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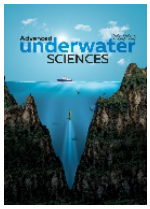

Morphometric comparison of different populations of *Nemipterus Randalli* Russell 1986 distributed in the Mediterranean coasts of Turkey

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Keywords
Biometry,
Morphometry,
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Lessepsiyan Species,
Biomorph.

ABSTRACT

It was aimed to compare the populations of *N. randalli* sampled from Antalya, Anamur, Silifke, Mersin, and Iskenderun by the biometric method. BioMorph program was used in the research. Principal Components Analysis (PCA), Intercluster Correlation Analysis (ICA), and Univariate Analysis of Variance (UAV) were used in the multivariate analyzes of the individuals. The comparison of the data was made with SPSS and Excel package programs. A statistical difference was found between the populations in terms of morphometric characteristics ($p<0.05$). There was no distinction between populations in terms of meristic characters. Fin rays of the samples (D: X+9-10; A:III+7-8; PEL:I+5; PEC:16-17) and the number of lateral line scales (44/47) were determined. While positive strong correlations were determined in Antalya, Anamur, Silifke, and Iskenderun populations in terms of morphometric characters ($p<0.001$). Positive and weak correlations were found between preorbital length, dorsal-fin base, anal fin base, eye diameter, and total length in the Mersin population ($p<0.05$). Length-weight relationships of different populations of *N. randalli* were determined (b=2.25-3.0; r2=0.90-0.99). It was determined that the species showed isometric growth in Anamur and Silifke populations and negative allometric growth in Antalya, Mersin, and Iskenderun populations. The condition factor values of the species were calculated as 1.21 in Antalya, 1.29 in Anamur, 1.36 in Silifke, 1.32 in Mersin, and 1.28 in Iskenderun. The distinction between populations may vary depending on fish size, the female-male ratio in the population, habitat conditions, sampling time, sampling method, nutritional status of individuals.

1. INTRODUCTION

Morphometric characteristics of the individual are used in biological research such as species identification, growth parameter, and population dynamics for ages (Slice, 2007). Traditional morphometric applications were enhanced by modern morphometric analysis in the mid-twentieth century, combining the quantitative description of morphometric characters with statistical analyzes showing shape variations within and between groups. In this application, the set of quantitative variables such as the individual's length, width, and height are determined by multivariate statistical analyzes (Adams et al., 2004) and most of the variables are created by the development of Cartesian coordinate analysis methods of anatomical points (Slice, 2007). In modern morphometric studies using biometric methods, morphological diversity analyzes can be made according to the biological characteristics of the individual. These analyzes allow the systematic classification of the organism and the determination of the founder effect within a particular species, family, or population (Hockaday et al., 2000).

The Northeast Mediterranean was influenced by the migration of aquatic organisms originating from the Indian Ocean and the Red Sea with the opening of the Suez Canal in 1869, which connects the Mediterranean Sea to the Red Sea for the purpose of international

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maritime trade (Por, 1978; Golani, 1998; Galil, 2000). The establishment of populations by migratory non-native species in the Eastern Mediterranean has brought a dynamic structure to the ecosystem and biodiversity has changed significantly. Opportunistic invasive species, which are among these species, are common to the food and habitat of native species, as well as causing adverse effects on ecological balance and fisheries as some species as predators (Zibrowius, 1994). The similar ecological character of the Northeast Mediterranean with the Red Sea increases the migration of the species. The Mediterranean coasts of Turkey have high nutrient content due to the abundant freshwater inflow, especially Mersin, Iskenderun, and Antalya Bays, due to the wide continental shelf, constitute important spawning areas. It has made the coast of our country the main migration route of migratory species (Golani, 1999).

There are also economically important and consumable species among the Lessepsian fish migrations. *N. randalli*, a demersal fish species belonging to the Nemipteridae family of the order Perciformes, has been recorded as one of the economically important species populating the coasts of Turkey. It is known that the species lives on sandy and muddy surfaces between 22-450 m depths of tropical waters and generally feed on crustaceans, mollusks, and small fish. Records of *N. randalli* from different regions have been reported in the Northeastern Mediterranean Sea. The continuity of its spread and the fact that each new population is formed from the group that left the previous population can cause variations between populations.

The feeding habits (Gürlek et al. 2010), age and growth relationships (Ergüden et al. 2010; Innal et al. 2015; Demirci et al. 2020), length-weight relationships (Erguden et al. 2010), the relationship between length and otolith size (Uyan et al. 2019), reproductive characteristics (Demirci et al. 2020 and Innal et al. 2015; Yazici et al. 2020) of the species from the Northeast Mediterranean. However, there are limited studies on morphometric characters.

In this study, it was aimed to analyze the possible differentiation between populations of *N. randalli* sampled from Iskenderun, Mersin, Silifke, Anamur, and Antalya on the Mediterranean coasts of Turkey, using the modern morphometric method.

2. MATERIAL AND METHOD

N. randalli was examined as material in this study. The economic importance and the origin and contribution to fisheries of *N. randalli* were taken into account in the selection of materials. Fish were purchased dead from trawler fishing boats from Antalya, Anamur, Silifke, Mersin, and Iskenderun. The migration route has been taken into account in the selection of the stations where the fish are sampled.

Fifty samples were taken from each station determined in the research and brought to Mersin University Fisheries Faculty Processing Technology Laboratory with a portable icebox. After determining the weight and total length of the samples brought to the laboratory, their photographs were taken by placing a millimetric ruler next to them on a white background. Photographs of each individual were uploaded to the BioMorph program and 14 different morphometric points were marked on them. With the help of these points, total length (TL), fork length (FL), head length (HL), eye diameter (ED), preorbital length (POL), body width (BW), dorsal fin base (DFB), predorsal length (PDL), anal fin base (AFB), preanal length (PAL), pectoral fin length (PFL), and caudal peduncle height (CPH) were measured (Figure 1).

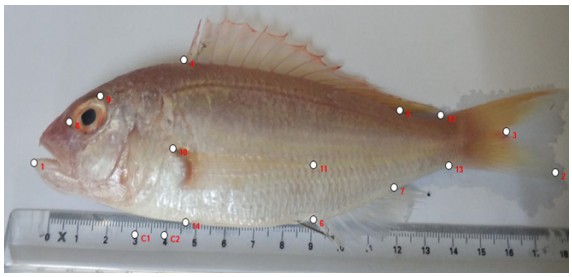

Figure 1. Points determined for morphometric measurements in the BioMorph program (C1 and C2 points were used for calibration)

The calibration value was taken as 1 cm (C1-C2; Figure 3.3.1) and the length between these points was measured using the BioMorph program. A linear (y = ax + b) regression model was used to determine the equations describing the relationships between morphometric characters and total length and head length. In calculated equations, 'y' is the dependent variable (morphometric character), 'x' is the independent variable (total length), and 'a' and 'b' are constants. To describe these relationships, the model with the highest coefficient of determination (r2) was chosen.

The allometric growth equation W(i)=a ×(L(i))b was used to examine the length-weight relationship of *N. randalli* sampled from five different populations (Ricker, 1975). Here, W(i): the total weight of each fish (g), L(i): the total length of each fish (cm), a and b are the relationship parameters, and a: a constant related to growth (where the line cuts the weight axis). point), b: is a constant (slope of the line) that represents growth and is calculated with the formula ln[W(i)] = lna + b× ln[L(i)].

Fulton's condition factor was used to compare the conditions of individuals belonging to *N. randalli* sampled from a different population, and the formula CF=W/L^3 x100 was used to calculate the condition factor (Froese, 2006). Here, CF is the condition factor, W is the bodyweight of the fish (g), L is the total length of the fish (cm).

The meristic characters of the species were determined separately for each individual and compared. The characters used in meristic measurements were D (Dorsal fin ray number), Pel (Pelvic fin ray number), Pec (Pectoral fin ray number), A (Anal fin ray number), Lateral line scale number was determined.

Principal Components Analysis (ABA), Intercluster Correlation Analysis (CCI), and Univariate Analysis of Variance (VA) were used in the multivariate analyzes of the individuals measured. Related calculations were made with SPSS and Excel package programs.

3. RESULTS

A statistical difference was found between the populations in terms of morphometric measurements determined in the study (p<0.05) (Table 1). It was determined that Antalya and Iskenderun populations were similar in terms of some morphometric characters. It was determined that the head length, eye diameter, predorsal length, and anal fin base had the highest values in the Mersin population while the other morphometric characters had the highest value in the Silifke population.

There is no distinction between populations in terms of some meristic characters of individuals sampled from determined stations. Fin ray numbers of the samples used in study D: X+9-10; A:III+7-8; Pel:I+5; Pec:16-17, the number of lateral line scales was determined as 44/47.

The results of the analysis of variance applied to the values obtained by taking the % of the total length ratio within each population of the determined morphometric characters were determined (Table 2).

In the study, some morphometric characters of *N. randalli* were determined to have a positive linear correlation in Antalya, Anamur, Silifke, Mersin, and Iskenderun populations (p<0.001), however, it was determined that the correlation between preorbital length, dorsal-fin base, anal fin base, eye diameter, and total length showed a weak positive correlation in Mersin population.

The length-weight relationship of different populations was determined and the range of the r2 value was determined as 0.90-0.99 among the populations (p<0.001). The b value of the populations was found in the range of 2.25-3.0. Negative allometric growth was observed in Antalya, Mersin, and Iskenderun populations, and isometric growth in Anamur and Silifke populations (Table 3). The length-weight relationship graph of the studied population of *N. randalli* is shown in Figure 2.

Table 1. Average of some morphometric characters determined in individuals belonging to different populations of *N. randalli* sampled from the Turkish coasts

Morphometric Characters (mm)	Antalya $\bar{x} \pm SE$	Anamur $\bar{x} \pm SE$	Silifke $\bar{x} \pm SE$	Mersin $\bar{x} \pm SE$	Iskenderun $\bar{x} \pm SE$
TL	172.96±3.63 ^{a}	183.26±6.17 ^{a}	212.56±6.76 ^{c}	196.81±3.44 ^{b}	173.08±2.88 ^{a}
FL	155.32±3.45 ^{a}	163.84±5.29 ^{a}	197.71±6.00 ^{c}	178.07±3.29 ^{b}	156.65±2.53 ^{a}
HL	41.38±1.08 ^{a}	41.87±1.49 ^{a}	46.37±1.39 ^{a}	46.93±4.12^{a}	42.40±0.88 ^{a}
ED	12.85±0.45 ^{a}	13.51±0.42 ^{ab}	14.39±0.44 ^{ab}	17.24±3.00 ^{b}	11.75±0.24 ^{a}
BW	45.55±1.28 ^{a}	48.19±1.78 ^{ab}	58.02±2.27 ^{c}	50.86±0.98 ^{b}	46.93±1.42 ^{ab}
DFB	68.75±1.86 ^{a}	74.14±2.73 ^{a}	89.71±3.08 ^{b}	74.17±6.52 ^{a}	68.27±5.25 ^{a}
PDL	54.09±1.46 ^{a}	54.36±1.53 ^{a}	63.82±1.81 ^{ab}	72.12±6.12 ^{b}	58.47±5.05 ^{a}
PFL	45.31±1.69 ^{a}	50.04±1.73 ^{ab}	56.32±2.26 ^{b}	48.70±4.13 ^{a}	47.87±1.14 ^{a}
AFB	25.15±0.69 ^{a}	28.09±1.08 ^{a}	34.71±2.14 ^{ab}	40.02±6.98 ^{b}	31.38±4.49 ^{ab}
PAL	92.58±2.01 ^{ab}	95.01±3.28 ^{ab}	111.14±3.46 ^{c}	100.02±6.18 ^{b}	86.29±3.85 ^{a}
CPH	13.98±0.26 ^{a}	14.53±0.41 ^{a}	16.99±0.50 ^{c}	15.70±0.33 ^{b}	14.20±0.36 ^{a}

$\bar{x} \pm SE$: Arithmetic mean ± standard error; The letters a,b,c indicate the statistical separation between the data. Statistical discrimination is at the p<0.05.

Table 2. Statistical differentiation (%) of *N. randalli* sampled from the Turkish coasts among different populations in terms of some morphometric characters (FL: Fork Length, TL: Total Length, HL:Head Length, ED: Eye Diameter, BH: Body Height, DFB: Dorsal Fin Base, PDL: Predorsal Length, PFL: Pectoral Fin Length, AFB: Anal Fin Base, PAL: Preanal Length, CPH: Caudal Peduncle Height).

Populasyon	FL/TL	BH/TL	ED/HL	BH/TL	DFB/TL	PDL/TL	PFL/TL	AFB/TL	PAL/TL	CPH/TL
	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$
Antalya	89.79± 0.51^{a}	23.96± 0.53^{bc}	31.07± 0.74^{c}	26.31± 0.35^{a}	39.70± 0.38^{a}	31.29± 0.58^{ab}	26.18± 0.77^{a}	14.53± 0.17^{a}	53.53± 0.37^{ab}	8.10± 0.13^{a}
Anamur	89,44± 0,45^{a}	22.92± 0.63^{ab}	32.49± 1.24^{c}	26.29± 0.38^{a}	40.43± 0.37^{bc}	29.76± 0.57^{a}	27.38± 0.80^{a}	15.32± 0.27^{ab}	51.85± 0.48^{a}	7.94± 0.07^{a}
Silifke	90.68± 0.33^{a}	21.96± 0.77^{a}	30.98± 0.60^{c}	27.60± 1.30^{a}	42.27± 1.05^{c}	30.10± 0.58^{a}	26.44± 0.46^{a}	16.20± 0.70^{b}	52.34± 0.63^{a}	7.99± 0.07^{a}
Mersin	90.47± 0.29^{a}	25.88± 0.76^{c}	28.06± 0.60^{b}	25.90± 0.62^{a}	42.26± 0.90^{c}	32.10± 0.56^{b}	24.57± 1.93^{a}	15.27± 0.32^{ab}	55.01± 1.06^{b}	7.98± 0.08^{a}
Iskenderun	90.52± 0.44^{a}	24.53± 0.53^{bc}	27.73± 0.41^{a}	27.11± 0.66^{a}	42.37± 1.73^{c}	30.91± 0.38^{ab}	27.68± 0.60^{a}	15.66± 0.30^{ab}	52.82± 0.73^{a}	8.20± 0.15^{a}

Duncan; The letters a, b, c indicate the statistical separation between stations for each group. Statistical discrimination is at the p<0.05. x̄±SE:Arithmetic mean ± Standard error

Table 3. Length-weight relationship of different populations of *N. randalli* sampled from the Turkish coast

		Total Lengthn (mm)	Weight (g)	$W=a \times TL^b$			
Populations	**N**	**Min-max**	**Min-max**	**a**	**b**	**95% CI (b)**	**r^2**
Antalya	50	156-190	43.06-78.00	0.0240	2.75	2.70-2.79	0.90
Anamur	50	150-210	46.53-111.5	0.0126	3.00	2.93-3.06	0.96
Silifke	50	190-235	93.44-173.62	0.0140	3.00	2.16-3.84	0.97
Mersin	50	179-215	80.60-119.21	0.0007	2.25	2.20-2.30	0.98
Iskenderun	50	153-189	58.43-82.30	0.0004	2.34	2.32-2.36	0.99

N: number of samples, a: intercept, b: slope, r2: coefficient of determination, CI: Confidence Interval

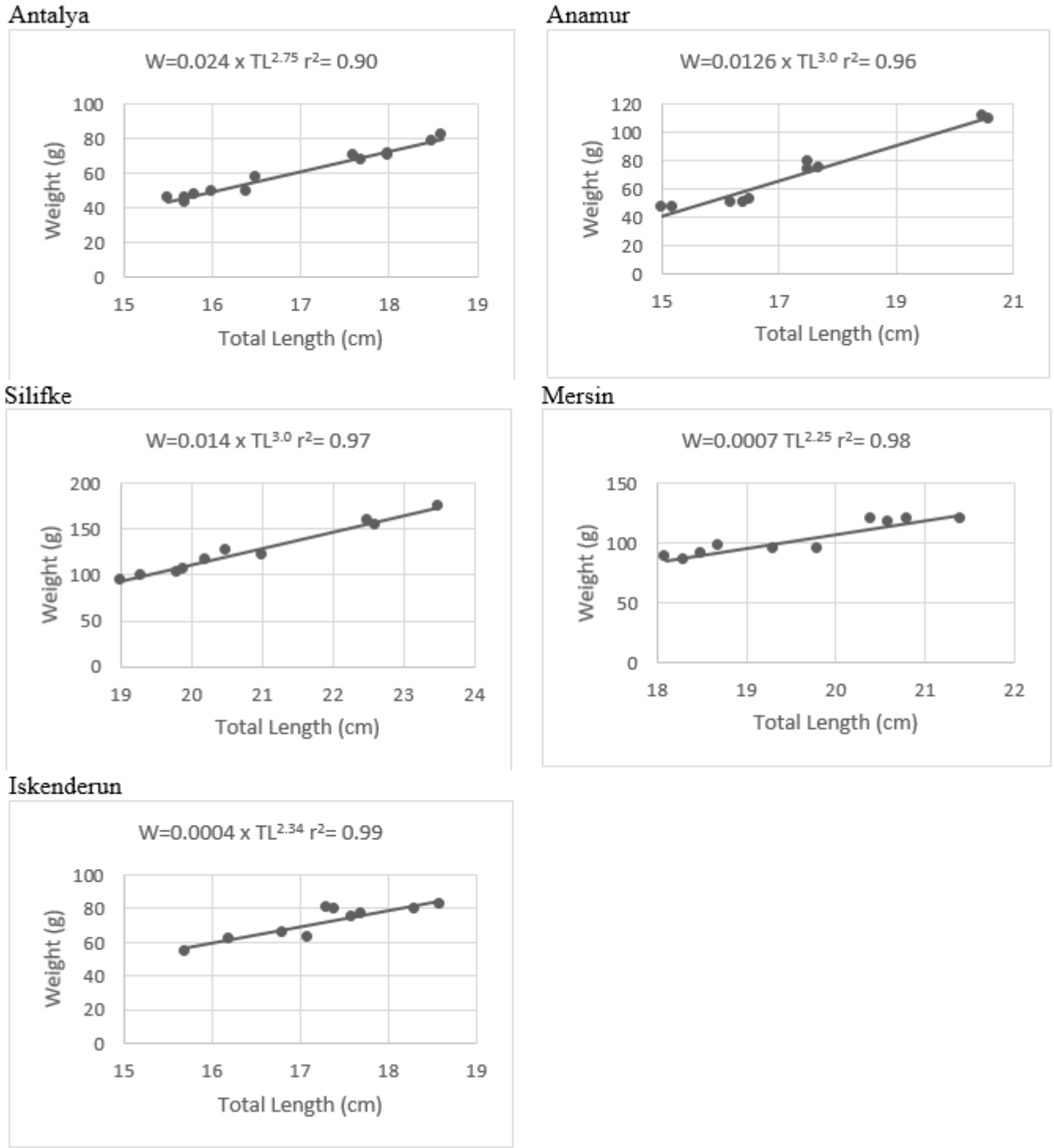

Figure 2. Length-weight relationship graph of the studied population of *N. randalli*

The mean of condition factor values of *N. randalli* was calculated as 1.21 in the Antalya population, 1.29 in the Anamur population, 1.36 in the Silifke population, 1.32 in the Mersin population, and 1.28 in the Iskenderun population.

4. DISCUSSION

Some morphometric characters of different populations of *N. randalli* were compared with previous studies. The maximum total length of *N. randalli* known in a previous study was reported as 25.0 cm (Gürlek et al., 2010). The highest total length among the populations examined in this study was found 23.5 cm from Silifke. It is consistent with the highest total length reported by Ali et al. (2013) from Syria (Table 4).

Since morphometric characters may vary depending on individual differences, environmental factors, age, and sex, the total length ratio of morphometric characters can be determined and the comparison of proportional values allows to obtain reliable results. The total length ratio of some morphometric characters of *N. randalli* was determined and compared with the different populations studied present and with previous studies (Table 5).

No distinction was found between the populations of *N. randalli* in terms of some meristic characters. Fin ray numbers of the samples examined in the study was D: X+9-10; A:III+7-8; Pel:I+5; Pec:16-17, the number of lateral line scales was determined as 44/47, which is consistent with previous studies (Lelli et al., 2008; Ali et al., 2013; Akyol & Aydın, 2016).

The positive linear correlation was found in some morphometric measurements in different populations of *N. randalli* except for preorbital length, dorsal-fin base, anal fin base, eye diameter, and total length were shown weak positive correlations in the Mersin population ($p<0.001$). Yazici et al. (2020) stated that some morphometric characters of *N. randalli* sampled from the Iskenderun Bay had positive regressions with total length, and the relationship between head length and total length showed the highest correlation among the morphometric characters examined. These research findings are consistent with previous research findings.

The length-weight relationships of *N. randalli* from Antalya, Mersin, and Iskenderun were shown negative allometric growth while from Anamur and Silifke were found isometric growth. Silifke has a rich nutritional content due to the nutrient salts carried by the Göksu River. This may have allowed the Silifke population to show isometric growth. Anamur population showed a similar growth relationship with the Silifke population. This may be due to the fact that Anamur and Silifke, unlike other study areas, are less affected by anthropogenic factors and thus provide suitable habitat and food. On the other hand, it can be thought that these two populations may have similar characteristics in terms of founder effect. The comparison of the determined length-weight relationships of different populations of the species with previous studies is presented in Table 6.

Table 4. Comparison of some morphometric characters of *N. randalli* sampled from different populations of Turkish coasts with previous studies (mm).

	Antalya	Anamur	Silifke	Mersin	Iskenderun	Bilecenoğlu and Russell, 2008 Iskenderun Bay	Ali et al., 2013 Syria	Gülşahin and Kara, 2013 Gökova Bay	Aydın and Akyol, 2016 Izmir Bay
	min-max								
TL	190.2-156.0	150.1-210.0	190.1-235.0	179.4-215.6	153.2-189.0	73.8-102.9	151-233	179-225	183
FL	136.3-185.1	135.3-200.0	170.1-232.1	159.9-192.8	143.2-168.0	-	-	164-208	157
HL	37.1-49.9	35.3-55.1	40.3-53.8	40.8-60.2	37.0-47.8	23.5-33.1	40-58	46.6-61.5	43
ED	10.4-17.3	11.5-15.6	11.4-16.4	12.2-15.6	10.5-13.3	7.4-8.9	12-15	13.6-18.7	13
BH	37.5-59.1	42.0-59.5	50.2-72.2	44.6-59.7	42.5-51.0	24.2-35.4	37-58	22.5-65.4	47
DFB	58.7-83.7	57.1-92.0	76.6-110.3	67.9-90.0	63.5-79.3	36.3-51.7	60-97	-	-
PDL	44.7-68.2	46.0-65.7	53.9-74.1	55.2-71.9	39.2-67.7	24.3-32.6	41-61	-	42
PFL	33.9-59.9	39.0-60.2	51.3-65.0	38.7-60.2	41.9-52.1	19.1-27.0	40-64	17-50.2	-
AFB	21.7-30.6	21.5-34.2	23.4-50.7	27.1-34.6	24.4-31.1	14.1-19.1	22-37	-	-
PAL	78.5-105	77.8-114.7	97.1-131.3	98.5-121.9	80.4-98.4	45.5-61.8	78-122	-	90
CPH	16.6-12.2	12.1-17.6	15.1-20.3	13.6-17.1	12.7-16.0	8.5-11.3	17-26	8.15-21.8	-

Table 5. The comparison of the total length ratio (%) of some morphometric characters among different populations of *N. randalli* sampled from the Turkish coasts with previous studies

	Present study					Russell, [11]	Aydın and Akyol, [30]
	Antalya	Anamur	Silifke	Mersin	Iskenderun		
FL/TL	89.79	89.44	90.68	90.47	90.52	87.4	85.8
HL/TL	23.96	22.92	21.96	25.88	24.53	23.7	23.5
ED/HL	31.07	32.49	30.98	28.06	27.73	27.5	30.2
BH/TL	26.31	26.29	27.60	25.90	27.11	26.5	25.7
PDL/TL	31.29	29.76	30.10	32.10	30.91	24.8	23.0
PFL/TL	26.18	27.38	26.44	24.57	27.68	25.0	-
PAL/TL	53.53	51.85	52.34	55.01	52.82	48.9	49.2

Table 6. The comparison of the length-weight relationships of different populations of *N. randalli* with previous studies.

			$W=a \times TL^b$		
Populations		**Total Length (mm)**	**a**	**b**	**r^2**
Antalya	Present study	156-190	0.0240	2.75	0.90
Anamur	Present study	150-210	0.0126	3.00	0.96
Silifke	Present study	190-235	0.0140	3.00	0.97
Mersin	Present study	179-215	0.0007	2.25	0.98
Iskenderun	Present study	153-189	0.0004	2.34	0.99
Indian Coast	Murty, (1982)	-	0.0223	2.88	-
Iskenderun Bay	Erguden et al. (2010)	48-215	0.0011	3.06	0.98
Israeli Coast	Edelist, (2014)	-	0.0101	3.08	0.97
Gulf of Oman	Al-Kiyumi et al., (2014)	-	0.0135	3.06	0.94
Antalya Bay	Ozvarol, (2014)	95-220	0.0120	2.97	0.93
Antalya Bay	Innal et al., (2015)	60-240	0.0105	3.04	0.98
Pakistani Coast	Kalhoro et al., (2017)	-	0.035	2.74	0.97
Tamil NaduPortonovo	Bandana et al., (2017)	130-259	0.0309	2.67	0.81
Gökova Bay	Ateş et al., (2017)	-	0.0201	2.98	0.96
Gökova Bay	Uyan et al., (2019)	108-219	0.0171	2.92	0.96
Iskenderun Bay	Demirci et al., (2020)	77-210	0.0106	3.09	0.97
Antalya Bay	Özen and Çetinkaya, (2020)	-	0.0173	2.85	-

The b value of *N. randalli* has been reported in previous studies ranged from 2.86 to 3.09 (Murty, 1982; Turan, 1999; Ergüden et al., 2010; Gürlek et al., 2010; Al-Kiyumi et al., 2014; Edelist, 2014; Ozvarol et al., 2014; Innal et al., 2015; Ateş et al., 2017; Kalhoro et al., 2017; Bandana et al., 2017; Uyan et al., 2019; Demirci et al., 2020; Özen et al., 2020; Yazıcı et al., 2020), in the present study it was found to be between 2.25 and 3.0. The reason why the species shows different growth characteristics may vary according to the sampling region, sampling tool, sampling time, sampling frequency, nutrient abundance, and other environmental factors.

The length-weight relationship of *N. randalli* in Antalya Bay was determined as W=0.08xTL3.1365 (r2=0.97) in females and W= 0.0079xTL3.1498 (r2=0.98) in males and positive allometric growth has been reported (Innal et al., 2015). Özvarol (2014) reported that the length-weight relationship of *N. randalli* in Antalya Bay was determined as W= 0.0120xTL2.9750 (r2=0.93) and the species showed negative allometric growth. In another study from Antalya Bay, the length-weight relationship of the species was reported as W=0.0173×TL2.8584 (Özen & Çetinkaya, 2020). In the present study, the length-weight relationship of *N. randalli* from Antalya was determined as W=0.0240xTL2.75 (r2=0.90), and it was determined that the species showed negative allometric growth that is consistent with Özvarol (2014) and Özen & Çetinkaya (2020).

The growth parameters of the species previously reported from Anamur, Silifke, and Mersin could not be reached. In this study, the length-weight relationship were found as from Anamur W=0.0126xTB3.00 (r2=0.96), from Silifke W=0.0140xTB3.0 (r2=0.97) and from Mersin W=0.0007xTB2.25 (r2=0.98). It was determined that the species showed isometric growth in Anamur and Silifke while negative allometric growth in Mersin and the findings are the first recorded growth records for the species from the Anamur, Silifke, and Mersin regions.

The length-weight relationship of the Iskenderun was determined as W= 0.0004xTB2.34 (r2=0.99) in present study. The previous research findings from Iskenderun Bay notified the growth relationships of *N. randalli* as W= 0.013xTB2,687 (r2=0.978) (Ergüden et al., 2009), W= 0.0011xTB3.061 (r2=0.982) (Gürlek et al., 2010), W= 0.00106xTB3.09 (r2 =0.97) (Demirci et al., 2020). Negative allometric growth was found in present study from Iskenderun and the result was consistent with Erguden et al (2010).

Other studies reporting the growth characteristics of the species on the Turkish coast are presented from the Gulf of Gökova (Ateş et al., 2017; Uyan et al., 2019). Ateş et al., (2017) found the length-weight relationship of *N. randalli* in Gökova Bay as W=0.0201xL2.98(r2=0.96), Uyan et al., (2019) found W=0.0171xL2.92 (r2=0.92). Both studies reported showing negative allometric growth of *N. randalli*.

In the Gulf of Oman, the length-weight relationship of *N. randalli* was determined as W=0.0109xL3.1569 in female individuals and W=0.0066xL3.3247 in male individuals, and it was reported that the species showed positive allometric growth. Edelist (2013) where the species showed positive allometric growth (b=3.08) on the coast of Israel, Edelist (2014), however, it showed negative allometric growth from the coast of Pakistan (Kalhoro et al., 2017) and the coast of East Indian Portonova (Swagat et al., 2017) has been reported.

In this study, it was determined that the species has isometric growth in Anamur and Silifke populations, and negative allometric growth in Antalya, Mersin, and Iskenderun populations, and the b value in Mersin and Iskenderun populations is outside the range of 2.5-3.5 commonly reported for bony fish (Teleost) by Froese (2006). The distinction between the populations examined in this study can be explained by changing environmental factors, as well as intra-species and inter-species competition for food and habitat. Among the sampling areas selected in the study, Iskenderun, Mersin, and Antalya regions are more affected by anthropogenic factors. This can cause changes in growth characteristics due to stress on populations.

The distinction between populations studied in present and previous studies may vary depending on fish size, the female-male ratio in the population, habitat conditions, sampling time and sampling method, and nutritional status of individuals (Innal et al., 2015).

The slope b value varied greatly between populations of *N. randalli*. It has been reported that the b value of Nemipterus species in the world varies between 2.63 and 3.28, and it has been stated that the separation between populations may depend on the season, geographical conditions such as the sampling region, as well as conditions such as limited food availability, disease and parasite loads (Bagenal & Tesch, 1978).

The condition factor values of *N. randalli* sampled from the Turkish coasts were between 1.92 and 3.77 in the present study. It has been reported that the range of condition factor values determined in a study conducted in Antalya Bay is 1.089 and 1.346 (Innal et al., 2015). It was emphasized that the condition factor of the species was high during the spawning season and these values decreased after the spawning took place. According to 44, performing the sampling during the spawning period of the species may explain the high condition factor due to gonad development.

There was a distinction between the populations in terms of the parameters examined in the present study. The distinction may be a result of the founder effect as well as ecological factors. This can be determined by genetic studies to be conducted with *N. randalli*.

5. CONCLUSION

It was reported that *N. randalli* is increasing along the northeastern Mediterranean coast, especially in the Iskenderun Bay, where fishing activities are important. It is estimated that the growth in the population of the species may place prey pressure on the economically important local species (Demirci et al., 2020). It is thought that the determination and management of successful species such as *N. randalli* among the alien species that joined the Eastern Mediterranean through tropical migration, and the relationship between local species and other migrating alien species will affect ecological change as well as fishing activities (Fox & Copp, 2014).

Each new population that the species establishes on the migration route may cause loss of genetic diversity and genetic variations due to its founding effect. Genetic diversity allows the species to adapt to the new environment. Its success in increasing new populations established in different habitats shows that *N. randalli* has genetic diversity. The weakening of gene variations of the species during adaptation to new habitats, and the success of adaptation may cause them to need anatomical changes. Increasing genetic diversity within a population will allow for increased variation selected from the most compatible alleles. Genetic variation also indicates mutation. Genetic drift that occurs in this way is one of the basic mechanisms of the evolutionary process and is important for the evolutionary development process of the species. In this study, the morphometric differences between different populations of *N. randalli* can be explained by the founder effect.

The distinction between the populations of the species may also be influenced by various factors such as ecological factors, developmental stage, prey-predator relationship, amount of food, the male-female ratio in the population, fishing pressure, and hunting method. Studies have shown that when the growth parameters of *N. randalli* are examined, it shows rapid growth and is less affected by prey pressure than species with similar growth characteristics (Demirci et al., 2020).

Finally, the finding of more than one record of *N. randalli* living in warm and salty waters in the Aegean Sea suggests that it can easily adapt to colder and lower salinity waters and establish populations. These data also confirm the hypothesis that tropical origin species migrated westward (Zenetos et al.,2008).

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Author contributions

The authors contributed equally.

Conflict of interest

The author declare that no conflict of interest pertaining to the publication of this manuscript.

Statement of Research and Publication Ethics

For this study is ethical approval not required.

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