32.991 cm, k =0.181 years^{-1}, t_0 = -1.928 years for all combined sexes, respectively. The growth performance indices for males, females and combined sexes were estimated as Ø = 5.237, Ø = 5.250, and Ø = 5.286, respectively. The von Bertalanffy growth parameters and growth performance indices (Ø) were given in Table 4.13 and Figure 4.8 and Figure 4.9.

Table 4.13. Von Bertalanffy Growth Parameters, Growth Performance Indices, Minimum, Maximum Length, and Standard Deviation

Sex	Parameter	Value	Min -TL (cm)	Max-TL (cm)	SD (cm)	Ø
Males	L_∞ (cm)	29.453	11.6	27.5	2.90	5.327
	k (y^{-1})	0.237				
	t_0 (y)	-1.626				
Female	L_∞ (cm)	32.991	11.8	27.7	3.39	5.25
	k (y^{-1})	0.136				
	t_0 (y)	-2.436				
Overall	L_∞ (cm)	32.991	11.7	25.5	3.15	5.286
	k (y^{-1})	0.181				
	t_0 (y)	-1.928				

L_∞ (cm) = asymptotic length, k = growth coefficient; t_0 = hypothetical age at zero length; Ø growth performance index

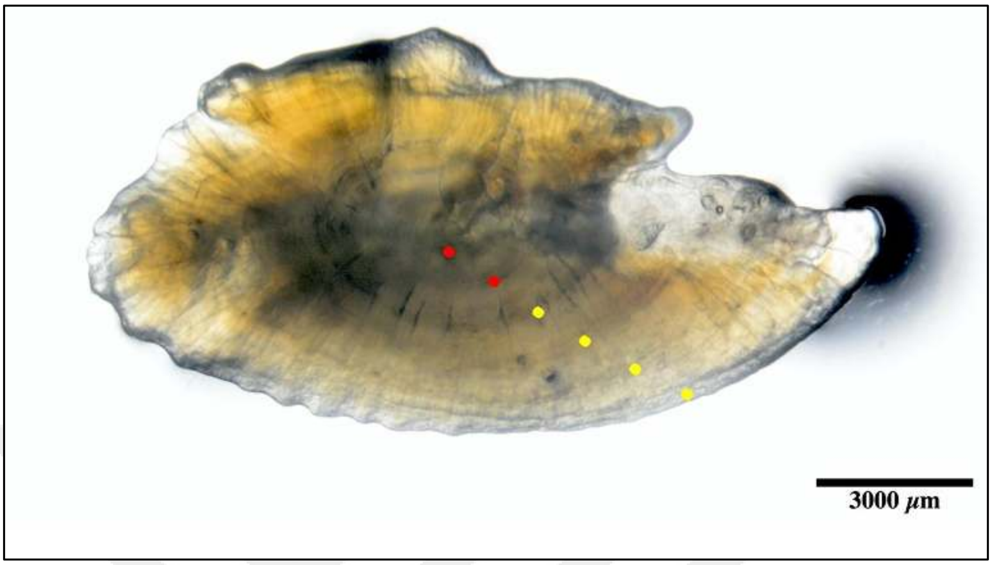

Figure 4.8. Sagittal Otolith Extracted from a Four-Year-Old Fish (yellow dots was counted as true rings)

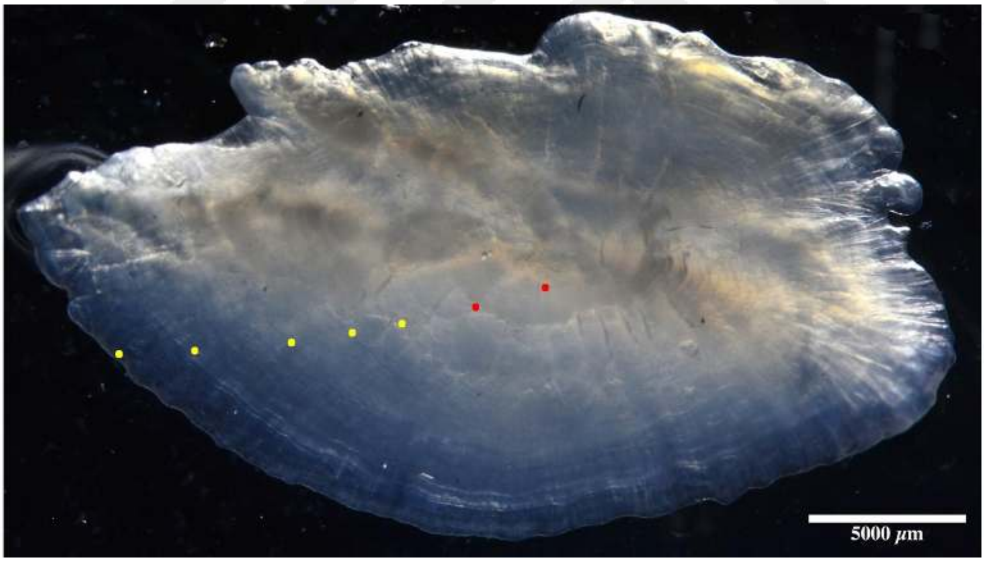

Figure 4.9. Sagittal Otolith Extracted from a Five-Year-Old Fish (yellow dots was counted as true rings)

Table 4.14. Age, Minimum Length, Average Length, Maximum Length and Standard Deviation of Bogue in Mersin Bay and Iskenderun Bay of the Eastern Mediterranean Sea

Age (y)	Age Classes No of Fish per age	Min-TL (cm)	Mean TL (cm)	Max TL (cm)	SD (cm)
1	131	11.	13.8	15.5	0.949
2	167	14.8	15.8	18.3	0.624
3	32	16.8	17.8	19.4	0.713
4	5	22.9	23.3	23.5	0.288
5	14	23.1	24.2	25.5	0.803
6	9	23.9	25.3	26.3	0.717

The growth coefficient (k= 0.181) for combined sexes was used to estimate the longevity of bogue in Mersin Bay and Iskenderun Bay and it was estimated as 14.6 years. The total mortality (Z), the natural mortality (M), the fishing mortality (F), and exploitation rate were estimated as M = 0.520, F = 0.882 and Z = 1.402 year ^{1}, and E = 0.629, respectively. As a result of overfishing, the mortality caused by fisheries were greater than the natural causes and therefore, the exploitation level which was higher than 0.5 indicated that the bogue stock was over exploited in Mersin Bay and Iskenderun Bay.

4.9. Feeding

For diet composition among the examined fish, 95 individuals were females, 94 where males and 1 individual were juvenile. The total length of examined specimens ranged from 13.3 to 27.7 cm. Food items were found in the stomachs of 46 individuals, while stomachs of 144 specimens were empty. Therefore, the feeding index was calculated as 24.21% and four different food items were found in the diet content of bogue (Table 4.15). Among them, *Bregmaceros nectabanus* was the most dominant food item (Figure 3.1), followed by unidentified shrimps (Figure 3.2), squids (Figure 3.3) and copepod. There was a positive correlation between prey and predator size (r=0.55, and p<0.001) showing the prey size increases with increase of predator size.

Table 4.15. Abundance (N), Biomass (W), Frequency of Occurrence (FO) and Relative Importance (IRI) of Food Items in the Diet of Bogue

Prey Type	N	W (g)	FO	N%	W%	FO%	IRI	IRI%
Bregmaceros nectabanus	1468	689.66	46	94.89	98.18	100	19307.4	99.336
Unidentified Shrimps	76	11.24	9	4.91	1.60	19.57	127.43	0.656
Unidentified Squid	2	1.51	2	0.13	0.21	4.35	1.50	0.008
Unidentified Copepod	1	0.03	1	0.06	4.3e^3	2.17	0.15	0.001

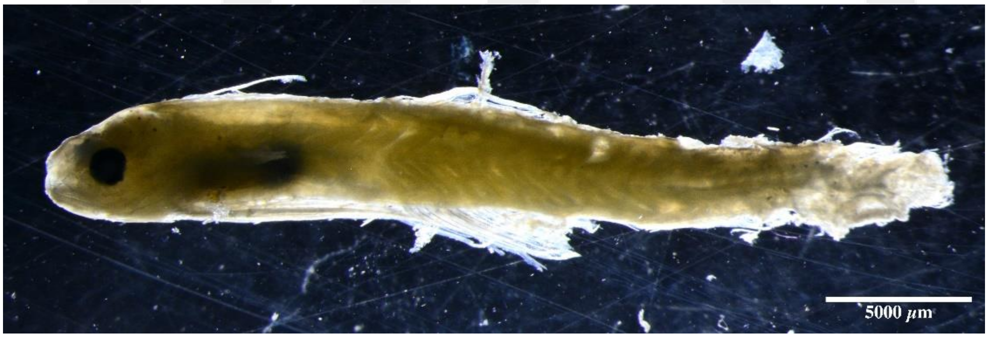

Figure 4.10. *Bregmaceros nectabanus* Specimen Found in the Stomach of Bogue

Figure 4.11. Unidentified Shrimp Found in the Stomach of Bogue

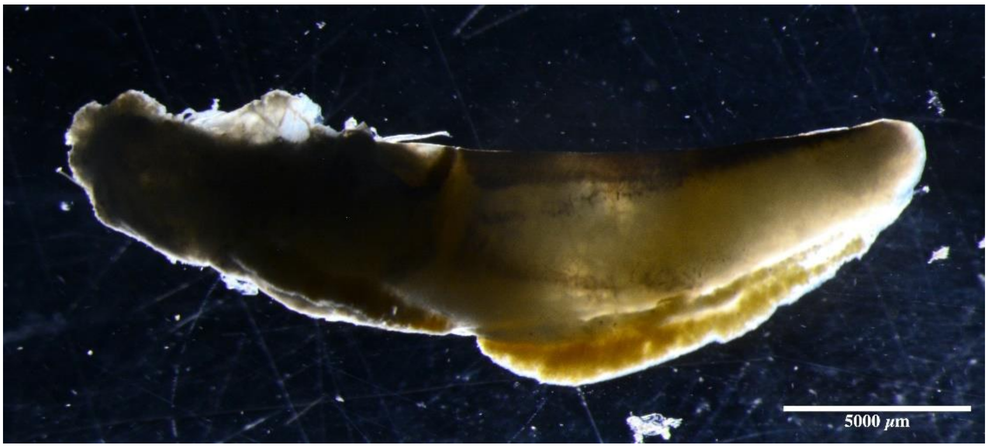

Figure 4.12. Unidentified Squid Found in the Stomach of Bogue

The minimum, maximum and averages sizes of diet items found in bogue stomach were given in Table 4.16.

Table 4.17. The Minimum, Maximum and Averages Size and Sum of Total Length of All Prey Individuals Found in Bogue Stomachs in Mersin Bay and Iskenderun Bay

Prey Type	Counts	Min Length(mm)	Max Length(mm)	Average Length (mm)	SD (mm)
B. nectabanus	1468	5.222	56.032	18.475	6.344
Unidentified shrimp	76	7.674	31.995	14.891	3.768
Unidentified Squid	2	10.61	11.321	10.967	0.501
Copepod	1			6.237	

5. DISCUSSION

Bogue, *Boops boops* (Linnaeus, 1958) is small semi-demersal fish but with large impact as its caught across all seas in Turkey. It's sold commercially in local fish markets, and it provides income for many fishers. This study is caried out to analyze some population dynamical parameters of bogue in Mersin Bay and Iskenderun Bay, Levant Sea (the Eastern Mediterranean).

The female:male ratio of bogue specimens in this study (1:1.04) indicates that the sex distribution is in balance which is in accordance with the previous studies. In previous studies, the sex ratio is detected as 1:0.99 by Manaşırlı et al. (2006) in Babadıllımanı Bight Mersin, 1: 1.17 by Kara and Bayhan (2015), 1:1.34 by Bilge (2008) in Izmir Bay, 1:1.83 by Bilge 2008 in Edremit Bay, 1:1.00 by Azab et al. (2019) in Alexandrian coast Egypt and 1:0.85 by Massaro and Pajuelo (2018) in central and eastern Atlantic Ocean.

The total length and total weight of examined specimens were ranged between 11.1-28.4 cm and 12.10-281.0 g, with average values of 13.4 ±1.19 cm and 21.20 ±5.62 g, respectively. In the Aegean Sea, the maximum length and maximum weight is reported as 40.2 cm and 986 g by Ceyhan et al. (2018), 23.9 cm and 154.4 g by Andsoy (2015), 28.1 cm and 237 g by Bilge (2008), 27.9 cm and 261.7 g by Kara and Bayhan (2015) which are in accordance with our results except for those of Ceyhan et al. (2018). Our size ranges were also in accordance with the studies conducted in Western Mediterranean Sea, in which maximum size and maximum weight values are 30.9 cm and 268.2 g in Algerian coast (Dahel et al., 2019), 30.9 cm and 291.2 g in the Gulf of Cadis Spain (Torres et al., 2012). Contrary to expectations, the maximum length and weight values were apparently smaller than our observations in the previous studies performed in the Eastern Mediterranean. For example, the maximum sizes were reported as 21.4 cm and 99.98 g by Manaşırlı et al. (2006) in Babadıllimanı Bay, 23cm and 133.1 g by

Azab et al (2019) in Alexandria coasts of Egypt, 21.0 cm and 113.0 g by Miled-Fathalli et al. (2019) in the Gulf of Tunis.

A reasonable explanation for the variations of total length and weight ranges may be differences in selectivity of sampling gears of different studies. For example, in this study samples were collected from commercial fishers. This may cause that our maximum length is found to be larger in comparison with Manaşırlı et al. (2006) in which the samples were collected with scientific bottom trawl operations. Differences in sampling or fixation procedures can be another explanation for observing different size ranges. For instance, after fish samples are collected or removed from the deep freezer it must weighed or scaled as soon as possible since fish's weight decreases as it dries out.

On the other hand, decreasing maximum size may also indicate disappearance of larger fish from the catch (Allam, 2003; Kara and Bayhan, 2015). The maximum size of fish is an indicator of overfishing pressure on the fish population as selective gears designed to remove large fish and release smaller ones (Shin et al., 2005). Therefore, these differences may be because of differences of fishing pressure on the bogue populations in space and/or time.

The length - weight relationship parameters calculated in this study and previous studies were compared in Appendix I. A positive allometric growth were observed except for the juveniles. Negative allometry in juveniles may be an artifact because of the smaller number of immature fishes in our sample since the sample size also effects the value of b. Therefore, it could be concluded that bogue in Mersin Bay and Iskenderun Bay of the Eastern Mediterranean revealed positive allometric growth. The b value for males (3.289), females (3.516) and the pooled data (3.382) of the present study was nearly similar with observed by Andsoy (2015) in Edremit Bay, Soykan et al. (2015), Kara and Bayhan (2008), and Bilge (2008) in Izmir Bay of the Aegean Sea. However, negative, and positive allometric growth profiles are reported for the males and females respectively by Manaşırlı et al. (2006) in Babadillimani Bight, Eastern Mediterranean; an isometric growth was reported by Dahel (2019) in Algerian Coast, Western Mediterranean and a negative allometric growth by Miled-Fathalli et al. (2019) in the Gulf of Tunis. As Appendix I shows there are some differences among the allometric coefficient of LWR. These differences may be because of spatial variations of food availability as well as water quality (Garcia et al., 1989; Mommsen, 1998), different fishing pressures or different sampling methods.

The lifespan of bogue was estimated as 14.8 years in the present study. This estimate nearly agrees with a study conducted in Algarve which reports a miximum age of 13.9 years (Monteiro et al., 2006). The maximum age was larger in central Adriatic Sea which reported as 16.6 by Algeria Hernendees (1989).

The ages of the population inhabiting in Mersin Bay and Iskenderun Bay were between 1 and 6 with dominance of 1st and 2nd classes. This observation was very similar to that of Manaşırlı et al. (2006) in Babadillimani Bight who reported the ages were between 1 and 6 years with dominance of 3rd year class. In the present study the maximum age was slightly larger than that of Kara and Bayhan (2015) in Izmir Bay, Aegean Sea and El-Okda (2008) in Alexandria, Egypt. Kara and Bayhan (2015) have reported that the maximum age was 5 years and 2nd age group is the most dominant in İzmir Bay. Accordingly, the ages reported by El-Okda (2008) in Alexandria were between 1 and 4 years, and 3rd year class is the most dominant. The ages were found between 0 and 9 years by Bilge (2018) both in Izmir and Edremit Bays with 2nd and 3rd age classes as the most dominant groups. In eastern Algerian coast, the age groups ranged from 1 to 5 years with the dominant age groups of 1 and 2 years (Dahel et al., 2019). On the other hand, in Algarve, the age classes were found to be from 0 to 11 years, with the 5th age class being the most dominant (Monteiro et al., 2006).

Monteiro et al. (2006) is the only study showing dominance of five years old fish and this could be related with the use of longlines in sampling, which can capture large fish. However, the rest of the findings as well as the findings of the present study, indicate that the young fishes dominate the bogue population in the Mediterranean, possibly due to overfishing pressure on large fishes.

The von Bertalanffy growth parameters calculated in this study and previous studies were compared in Appendix II. According to the value presented in Appendix II, the asymptotic length (L_∞), the growth coefficient (k) and theoretical age (t_0) of bogue are nearly similar amongst different regions in Mediterranean Sea. For instance, asymptotic length and growth coefficient of pooled data of the present study was calculated as L_∞= 32.991 cm, k = 0.181 years^{-1}. This observation was close to that of Manaşırlı et al. (2006) in Babadillimani Bight and the one reported by Bilge (2008) in Edremit bay. Manaşırlı et al. (2006) have given the growth parameters as L_∞= 33.62 cm, k=0.109 year^{-1}, while the growth parameters of Bilge (2008) were found as L_∞ = 31.54 cm, k = 0.129 year^{-1}. In alexandria coast, slightly lower L_∞ (30.65 cm) and bigger k (0.279 year^{-1}) values were reported. Appendix II shows that in Western Mediterranean and Atlantic Ocean, the growth coefficients appear to be higher than those of present study.

The possibility of this differences among studies may be explained due to difference of maximum length values of studies which has a well-known effect on the von Bertalanffy growth parameters (Sparre and Venema, 1998). Asymptotic length (L_∞) is a theoretical size of infinitely old fish. Its value is determined with the presence of several large fishes in the sample. As a result, asymptotic length is not a reliable index of maximum growth potential of an average fish in a population, if the sample is not representatively sampled including all size classes (Avşar et al., 2020).

The growth performance index (Ø; Pauly and Munro, 1983) was used to compare the growth of bogue populations from different regions of the Mediterranean Sea. However, the previous studies used different logarithmic bases to calculate this index which makes the comparisons impossible. Therefore, using

L_∞ and k values reported in previous studies, Ø values of bogue population were recalculated applying the same formula used in this study. Based on a comparison among present and previous studies, the growth performance of bogue was found to be variable in space and time without showing a clear spatial pattern (Appendix II). In this study, the Ø was calculated as 5.29 for the population distributed in the Mersin Bay and Iskenderun Bay. This value was in the range reported in the previous studies. The growth performance calculated in previous studies vary between 4.65 (Bilge, 2008; Edremit Bay Aegean Sea) and 6.16 (Massaro and Pajuelo, 2018; Central and Eastern Atlantic Ocean). The growth performance reported by Manaşırlı et al. (2006) from Babadillimani Bight (4.81) and El-Okda (2008) from Alexandria coasts (4.86) was lower than that of reported in present study. On the other hand, higher values were reported from the Alexandrea coasts by Fahmy Mahena (2014) and Azab et al. (2019). The variability of growth performance of bogue populations could be as a result of several factors such as differences in environmental conditions, mortality rates or just genetic variations (Dutka-Gianelli and Murie, 2001). In addition the influence of water quality and food availability (Garcia et al., 1989; Mommsen, 1998) as well as temperature differences (Jones, 1976) can be another reasons.

Mortality rates and exploitation level of bogue from different regions of Mediterranean Sea were compared in Appendix I. Allam (2003) reports that the exploitation level of bogue in Alexandria was at optimum rate (E=0.464) in 1999. However, mainly all previous studies conducted after that period revealed that the populations of bogue are overfished. For example, Manaşırlı et al. (2006) reported that the E value is 0.72 in Babadıllımanı Bight. In Aegean Sea, Soykan et al. (2015) gives E value as 0.87. In Alexandria, Azab et al. (2019) and Dahel et al. (2019) has reported E value as 0.70 and 0.64, respectively. In accordance with the previous studies, the present study showed that the fishing mortality in Mersin Bay and Iskenderun Bay was greater than the mortality caused by natural factors

(E=0.63). Even though the exploitation rate which were determined in the present study was lower than those determined in the previous studies performed in the Mediterranean Sea, it still indicated that the bogue population is overexploited in the study area. Therefore, if the current fishing efforts continue at this level, it may lead reduction of bogue landings and finally collapse of its stock. Therefore, management measures to reduce its fishing efforts should be taken.

Table 5.1. Mortality and Exploitation Rates of Bogue Estimated from Different Geographical Regions of Mediterranean Sea

Study Area	Sex	Z (y^{-1})	M (y^{-1})	F (y^{-1})	E	References
Gulf of Mersin & Iskenderun, Turkey	C	1.402	0.520	0.882	0.629	Present Study
Babadillimani Mersin	C	1.257	0.351	0.906	0.721	Manaşırlı et al.2006
East Central Aegean Sea	C	1.040	0.330	0.710	0.680	Soykan et al. 2015
Alexandria Egypt	C	1.283	0.458	0.824	0.464	Allam, 2003
Alexandria Egypt	C	2.260	0.671	1.589	0.703	Azab et al., 2019
Algeria East coast	C	1.030	0.370	0.660	0.641	Dahel et al., 2019

C= combined sexes, Z = total mortality, M= natural mortality, F= fishing mortality, E= exploitation rate

Based on Studies from Bilge (2008) from the Aegean Sea and Hamad El-Maremie and Mohammad El-Mor (2015) from the eastern Libyan coastlines of the central Mediterranean Sea, the diet of bogue contains benthic organisms such as seagrasses, mollusks, crustacea and porifera. However, in present study it was fund that the pelagic prey species were dominant in the diet of bogue. Larval and juvenile stages of invasive *Bregmaceros nectabanus* (Orfanidis et al., 2021: Bilecenoğlu et al., 2014) were the most dominant prey items occurring in 95% of the full stomachs. This provided a good example of how an invasive species became an important food item for a native species and can restructure the marine food web.

Biological invasion is a global threat to biodiversity having effects on native biota (Bax et al., 2003). Invasive fishes make up 85% of Teleost fish biomass in the Southern Turkey (Mavruk et al., 2017). Therefore, the predation pressure asserted by bogue on invasive *Bregmaceros nectabanus* may provide a good control strategy for *Bregmaceros nectabanus* population in the eastern Mediterranean. Therefore, protecting bogue stocks not only provides sustainability of fisheries but also have some ecological benefits for the Mediterranean ecosystem.

6. CONCLUSION

Bogue is among the most important commercial marine species caught across all seas of Turkey. The present study analyses some population dynamical parameters of bogue in Mersin Bay and Iskenderun Bay, Levant Sea (Eastern Mediterranean). Although the exploitation rate that we found in Mersin Bay and Iskenderun Bay is relatively lower than the exploitation level observed in other parts of the Mediterranean Sea, the present study reveals that the stock of bogue in the Gulf Mersin and Iskenderun was overexploited. Thus, it is necessary to take conservational measures and management steps to protect its stock and consequently market landings from further losses.

It is, therefore, recommended that decreasing fishing efforts of bogue either by increasing the mesh size used for nets of bogue capture or a temporal ban in its spawning season can be applied. Currently, there’s no regulations on bogue fisheries in Turkey and the main catch of bogue come from purse seiners. This type of fishing is allowed in winter season when bogue spawns. Therefore, a temporal ban in this period may help to the protection of bogue stock and this can be a beneficial effort to sustain and manage its future stocks in Turkish coasts and in the Eastern Mediterranean Sea.

Conservation and better management of bogue population in the Eastern Mediterranean is not only vital for commercial fishers but also important for the Eastern Mediterranean ecosystem. Because bogue is a native species and the invasive *Bregmaceros nectabanus* was the most important prey item in its diet. Therefore, the health of its population may be important in controlling an invasive population. However, further investigations are required to fully understand the interactions between the bogue population and invasive *Bregmaceros nectabanus*.

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BIOGRAPHY

Liban Isse Farah was born and grow up in Mogadishu Somalia, he attained his Islamic studies, primary, and secondary education in Mogadishu. On June 31, 2018, he earned his first degree in Bachelor of Science in Marine Science and Fisheries at City University of Mogadishu-Somalia. In September 2018 he become the first Somalian marine science and fisheries graduate awarded with a full master degree scholarship by the Republic of Turkey under the Presidency of Turks Abroad and Related Communities Scholarship.

During his master study (2019-2021), he joined several field and cruise work in the Mediterranean Sea with the Fisheries Research Team of Çukurova University in Adana, Turkey. He worked projects including operational research for sampling ichthyoplankton samples to designate MPAs in the eastern Mediterranean, a cruise work of assessing the effects of power producing plants on marine environment and marine organisms in Iskenderun Bay, eastern Mediterranean Sea, Turkey. In Somalia he worked a project called "Kalluun" the first catch database collection of Somali fisheries. His published research includes Somali commercial fishes, catch data from Somali Fisheries.

In his MSc thesis, he studied the population dynamics of Bogue economically an important marine fish and he obtained important findings which is vitally useful its fisheries managements.

APPENDICES

Appendix I. Length Weight Relationship Parameters of Bogue from Different Geographical Regions

<table>
<tr><th rowspan="2">Study Area</th><th rowspan="2">N</th><th rowspan="2">Sex</th><th rowspan="2">TL range (cm)</th><th rowspan="2">W range (g)</th><th colspan="3">LWR Parameters</th><th rowspan="2">Reference</th></tr>
<tr><th>a</th><th>b</th><th>r²</th></tr>
<tr><td rowspan="4">Gulf of Mersin & Iskenderun, Turkey</td><td>53</td><td>J</td><td>11,1-15.6</td><td>12.1-32.3</td><td>0.011</td><td>2.896(-A)</td><td>0.48</td><td rowspan="4">Present study</td></tr>
<tr><td>448</td><td>M</td><td>11.6-28.4</td><td>14.1-210.0</td><td>0.004</td><td>3.289(+A)</td><td>0.912</td></tr>
<tr><td>466</td><td>F</td><td>11.8-27.8</td><td>14.8-281.0</td><td>0.002</td><td>3.516(+A)</td><td>0.947</td></tr>
<tr><td>967</td><td>C</td><td>11.6-28.4</td><td>14.1-281.0</td><td>0.003</td><td>3.382(+A)</td><td>0.941</td></tr>
<tr><td>Babadıllimanı Bay (Mersin, Eastern Mediterranean, Turkey)</td><td>314</td><td>C</td><td>7.5-21.4</td><td>3.52-99.98</td><td>0.008</td><td>3.030(+A)</td><td>0.945</td><td>Manaşırlı et al. (2006)</td></tr>
<tr><td rowspan="3">Edremit Bay (Aegean Sea, Turkey)</td><td>393</td><td>M</td><td>13.5-28.1</td><td>22.4-237.6</td><td>0.005</td><td>3.26 (+A)</td><td>0.95</td><td rowspan="3">Bilge (2008)</td></tr>
<tr><td>718</td><td>F</td><td>9.3-25.4</td><td>7.74-178.7</td><td>0.007</td><td>3.11 (+A)</td><td>0.98</td></tr>
<tr><td>1150</td><td>C</td><td>9.3-28.1</td><td>7.74-237.6</td><td>0.007</td><td>3.15(+A)</td><td>0.99</td></tr>
<tr><td>Izmir Bay, (Aegean Sea, Turkey)</td><td>1190</td><td>C</td><td>9.2-27.6</td><td>7.18-218.7</td><td>0.004</td><td>3.417(+A)</td><td>0.990</td><td>Kara & Bayhan (2008)</td></tr>
<tr><td rowspan="3">Edremit Bay (Aegean Sea, Turkey)</td><td>78</td><td>M</td><td>7.7-20.9</td><td>3.81-110.7</td><td>0.004</td><td>3.304(+A)</td><td>0.979</td><td>Andsoy (2015)</td></tr>
<tr><td>297</td><td>F</td><td>7.9-23.9</td><td>3.52-154.4</td><td>0.004</td><td>3.295(+A)</td><td>0.971</td><td></td></tr>
<tr><td>389</td><td>C</td><td>7.7-23.9</td><td>3.52-154.4</td><td>0.004</td><td>3.299(+A)</td><td>0.972</td><td></td></tr>
<tr><td rowspan="3">Izmir Bay (Aegean Sea, Turkey</td><td>429</td><td>M</td><td>12.2-27.0</td><td>17.7-241.7</td><td>0.003</td><td>3.420(+A) ±0.231</td><td>0.956</td><td rowspan="3">Kara & Bayhan (2015)</td></tr>
<tr><td>503</td><td>F</td><td>11.3-27.9</td><td>12.1-261.8</td><td>0.007</td><td>3.128(+A) ±0.065</td><td>0.954</td></tr>
<tr><td>932</td><td>C</td><td>11.3-27.9</td><td>12.2-261.7</td><td>0.005</td><td>3.237(+A) ±0.060</td><td>0.956</td></tr>
</table>

Appendix I Continued…

East Central (Aegean Sea, Turkey)	421	C	11.0-23.8	13.0-240	0.005	3.251(+A)	0.968	Soykan et al. (2015)
Alexandria (Eastern Mediterranean, Egypt)	920	C	9.6-17.07	9.88-48.20	0.025	2.66(I)	0.989	El-okda (2008)
Alexandria (Eastern Mediterranean, Egypt)	900	C	9.0-23.1	4.0-140.0	0.006	3.153(+A)	0.985	Fahmy Mahena (2014)
Alexandria coast, Egypt	683	M	9.3-21.6	7.7-116.7	0.010	2.978(-A)	0.919	Azab et al. (2019)
	684	F	10.0-23.1	7.4-133.1	0.012	2.912(-A)	0.913	
	1367	C	9.3-23.0	7.4-133.1	0.011	2.96 (-A)	0.917	
Algeria Coast	1372	C	9.0-29.0	22.8-80.18	0.016	2.798(I)	0.996	Rachid et al. (2014)
Algeria East Coast	1434	C	10.1-30.9	12.5-268.2	0.016	2.815 (I)	0.928	Dahel et al. (2019)
In the Gulf of Tunis (Central Mediterranea)	45	C	12.5-21	16.1-113.0	0.011	2.887(-A)	0.980	Miled-Fathalli et al. (2019)
In the Gulf of Cadis, SW-Spain	454	C	8.5-30.9	4.6-291.2	0.015	2.842(-A)	0.940	Torres et al. (2012)

(C= Overall, M=male, F=female, a = intercept, b= slope of coefficient, r^2= determination coefficient, b± 95% CI= b-value ± 95 confidence interval, TL= total Length, W= weight, +A= positive allometric growth, -A= negative allometric growth, I= isometric growth)

Appendix II. Growth Parameters (L_∞, k, t_0) and Growth Performance Index (Ø) of Bogue from Different Studies in its Distribution Range

Study Area	TL range (cm)	Sex	Growth Parameters			Ø	T_{max}	Method	Reference
			L_∞ (cm)	K (y^{-1})	t_0 (years)				
Gulf of Mersin & Iskenderun, Turkey	11.6-28.4	C	32.99	0.181	-1.928	5.29	6	O	Present study
Babadillimani (Mersin bay, Turkey)	7.5-21.4	C	33.62	0.109	-1.900	4.813	6	O	Manaşırlı et al. (2006)
Edremit Bay (Aegean Sea, Turkey)	13.5-28.1	M	30.47	0.113	-2.045	4.653	9	O	Bilge, (2008)
	9.3-25.4	F	35.20	0.091	-2.733	4.725			
	9.3-28.1	C	31.54	0.129	-3.107	4.855			
Izmir bay (Aegean Sea, Turkey)	11.3-27.9	M	29.87	0.247	-0.98	5.390	5	O	Kara & Bayhan (2015)
		F	30.79	0.239	-0.90	5.423			
East-central (Aegean Sea, Turkey)	11.0-23.8	C	29.58	0.266	-1.142	5.450	6	O	Soykan et al. (2015)
Alexandria coast, Egypt		C	31.68	0.153	-1.784	5.034	5	S	Allam (2003)
Alexandria coast, Egypt	9.6-17.07	C	30.11	0.151	-1.508	4.919	4	O	El-okda (2008)
Alexandria coast, Egypt	9.0-23.1	C	27.24	0.540	-0.330	5.993	3	O	Fahmy Mahena (2014)
Alexandria coast, Egypt	9.3-23.0	C	30.65	0.279	-0.156	5.568	4	S	Azab et al., (2019)
Eastern Algeria	10.1-30.9	C	32.03	0.28	-0.580	5.660	5	Fi	Dahel et al. (2019)
Algeria Coast	9.0-29.0	C	29.66	0.330	0.00	5.671	5	B	Rachid et al. (2014)
Central & Eastern Atlantic Ocean	8.5-34.5	M	35.3	0.38	-0.81	6.160	4	O	Massaro & Pajuelo, (2018)
	10.0-30.5	F	32.30	0.44	-0.80	6.129	5		
Algarve (Southern Portugal)	7.4-30.5	C	28.08	0.22	-1.42	5.156	11	O	Monteiro et al.,2006

C= overall sexes, M= Males, F=Females, Fi= FISAT, Ø = growth performance index, T_{max} = Maximum recorded age, B= Bhattacharya, S= Scale, O=otolith