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Population Composition, Growth and Fisheries of *Nemipterus randalli* Russell, 1986 in Antalya Gulf, Mediterranean Sea, Turkey

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Research Article

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Abstract

Most of the species migrating to the Mediterranean Sea as a result of the Lessepsian migration have been forming a sustainable population. In this study, population composition, growth, and fisheries of *Nemipterus randalli* Russell, 1986, an Indo-Pacific fish and live in Antalya Gulf, North-East Mediterranean Sea, were analyzed. The monthly samples were collected (N = 1715) by using experimental bottom trawl. The fish size ranges between 3.9 and 23.8 cm in total length, 0.73 and 171.78 g in weight, males are larger than females, and the length-weight relation was estimated as $W = 0.0173 \times TL^{2.8584}$. The male and female ratio was calculated as 1:1.402, females are predominant in the population. The average condition factor fluctuated seasonally and ranged between 1.089 and 1.346. Five age groups were identified in the population; Von Bertalanffy Growth Equation was estimated as $Lt = 32.56\ [1\text{-}e^{-0.20\ (t+1.75)}]$. The size, sex, and age composition show that it established a sustainable population in Antalya Gulf, grows well, reproduce and to be an item of bottom trawl fisheries, and sold in small percentages.

Keywords: Randall's threadfin bream, population composition, growth, fisheries, Antalya Gulf.

Antalya Körfezi (Türkiye, Akdeniz) *Nemipterus randalli* Russell, 1986 Poulasyonunun Kompozisyonu, Büyümesi ve Balıkçılığı

Özet

Lessepsiyen göçü sonucu Akdeniz'e göç eden türlerin çoğu sürdürülebilir bir populasyon oluşturmaktadır. Bu çalışmada, Kuzey-Doğu Akdeniz'in Antalya Körfezi'nde yaşayan ve Hint-Pasifik balıklarından *Nemipterus randalli*' Russell, 1986 *popülasyon* kompozisyonu, büyümesi ve balıkçılığı incelenmiştir. İncelenen örnekler (n = 1715) dip trolü ile, aylık olarak toplanmıştır. Yakalanan balıkların boyları (TL); 3,9-23,8 cm, Ağırlıkları ise (TW); 0,73-171,78 g arasında değişmektedir. Erkeklerin, dişilerden daha büyük olduğu görülmüştür. Boy-ağırlık ilişkisi $W = 0{,}0173 \times TL^{2{,}8584}$ olarak hesaplanmıştır. 1: 1,402, dişiler oransal olarak popülasyonda daha baskındır. Ortalama kondiyon faktörü mevsimsel olarak 1,089-1,346 arasında dalgalanma göstermiştir. Popülasyonda beş yaş grubu tespit edilmiştir. Von Bertalanffy Büyüme Eşitliği $Lt = 32{,}56\ [1\text{-}e^{-0{,}20\ (t+1{,}75)}]$ olarak hesaplanmıştır. Büyüklük, cinsiyet ve yaş kompozisyonlarına bakıldığında türün Antalya Körfezi'nde sürdürülebilir bir popülasyon oluşturduğu, iyi büyüdüğü ve ürediği; düşük oranlarda dip trol balıkçılığı tarafından avlandığı ve pazarlandığı görülmektedir.

Anahtar Kelimeler: Telkuyruk mercan , populasyon kompozisyonu, büyüme, balıkçılık, Antalya Körfezi

INTRODUCTION

The settlement of Indo-pacific and Red sea species to the Mediterranean Sea, known as the Lessepsian migration, is a process that began after the opening of the Suez Canal in 1869 and continues today (Por, 1978; Lelli et al., 2008). One of the Lessepsian fish species, Randall's threadfin bream (RTB) *Nemipterus randalli* Russell, 1986 was reported the first time mistakenly as *Nemipterus japonicus* (Bloch, 1791) in East Mediterranean (Golani and Sonin, 2006). RTB is widespread in the western Indian Ocean, east and west coast of India, Pakistan, Iranian Gulf, the Red Sea including Aqaba and Aden Gulfs, east African coast, Seychelles and Madagascar in sandy or muddy bottoms at depths of 22-225 m (Russell, 1986; Lelli et al., 2008; Kalhoro et al., 2017). Threadfin breams are an important component of commercial and artisanal fisheries in the Indo-West Pacific region. They are caught mainly by bottom trawl or by hang-line, and other fishing methods are used occasionally

(Russell, 1990). In their native ranges, threadfin breams are usually taken in multispecies catches (3 or more species) so there are no separate landings statistics. Among the threadfin breams, RTB is the most abundant species contributing over 60% of threadfin bream landings of the Kerala, India (Sobhana *et al*., 2011). Based on demersal trawl fisheries samples, population dynamics, growth, mortality, and yield of RTB were investigated in its natural range (Murty, 1982; Russell, 1986; Russell, 1990; Al-Kiyumi et al., 2014; Kalhoro et al., 2017). This species is first reported by Bilecenoğlu and Russell (2008) in Iskenderun Gulf of the Turkish coast of the North-Eastern Mediterranean (NEM). The species started to see in the Antalya Gulf (Gökoğlu et al., 2009; Özvarol, 2014). Ergüden et al., 2009; Ergüden et al., (2010) studied length-weight relationships, age, and growth characteristics of İskenderun Gulf's *N.randalli*. Length-weight relationships and some other growth characteristics were studied also in south eastern Mediterranean sea (Edelist, 2014), Antalya Gulf (Özvarol, 2014) in Gökova Bay (Ateş et al., 2017; Uyan et al., 2019) The age and growth were investigated by Innal et al. (2015) on market samples taken from Antalya Gulf by trawl catch.

In recent years, the marine biodiversity of the Mediterranean has gone through a rapid change. Mediterranean coasts of southern Turkey are affected by this change. The biodiversity change of the Mediterranean has been enhanced especially with the entrance of Indo Pacific originated alien species (Öztürk, 2010; Ergüden et al., 2018). Two Nemipterid species are started to exploit by fishermen and created a new market in the area. Fisheries status of them classified as commercial (*N. japonicus*) and minor commercial (*N. randalli*) in the Mediterranean (Öztürk, 2010). The alien species (e.g. *N. randalli*) might have negative, in some cases fisheries point of view positive, effects on biodiversity and fisheries on new settlement area. Their population dynamics, effects on native biota, and future development should be monitored and evaluated for ecosystem and fisheries management. In this study, it is aimed to collect and evaluate information on population composition, growth, and fisheries aspects of new established *N. randalli* population in Antalya Gulf.

MATERIALS and METHODS

The experimental trawl samples were taken from Antalya Gulf in the project of "Histological examination of gonadal development and reproductive characteristics of Lessepsian fish *N. randalli* entered into Antalya Gulf". The monthly samplings were undertaken December 2013 - October 2015 with Akdeniz Su R/V between Lara and Side Deniz Feneri (36°41' N, 31°22' E; 36°41' N, 30°56' E) in Antalya Gulf. The 9 mm code ended bottom trawl was used in catch operation conducted in depths of 25-55 m. After trawl operation, the caught sorted and *N. randalli* specimens separated, transferred in cool condition to Laboratory for measurement. Total lengths (TL), fork lengths (FL), and standard lengths (SL) were measured near to 0.1 cm, weights to 0.1 g. All calculations and considerations were made on TL. Sex determination was made the morphological observation of the gonads with the eye, a granular structure, and larger gonads were considered female and the individuals with small gonads in the flat structure were males. Age group determined by Bhattacharya methods from length frequencies using FISAT software (Gayanilo et al., 1995) and Condition Factor calculated as $CF = (W(g)/TL^3(cm)) \times 100$. Length-weight relationship (LWR), von Bertalanffy growth equation (VBGE), and length conversion formulas were estimated by regression procedures by Excel and SPSS v.17 (Avşar, 2005; Çetinkaya et al., 2010).

RESULT and DISCUSSION

Size composition

A total of 1715 specimens was taken from trawl operations. To be able to compare with the results of the studies using different size measurements length transformation equations were estimated by using convenient samples that represent all size groups (n = 601).

$FL = 1.0746 \times SL + 1.6663$ ($r^2 = 0.998$); $TL = 1.1275 \times FL - 1.1328$ ($r^2 = 0.9972$); $TL = 1.2125 \times SL + 0.6685$ ($r^2 = 0.9967$). Variation coefficients (VC) of mean length values are very close to each other (VC %) 39.12 for SL; 38.48 for FL; 38.94 for TL. All length values can also be used safely. The most characteristic feature of the species is that the upper lobe of the caudal fin has an extension of the whip-shaped (threadfin). This extension may be either broken naturally or by fishing operation so it should be excluded from TL measurement. The TL of *N. randalli* was found between 3.9 and 23.8 cm and the weight range were found as 0.73and 171.78 g in the study. The TL frequency of all individuals is given in Figure 1.

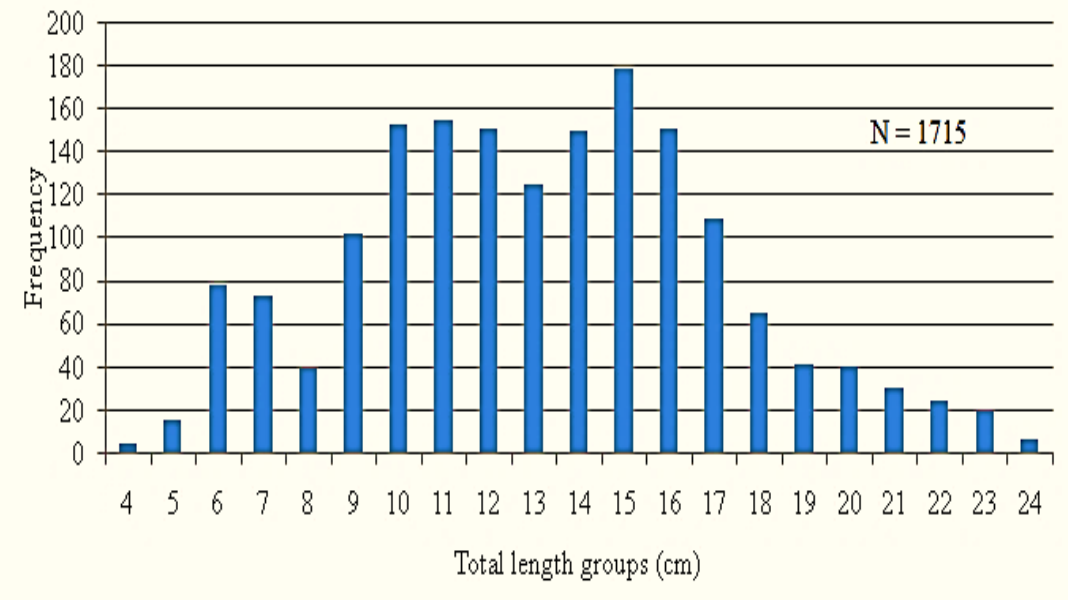

Figure 1. Total length frequency of *N. randalli*, Antalya Gulf.

The males of the Antalya RTB population have a larger size than females ($p < 0.01$). The size difference between sexes also found in some Nemipterid (e.g. *N. mesoprion, N. japonicus*) (Russell, 1990; Raje 1996). No individual was found longer than 23.9 cm in Antalya Gulf similar to Innal et al., (2015). TL varied between 4.8 and 21.5 cm, weights from 1.10 to 138.36 g. in İskenderun Gulf (Ergüden et al., 2010). The size composition of RTB in Gökova Bay was found between 10.8 and 21.9 cm on trammel net samples (Uyan et al., 2019). Antalya Gulf's RTB has similar size composition as the natural range's populations and İskenderun Gulf's. TL distribution of the 1386 *N. randalli* obtained from commercial trawl boats on the coasts of Kakinada, East India ranged between 3.2 and 21.5 cm (Murty, 1982). Following size, ranges were reported as 4-22.2 cm and weight as 1.5-150 g in the Arabian Sea off Oman (Al-Kiyumi et al., 2014), maximum TL 25 cm weight 251 g in Pakistani waters of Northern Arabian Sea (Kalhoro et al., 2017).

Sex composition, male and female (M: F) ratio

During this study 425 male (24.8%); 609 female (35.5%) and 681 juveniles and unsexed (39.7%) were identified (N = 1715). M: F ratio was calculated as 1:1.402. Females are dominant ($p<0.05$). While females were dominant in January - March, and November - December in 2014, and April - August 2015 ($p < 0.05$), males were found dominant only in September 2014 sampling ($p < 0.05$). In other sampling months M: F ratio was found statistically insignificant ($p>0.05$). The size differences between males and females affect also the sex ratio of the population. If small individuals are dominant in the sample, females dominate, in the presence of large individuals M: F ratio develops in favour of males. Gear selection of commercial fishing takes larger individuals (males) and leave smaller (females) in population. This selectivity enhances the biological potential of the population and changes M: F ratio in favour of females. The males were found as 43%, females 48.0%, juveniles as 11%, and M: F ratio as 1:1.111 ($p>0.5$) in RTB population of Antalya Gulf (Innal et al., 2015). Some differences are depending on the sampling equipment (experimental and commercial trawls) and the sampling months and consequently the emergence activities (only from reproduction to free time for all years). These differences can be caused also that the species started to form a new sustainable population in Antalya Gulf, and the low population density and better growth.

In the Veraval Region of India, the M: F ratio was reported to be 2.57: 1 (Raje, 1996). In both the Veraval region and Waltair Beach, male individuals seem to be more dominant (Raje, 1996; Appa Rao, 1989). Due to the gathering of male and female fish in the same location in September; M: F ratio was found 1:1. According to Lelli et al. (2008), Eastern Mediterranean found the sex ratio (F/M + FSR = 0.53) in the 30 *N. randalli* that they had sampled from the coast of Lebanon. It is close to a 1:1 ratio, but it hardly represents the population as the number of samples (n = 30) remains very small. In the same population, sex ratios change by time, place, and sampling techniques. Many Nemipterid

fishes show size-related differences in sex ratios, with small fishes being mainly females and larger fish males. The size-related skew appears the ratio in sex to be due to higher growth rates in males (Russell, 1990).

Lengths-weight relationships

Lengths-weight relationships **(**LWR) estimated as $W = 0.0173 \times TL^{2.8584}$ for pooled samples. There was no significant difference between sexes. The coefficient b (2.8584) mainly is below 3.000 in monthly samples and decreases to 2.500 - 2.600 in females after reproduction. The population has negative allometric growth.

LWR was found as $W = 0.0105 \times TL^{3.0426}$ (Innal et al., 2015) in Antalya Gulf as $W = 0.0011 \times TL^{3.061}$ in İskenderun Gulf (Ergüden et al., 2010), $W=0.171xTL^{2.92}$ in Gökova Bay (Uyan et al., 2019) and $W = 0.0135 \times TL^{3.0642}$ (Al-Kiyumi et al., 2014) on the Arabian Sea coast of Oman; $W=0.0101xTL^{3.08}$ in the east Mediterranean (Edelist, 2014). These LWR's are representing isometric growth, but samples were taken commercial trawls and long lines (i.e. no adequate small fish represented). Seemingly, the difference can be attributed to the sample composition since those samples sorted by fishermen and with a good condition; well-grown individuals are landed and sold.

Condition factor

The monthly averages of condition factor **(**CF) ranged between 1.089 and 1.346 (n = 1715), there was no statistically significant difference CF among male, female and juvenile in most sampling months ($p > 0.05$). The differences were significant ($p < 0.05$) in favour of females in May 2014 and 2015 samples. Females have higher CF values due to speed gonad development and onset to spawning activity. While CF was determined highest in May 2014 and 2015 (two years' avg. 1.333), there was a decrease in August (1.177) following egg-laying and in December (1.155) likely due to winter condition. CF changes are mainly due to gonadal development and egg-laying, and more pronounced in females. In the Veraval (Gujarat) region of India (Raje, 1996), females had the highest levels of CF in April and the values decreased after the spawning (Figure 2). The study area has subtropical climatic conditions and monsoon rains are effective.

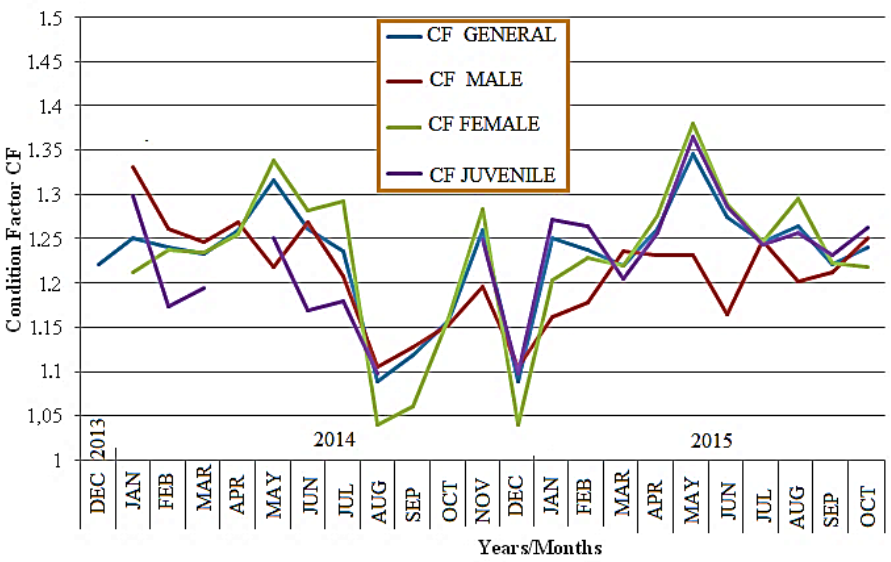

Figure 2. Condition factor of *N. randalli* population in the Antalya Gulf.

Age and growth

By applying modal progression analysis on monthly length distribution frequencies of 1715 individuals, there are 5 age groups identified as 0+, I+, II+, III+ and IV+. The average TL of each age group is given in Table 1. VBGE was estimated as $Lt = 32.56 \times [1-e^{-0.20(t+1.75)}]$ (Figure 3).

Table 1. Age groups and corresponding mean TL of *N.randalli* population, Gulf of Antalya.

Sampling months	Years	0+Age	I+ Age	II+ Age	III+ Age	IV+ Age
December	**2013**		13.65	19.5	21.5	
January		8.77	12.7	16.93	21.5	
February		11.86	15.19	16.5	21.5	
March		12.34	15.5	20.5		
April			14.15	17.84	22.83	
May		11.28	15.13	19.79		
June		10.5	14.42	15.5	20.92	
July	**2014**	14.26	16.5	18.5	20.5	
August		13.85	15.84	17.5	22	
September			16.6	19.61		
October			15.61	17.5	21.86	
November			15.34	19.17		
December		6.11	11.84	14.5		
January		6.82	10.39	14.68	16.5	21.83
February		9.91	13.64			
March		11.85	16.02	20		
April		7.7	12.5	14.5	16.5	
May	**2015**	8.54	14.36	16.5	23.17	
June		9.64	14.94	18.5		
July		10.22	14.51	20.5		
August			11.51	15.35		
September			12.1	14.42	17.87	23
October			14.19	16.48	19.15	
Mean TL(cm)		**10.24333**	**14.2013**	**17.46682**	**20.44615**	**22.415**

Innal et al. (2015) reported maximum age as III+ in females and IV+ in males, and VBGE as $Lt = 33.15\times[1- e^{- 0.218(t+0.215)}]$ in Antalya Gulf. Maximum age was III+ for both sexes and VBGE parameters are L = 34.96 cm K = 0.214 y^{-1} in İskenderun Gulf (Ergüden et al., 2010), $Lt = 27.57\times[1- e^{- 0.183(t+288)}]$ in Gökova Bay (Uyan et al., 2019).

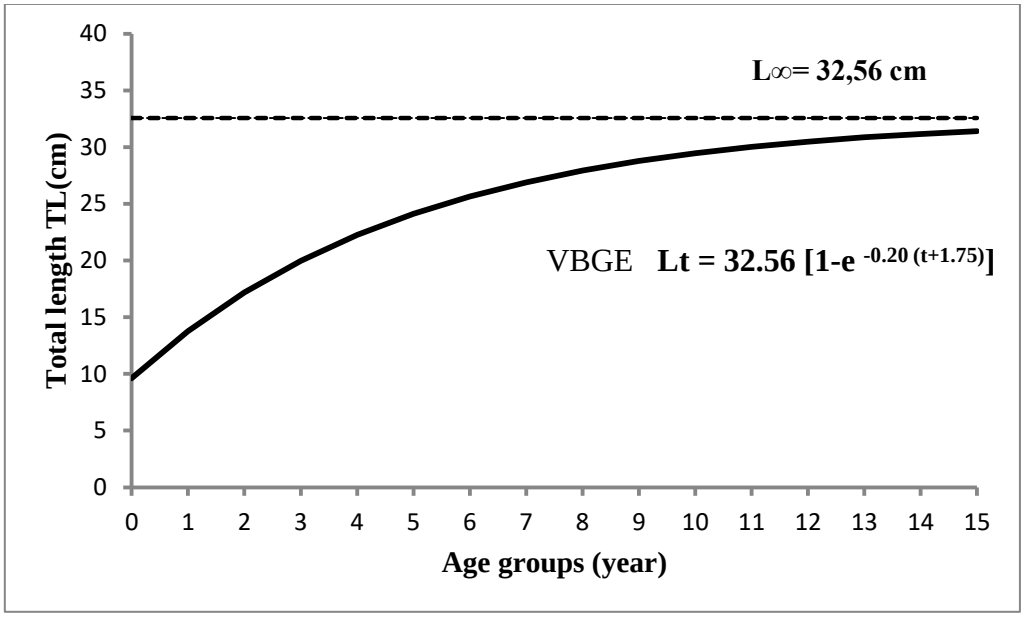

Figure 3. Von Bertalanffy growth equation of *N. randalli* population in Antalya Gulf.

In natural range, in coasts of Kakinada, India VBGE of *N. randalli* (as *N. mesoprion*) was determined as $Lt = 21.9 \times [1-e^{-0.8325(t-0.2562)}]$ (Murty, 1982).

The maximum age for both sexes reported as II+ and VBGE parameters as $L\infty = 22.12$ cm $K = 0.64$ y^{-1} in the Arabian Sea off Oman (Al-Kiyumi et al., 2014). *N. randalli* has a smaller size ($L\infty$= 21.9 and 22.12 cm) and a shorter life span (II+ age). But it grows quickly ($K = 0.64$ y^{-1}) and attains to asymptotic length (22.12 cm) in shorter time in the Arabian Sea off Oman comparing to Antalya and İskenderun Gulfs. The individuals in Antalya Gulf are growing quite well in the first year of life (0+) (40 – 50% of the current maximum length), followed by a slowdown in growth. The $L\infty$ is also close to the maximum TL in samples. The Nemipterus species do not live longer than 10 years and the life span of females is shorter. The life span depends on the environmental conditions, growth and fishing pressure on population (Murty, 1982; Raje, 1996; Naik, 2000). This species is newly settled in Antalya Gulf, population density is proportionally still low. Due to low density and convenient environmental conditions (salinity, feed, temperature, etc.), good growth is observed.

Present Fisheries of *N. randalli*

N. randalli has recently established populations in the Turkish Mediterranean coast and started to exploit by commercial fishing, there is no minimum catch size limitation yet. The sold fish in markets are 15-24 cm (TL) (ca. 30-150 g) in size. All Turkish seas, closed fishing period is between 15 April and 1 September. This is convenient for *N. randalli*'s reproduction period. Length range of *N.randalli* in the fishery of Kerala, India was 5 to 29 cm TL, annual mean size being 13.56 cm TL with 2 modes at 8.5 cm and 11.5 cm. During the first and last quarters of the year, immature fishes dominated the fishery. Mature fishes were dominant from June to October. Trawl banned period is July (Sobhana et al., 2011).

In the trawling area of Antalya Gulf, the number of trawled specimens at a depth of 25-55 m was found to be relatively low (< 1% in all operation). This is probably related to being established newly of the population (ca. 8 - 10 years) of *N. randalli* in the Gulf. In the Turkish Mediterranean coast waters, the abundance of individuals is very low yet (Ergüden et al., 2010). According to Lelli et al., (2008) reported that the small and immature individuals sampling on the Lebanese (Tire) shores is evidence of mature stock in this region that reproduce and participation to stock took place. A new *N. randalli* population has emerged in the Eastern Mediterranean and will be an important species in the future for regional fishing. *N. randalli*, even at low amounts, is being fished by trawlers during the fishing period (01 September-15 April). In the Antalya fish market, it is sold under the names of "kaya mercanı" (rock bream), “telkuyruk mercan" (threadfin bream), and "mercan" (sea bream) and consumed as fresh. The catch amount record cannot be obtained yet. *N. randalli* is dominant in its natural spreading areas (India, North Arabian Sea, Persian Gulf), and is being trawled demersal fishing areas with other Nemipterus species (Murty, 1982; Raje, 1986; Kalhoro et al., 2017). There is also reported intense fishing pressure on juvenile individuals at some points (Sobhana et al., 2011). In the Veraval (Gujarat) region of India, Nemipterus species constitute a significant portion of demersal fish stocks. *N. randalli* (as *N. mesoprion*) was the second among the Nemipterus species caught in the region by a rate of 16% between 1982 and 1986 (Raje, 1996). The commercial trawl catches of RTB reached to 14,7% in some east Mediterranean fishing area (Edelist, 2014)

As a result; the population composition, M: F ratio, length-weight relationships of Antalya Gulf RTB is similar to the natural distribution area. However, age and growth characteristics and possibly reproduction patterns are different. *N. randalli* lives longer in the Mediterranean and reaches a higher asymptotic length (VBGE, $L\infty$). In native populations growth rate is higher (VBGE, K) and individuals have a shorter life span. It has remarkable fishery and moderate economic value in its native distribution range.

The RTB shows that environmental adaptation from East to West or further north to the Mediterranean (Gülşahin and Kara, 2013) is not difficult for species. Lessepsian aliens are more successful in the shallower part. Por (1978) considers that temperature is the most important and single factor for the colonization success of the Lessepsian migrants and their success in the intermediate layers at about 20-40 m is attributed to the relatively higher and stable temperature at this is a bath. While RTBs continue to spread through the Suez Canal and the Mediterranean, it seems impossible to stop the passage of the Lessepsian alien species (Öztürk, 2010). RTB is an exotic species in Antalya Gulf. It will be interested because of its ecological interactions (biodiversity issues, competition with other native and exotics, etc.) since it could adapt the habitat, grow successfully in the Turkish

Mediterranean coasts. On the other hand, it has the chance to exploit by fisheries, marketing, and consumption. It should be considered an economic fish stock also. It is necessary to carry out further research on stock assessment, feeding, competition, habitat sharing, fishing activity, and yield.

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