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Deniz Innal
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Mehmet Aksu
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Duygu Akdoganbulut
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Burcu Kisin
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Mehmet Can Unal
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Mustafa Oztop
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Bugrahan Dogangil
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Engin Pek
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Correspondence
Deniz Innal
Mehmet Akif Ersoy University, Department of Biology, Istiklal Campus. 15100, Burdur Turkey.

Age and growth of *Nemipterus randalli* from Antalya Gulf-Turkey

Deniz Innal, Mehmet Aksu, Duygu Akdoganbulut, Burcu Kisin, Mehmet Can Unal, Mustafa Oztop, Bugrahan Dogangil, Engin Pek

Abstract
Age, growth, length-length and length-weight relationships were estimated for *Nemipterus randalli* Russell, 1986 specimens captured between September 2012 and April 2014 from Gulf of Antalya, Turkey. We examined a total of 175 individuals, of which range in size between 6 and 24 cm in total length, 3.4 and 201 g in total weight. Maximum ages were III for female and IV for male. The overall male to female ratio was 0.90/1.0. The length–weight relationship for all individuals were described by the parameters: a = 0.0105 and b = 3.0426. Von Bertalanffy growth equations were estimated as $Lt = 33.15[1-e^{-0.218(t+0.215)}]$ and $Wt=444[1-e^{-0.218(t+0.215)}]^{3.0426}$ and the phi-prime test estimation was calculated as 2.38 in the population. This study also presents the relationships between total length-standard length, total length-fork length, standard length-fork length, total length-head length, total length- head depth, total length- body depth, total length-otolith length, total length-otolith width, body depth-head depth, head length-head depth and body depth-head length for *N. randalli*.

Keywords: *Nemipterus randalli,* age, growth, length-length and length-weight relationships, Antalya Gulf

1. Introduction
Non-indigenous fish species have become established in various parts of the inland waters and coasts of Turkey. The colonization of Red Sea species in the Mediterranean Sea is an ongoing process that began some time after the opening of the Suez Canal in 1869. *Nemipterus randalli* is one of the Lessepsian migrant species, first recorded by Golani and Sonin (2006) [14] on the Mediterranean coast of Israel mistakenly as *Nemipterus japonicus*. However, *Nemipterus japonicus* have nowadays been recognized as an invasive species from the Meditterranean [7], together with *N. randalli*.
Tropical and subtropical regions are the ideal habitat for Nemipterid fishes and this family (Nemipteridae) includes 67 species belonging to 5 genera, namely Nemipterus, Parascolopsis, Pentapodus, Scaevius, and Scolopsis [12]. The threadfin breams of the genus Nemipterus (family Nemipteridae) are widespread species that occur at Indo-West Pacific region, including the western Indian Ocean, the east and west coasts of India, the Persian Gulf, and the Red Sea south to Madagascar and more than 20 species are recognized [27]. They are small to moderate-sized fishes and most inhabit shallow sand or mud bottoms, and are taken commercially by hook-and-line and bottom trawl [28].
Various biological parameters of *N. randalli* have been studied in the Mediterranean by various authors; for example, distribution [14, 20, 5, 13, 1, 15] diet [16], population structures and some growth properties [20, 5, 13, 16, 15, 1, 2, 23].
Nemipterus species are commercially important in many parts of the world [9]. This species has rapidly extended and now succesfully established in Eastern Mediterranean Sea [16]. There is no catch statistics for threadfin bream in Antalya Gulf Turkey, although the abundance of this species rapidly increase (pers observation, D. Innal).
Although *N. randalli* has been studied along the Mediterranean Sea, there has been no previous references for biological properties from Antalya Gulf. The objective of this study was to provide information on the length-length, length-weight relationships and some growth properties of *N. randalli* in the Antalya Gulf.

2. Material and Methods

2.1 Data collection and analysis

Samples (175 individuals) were collected during September 2012 and April 2014 from trawl surveys conducted in the Antalya Gulf (Mediterranean-Turkey). Fish samples were immediately transported to the laboratory in the Department of Biology, Mehmet Akif Ersoy University (Turkey). Size (total length cm TL, precision 1 mm) and weight (total weight W to nearest 0.1 g) were calculated. Sex was identified macroscopically and microscopically by examining the gonads. Metric characters were measured with digital slide calliper on the fish body (4 characteristics; total length, standard length, fork length, body depth at dorsal fin), head (4 characteristics; head length, head depth, otolith length, otolith width). Morphometric relationships between parameters (total length-standard length, total length-fork length, standard length-fork length, total length-head length, total length- head depth, total length- body depth, total length-otolith length, total length-otolith width, body depth-head depth, head length-head depth and body depth-head length) were calculated using the linear regression.

For age determination, 175 sagittal otoliths were extracted, washed, dried, and mounted on black slides. A stereo microscope with reflected light was used for age determination. Length-weight relationship was calculated using the equation $W = aL^b$ [24], where *a* is a coefficient related to body form and *b* is an exponent indicating isometric growth when equal to 3. The *b*-value of each species was tested by Student's t-test to verify if it was significantly different from isometric growth [11]. The von Bertalanffy growth equations were calculated according to: $Lt = L\infty[1-e^{-k(t-to)}]$ in length and $Wt = W\infty[1-e^{-k(t-to)}]^b$ in weight, where Lt is the fish total length (cm) at age t, 'e' is the base of natural log (2.71828), 't' the fish age (in years) to the hypothetical time at which the length of the fish is zero, and k is a relative growth coefficient. Wt is the fish weight (g) at age t [24]. Munro's phi prime index (growth performance index) was estimated by formula $Ø' = \log(k)+2\log(L\infty)$ [25]. Differences in Size frequency distributions for males and females were calculated by t-test. Comparisons if sex ratio departed from the expected 1 : 1 rate were determined by t-test.

3. Results

3.1 The Sex and Age Compositions

The sex and age compositions of *N. randalli* are shown in Table 1. The 175 *N. randalli* individuals consisted of 76 (43.43%) males, 84 (48%) females and 15 (8.57%) immature individuals, sex ratio is significantly different ($P < 0.05$) from the expected 1 : 1 (male, 0.90: female, 1). Ages of captured specimens ranged from 0 to IV, with first year-class being dominant in the population.

3.2 Length and Weight Composition

Length and weight distribution and Length-weight relationships (LWR) of *N. randalli are* given in Fig. 1. Age-length and age-weight composition of *N. randalli* are shown in Table 1. Specimens of *N. randalli* ranged from 6 to 24 cm TL and from 3.4 to 201 g weight. Among all individuals, dominancy (66.8%) was in the size range of 13–17 cm. Adult males ranged from 12 to 24 cm TL and females from 12.2 to 22.9 cm TL. Size frequency distributions for males and females were not significantly different (t-test, $P > 0.05$). The length–weight relationship for all individuals were described by the parameters: a = 0.0105 and b = 3.0426**.** LWRs were also calculated for sexes separately. In *N. randalli* these were $W = 0.008\ L^{3.1365}$ ($R^2 = 0.97$) for females and $W = 0.0079\ L^{3.1498}$ ($R^2 = 0.98$) for males.

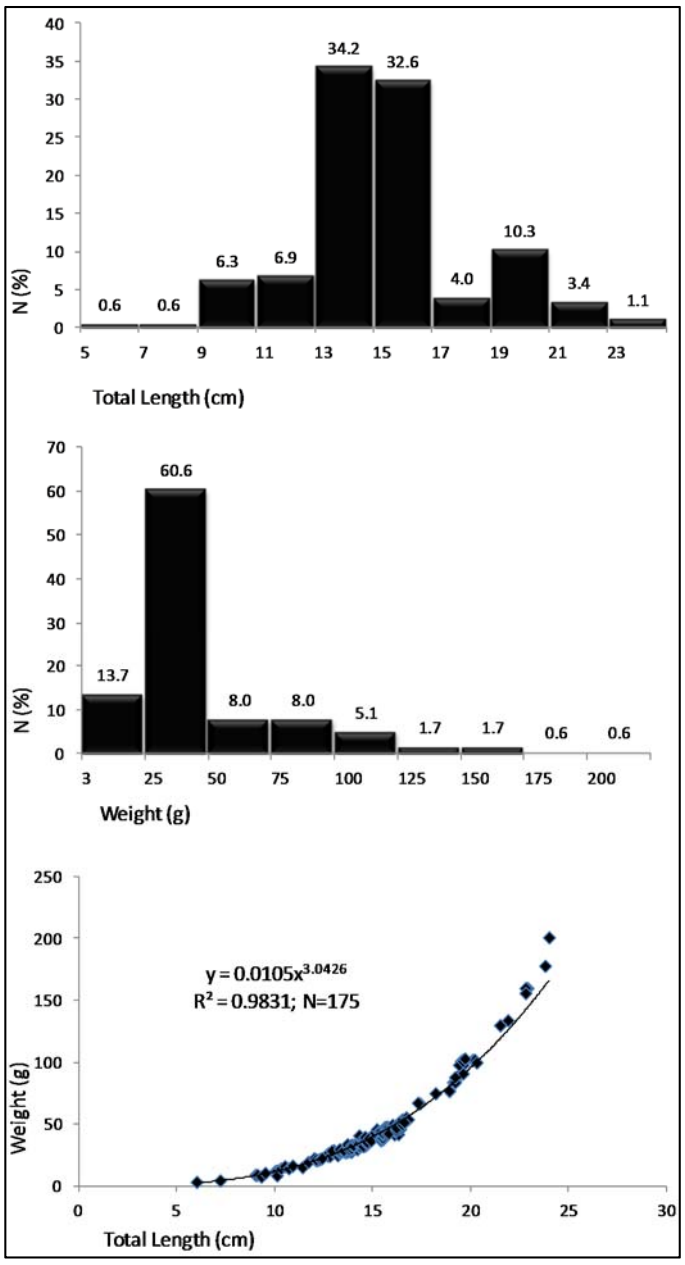

Fig 1: Length and weight distribution and Length-weight relationships (LWR) of *N. randalli*

Table 1: Sex and age compositions; Age-length and Age-weight key of *N. randalli*

Length classes	age classes					N
	0	1	2	3	4	
5-6.9	1					1
7-8.9	1					1
9-10.9	7	4				11
11-12.9		12				12
13-14.9		60				60
15-16.9		18	39			57
17-18.9			6	1		7
19-20.9			14	4		18
21-22.9			1	2	3	6
23-24.9					2	2
5-24.9	9	94	60	7	5	175
Sex ratio (f/m)	immature	0.80/1	2.33/1	0.75/1	0/1	1.11/1
Length						
Mean±std	8.92±1.41	13.90±1.22	17.26±1.59	20.39±127	23.06±0.85	14.9±2.44
Min	6	10.3	15.7	18.9	21.9	9
Max	10.1	15.8	21.5	22.9	24	24
Weight						
Mean±std	8.63±3.06	31.93±7.42	62.79±22.19	108.6±27.9	165.8±25.14	42.22±26.24
Min	3.4	14.2	41.8	77.2	134	7.7
Max	12.5	47.5	130	160	201	201

3.3 Length- length relationships

Regression analysis between the different body and head measurements for *N. randalli* are shown in Table 2. All Length-length relationships were highly significant with r^2 values greater than 0.87. Except only one relationships was found with r^2= 0.74 (otolith length-total length relationships)

Table 2: Length- length relationships and corelation coefficients for *N. randalli* from the Antalya Gulf (Mediterranean-Turkey).

Correlates	Equations	r^2
TOTAL LENGTH - FORK LENGTH	TL = 1.066 (FL) +0.9032	0.98
TOTAL LENGTH - STANDART LENGTH	TL = 1.1026 (SL) +2.1023	0.94
FORK LENGTH - STANDART LENGTH	FL = 1.0051 (SL) +1.4643	0.93
TOTAL LENGTH – BODY DEPTH	BD = 0.2405 (TL) -0.224	0.87
TOTAL LENGTH - HEAD LENGTH	HL = 0.2722 (TL) -0.4212	0.93
TOTAL LENGTH - HEAD DEPTH	HD = 0.2412 (TL) -0.8785	0.91
BODY DEPTH - HEAD DEPTH	HD = 0.833 (BD) -0.0827	0.87
HEAD LENGTH - HEAD DEPTH	HD = 0.8436 (HL) -0.3498	0.93
BODY DEPTH - HEAD LENGTH	HL = 0.9175 (BD) +0.5521	0.87
OTOLITH LENGTH - TOTAL LENGTH	OL = 0.3486 (TL) +0.7416	0.74
OTOLITH WIDTH - TOTAL LENGTH	OW = 0.2404 (TL) +0.4728	0.87

3.4 Von Bertalanffy growth

The von Bertalanffy growth model of the *N. randalli* population in Antalya Gulf was described as $Lt = 33.15[1- e^{-0.218(t+0.215)}]$ and $Wt=444[1- e^{-0.218(t+0.215)}]^{3.0426}$ The phi-prime test estimation was calculated as 2.38 in the population.

4. Discussion

During the present study females were more abundant in the catch of *N. randalli*. The sex ratio, which differs from one population to another in the same species, was 1.0 females to 0.90 male in the *N. randalli* populations in present study. The sex ratio (female:male) in previous studies of *N. randalli* populations was as follows: Iskenderun Bay, 1.29:1 [9]; Arabian Sea coast of Oman, 0.9:1 [2]. The sex ratio may vary from year to year in the same population, indicating that it is either determined genetically or by environmental factors [4]. This variation may arise from many reasons, including seasonal aspect, feeding and maturation periods, different growth rates in males and females, mortality difference for each sex, and perhaps, size-selective effects of the fishing gear.

The life span of males and females differs in *N. randalli* populations of Antalya Gulf. Maximum ages were III for female and IV for male in this study. This differences in the age distribution of the populations may be due mainly to ecology of species, sampling differences, fishing activity, trophic status and ecological characteristics of the marine systems. The age composition in previous studies on species of *N. randalli* populations was as follows: Iskenderun Bay, 0-III [9] and Arabian Sea of Oman, I-II [2]. The age structure found in the population of the Antalya Gulf is different from that reported in the İskenderun Bay and Arabian Sea of Oman.

Males attained larger length and weight than females. There are few papers from previous studies about growth parameters in *N. randalli* for comparing with results of the present study. Available literature data about the length-length relationships and morphometrics characters of *N. randalli are* very scarce [20]. The ratio of standard length:body depth, standard length:head length and head length:body depth are similar to results of Lelli *et al.*, 2008 [20].

The slope (b) value of the length weight regression of *N. randalli* populations was 3.0426. The values of b were within the limits of 2.5-3.5 commonly reported for teleosts by Froese (2006) [10]. The slope b value of the LWR equations showed a great variation from one population to another within the same

species and species of the same genus (Table 3). The b value of Nemipterus species in the world has been shown to range from 2.63 to 3.28. Geographic location and associated environmental conditions, such as seasonality (date and time of capture), stomach fullness, disease and parasite loads, can also affect the value of b (Le Cren, 1951; Bagenal and Tesch, 1978) [19, 3]. This study also provides a new maximum length for *N. randalli* Turkish Coast of Mediterranean.

Table 3: Records of Nemipterus specimens from the world and showing some growth values

Species	Locality	L_{MIN}	L_{MAX}	a	b	R^2	References
N. bathybius	Beibu Gulf. Northern South China Sea	4.2	24.0	0.0353	2.88	0.999	Wang *et al*. 2011
N. bipunctatus	Chennai Fisheries Harbour			0.0000096	3.051	0.954	Kizhakudan and Rajapackiam. 2011
N. furcosus	Beibu Gulf. Northern South China Sea	6.20	22.2	0.0237	3.02	0.999	Wang *et al*. 2011
N. hexodon	Beibu Gulf. Northern South China Sea	5.20	13.3	0.0354	2.88	0.961	Wang *et al.* 2011
N. hexodon	Thailand Gulf	13.10	21.7	0.00576	3.277	0.99	Yanagawa. 1988
N. japonicus	Karnataka State	9.50	30.8	0.039	2.664	0.99	Zacharia. 1998
N. japonicus	Arabian Sea			0.0407	2.765	0.96	McIlwain *et al*. 2006
N. japonicus	Ratnagiri coast				2.629	0.9870	Kumar *et al.* 2011
N. japonicus	Persian Gulf. Iran	7.30	24.5	0.0517	2.664	0.928	Raeisi *et al.* 2012
N. japonicus	Chennai Fisheries Harbour			0.0000308	2.843	0.934	Kizhakudan and Rajapackiam. 2011
N. japonicus	Beibu Gulf. Northern South China Sea	4.0	20.50	0.0329	2.94	0.999	Wang *et al.* 2011
N. mesoprion	Chennai Fisheries Harbour			0.0000125	3.014	0.933	Kizhakudan and Rajapackiam. 2011
N. metopias	Beibu Gulf. Northern South China Sea	5.60	22.5	0.0384	2.84	0.999	Wang *et al.* 2011
N. nematophorus	Chennai Fisheries Harbour			0.000032	2.814	0.960	Kizhakudan and Rajapackiam. 2011
N. nemurus	Beibu Gulf. Northern South China Sea	6.50	19.8	0.0263	2.97	0.988	Wang *et al*. 2011
N. peronii	Coral Reef-Lagoons of new Caledonia	16	24.50	0.0157	3.029		Letourneur *et al.* 1998
N. peronii	Chennai Fisheries Harbour			0.0000279	2.835	0.955	Kizhakudan and Rajapackiam. 2011
N. randalli	Israel continental shelp	4	23.5	0.0101	3.08	0.97	Edelist. 2014
N. randalli	Iskenderun Bay	4.6	15.3	0.013	2.687	0.979	Erguden *et al.* 2009
N. randalli	Iskenderun Bay	4.8	21.5	0.0011	3.061	0.982	Erguden *et al.* 2010
N. randalli	Antalya Gulf	9.50	22	0.0120	2.975	0.937	Ozvarol. 2014
N. virgatus	Beibu Gulf. Northern South China Sea	4.30	31.6	0.0263	2.97	0.999	Wang *et al*.2011
N. zysron	Chennai Fisheries Harbour			0.0000132	2.984	0.964	Kizhakudan and Rajapackiam. 2011
N. zysron	Coral Reef-Lagoons of new Caledonia	11.50	27	0.0103	3.167		Letourneur *et al.* 1998
N. randalli	Antalya Gulf	6	24	0.0105	3.0426	0.983	This study

The differences obtained in the growth parameters k and $L\infty$ between the populations of *N. randalli* could be explained on the basis of different oceanographic conditions, sampling differences and age readings. The phi-prime test estimations provide an indicator of the reliability of estimates since it is suggested that values are similar for the same species and genera. The phi-prime test estimation was calculated as 2.38 in the *N. randalli* population and the phi-prime test estimation values for the Nemipterus genus ranged from 2.42 to 2.97. These growth performance variations could be caused by different results obtained in age readings by the different researchers. However, it is possible that variations in population parameters of the genus Nemipterus represent epigenetic responses to the different environmental conditions, such as temperature, pH, dissolved oxygen levels, and geographic location. Nutrient levels also probably vary between study areas.

The rate of fish invasions into the Mediterranean Sea has increased in recent decades. They have collectively significant ecological and economic impacts on the Eastern Mediterranean fish populations [7]. Threadfin bream, *N. randalli*, become an important fisheries resources for small trawlers, especially coast of Antalya Gulf. In conclusion, this study provides some basic information about one of the Lessepsian migrant species and is thought to be useful for future studies. The role of *N.randalli* within the coastal ecosystem and its effect on local populations need to be the subject of future research.

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