Received: 19 October 2016 | Accepted: 26 January 2017
DOI: 10.1111/jai.13384

ORIGINAL ARTICLE

WILEY Journal of Applied Ichthyology DWK

A study on age and growth characteristics of spiny gurnard (*Lepidotrigla dieuzeidei* Blanc & Hureau, 1973), northeastern Mediterranean Sea

A. Başusta | N. Başusta | M. Calta | E. I. Ozcan

Fisheries Faculty, Firat University, Elazığ, Turkey

Correspondence
Asiye Başusta, Fisheries Faculty, Firat University, Elazığ, Turkey.
Email: agirgin@firat.edu.tr

Summary

This study investigated the age and growth characteristics of spiny gurnard, *Lepidotrigla dieuzeidei*, from the northeastern Mediterranean. Samples were collected by commercial trawls during the 2012–2013 fishing seasons. A total 1,878 speciments ranged from 7.10 to 15.90 cm total length and 2.28–35.88 g in weight. Female/male ratio was 1.2/1. The total length–weight relationship was $W = 0.002\ \mathrm{TL}^{3.579}$ ($r^2 = .909$) for sexes combined, $W = 0.0021\ \mathrm{TL}^{3.551}$ ($r^2 = .914$) for males and $W = 0.0019\ \mathrm{TL}^{3.602}$ ($r^2 = .904$) for females. Age determination was conducted using the sagittal otoliths. Ages of examined individulas ranged from 3 to 11 years. Total length-at-age data were fitted using the von Bertalanffy growth model. Estimated growth functions were $\mathrm{TL}_t = 18.100\ [1-e^{-0.14\ (t+0.63)}]$ for sexes combined, $\mathrm{TL}_t = 23.587\ [1-e^{-0.08\ (t+1.56)}]$ for males and $\mathrm{TL}_t = 16.612\ [1-e^{-0.19\ (t+0.15)}]$ for females.

1 | INTRODUCTION

The spiny gurnard, *Lepidotrigla dieuzeidei*, lives on muddy substrate at 50–250 m depths and feeds on benthic invertebrates, especially amphipod crustaceans (Golani, Oztürk, & Başusta, 2006). An Atlanto-Mediterrenean species, it is usually distributed along the Mediterranean from Gibraltar to Mauritania (Golani et al., 2006). The spiny gurnard is a triglid member, and studies have also focused on other Mediterranean triglids (Eryilmaz & Meriç, 2005; Işmen, Işmen, & Başusta, 2004; Uçkun, 2005; Uçkun & Toğulga, 2007; Valisneri, Montanini, & Stagioni, 2010). There are some biological studies on spiny gurnard from other areas of the Mediterranean, with the exception of the northeastern Mediterranean. Few studies on length–weight relationship, condition factor and relationship between fish length and otolith dimensions of spiny gurnard from the Northeastern Mediterranean have been found (Başusta, Başusta, Calta, Özer, & Girgin, 2013; Başusta, Özer, & Girgin, 2013). This is the first study on age and growth of spiny gurnard inhabits in the northeastern Mediterranean.

2 | MATERIAL AND METHODS

In this study, spiny gurnard samples were collected as by-catch using a commercial bottom trawler in the northeastern Mediterranean (36°10′811″N–34°25′672″E) during the 2012–2013 fishing season and processed in the Fish Ecophysiology Laboratory in the Fisheries Faculty, Firat University, Elazig, Turkey. Total lengths (nearest 0.1 mm) and weights (nearest 0.01 g) of fish samples were measured and the sexes determined by macroscopic observation of gonads; sex ratios were checked with a chi-square test as to whether the ratio differed from 1:1. The sagittal otoliths were chosen for age reading and interpretation, since they are the largest and most commonly used in ageing studies (Secor, Dean, & Laban, 1991). Sagittal otoliths were removed, cleaned and stored dry in labelled envelopes for later examination and age determination. Age was read under a stereoscopic zoom microscope with reflected light against a black background. Opaque and transparent rings were counted; one opaque zone and one transparent zone together were considered to be 1 year (Chugunova, 1963). Each otolith was read at least twice. The index of the average percentage error (IAPE) was calculated to assess the precision of the age determinations between two independent readers. The equation is expressed as:

$$\mathrm{IAPE} = 1/N \sum (1/R) \sum \left(\frac{x_{ij} - x_j}{x_j} \right)$$

where N is the number of fish aged, R is the number of times each fish was aged, x_{ij} is the ith age determination of the jth fish, and x_j is the

TABLE 1 Individual numbers (*N*), total length (TL), weight (*W*) and condition factors (CF) with ±standard deviation (*SD*) at age of *L. dieuzeidei*, ortheastern Mediterranean

	Males				Females			
Age groups	*N*	TL ± *SD*, cm (Min–Max)	*W* ± *SD*, g (Min–Max)	CF ± *SD* (Min–Max)	*N*	TL ± *SD*, cm (Min–Max)	*W* ± *SD*, g (Min–Max)	CF ± *SD* (Min–Max)
3	6	7.48 ± 0.29 (7.10–7.80)	3.82 ± 0.77 (2.74–5.10)	0.91 ± 0.16 (0.70–1.11)	4	7.55 ± 0.40 (7.20–7.90)	3.51 ± 1.42 (2.28–5.43)	0.81 ± 0.26 (0.53–1.10)
4	11	8.16 ± 0.53 (7.50–8.90)	4.41 ± 0.71 (3.48–5.82)	0.83 ± 0.20 (0.62–1.23)	16	8.06 ± 0.29 (7.70–8.80)	4.65 ± 1.03 (2.84–5.88)	0.89 ± 0.21 (0.57–1.13)
5	415	9.55 ± 0.66 (7.60–12.50)	6.37 ± 1.61 (2.47–16.70)	0.72 ± 0.12 (0.43–1.21)	517	9.50 ± 0.61 (8.00–11.40)	6.23 ± 1.54 (3.00–11.80)	0.71 ± 0.13 (0.49–1.17)
6	269	11.47 ± 0.61 (8.50–12.90)	12.99 ± 2.54 (3.25–19.39)	0.85 ± 0.08 (0.53–1.11)	318	11.48 ± 0.68 (8.50–12.80)	12.96 ± 2.67 (3.72–19.66)	0.84 ± 0.08 (0.56–1.08)
7	34	12.44 ± 0.46 (10.80–12.80)	16.99 ± 2.42 (9.83–19.76)	0.88 ± 0.07 (0.68–1.01)	28	12.50 ± 0.54 (10.70–13.00)	17.17 ± 2.69 (9.19–23.33)	0.87 ± 0.08 (0.75–1.09)
8	23	13.20 ± 0.45 (12.70–14.30)	21.16 ± 3.06 (16.99–28.20)	0.91 ± 0.07 (0.79–1.05)	20	13.12 ± 0.40 (12.70–14.00)	20.43 ± 2.84 (16.42–27.50)	0.90 ± 0.06 (0.76–1.02)
9	20	13.35 ± 0.29 (12.80–13.90)	21.27 ± 2.57 (15.78–25.69)	0.89 ± 0.07 (0.72–1.02)	17	13.41 ± 0.39 (13.00–14.40)	22.41 ± 2.59 (17.47–26.49)	0.93 ± 0.08 (0.76–1.06)
10	3	14.30 ± 0.44 (13.80–14.60)	28.71 ± 2.09 (26.82–30.96)	0.98 ± 0.06 (0.91–1.02)	2	14.10 ± 0.14 (14.00–14.20)	26.07 ± 0.77 (25.52–26.61)	0.93 ± 0.01 (0.92–0.93)
11	2	15.30 ± 0.85 (14.70–15.90)	33.70 ± 3.09 (31.51–35.88)	0.94 ± 0.07 (0.89–0.99)	2	13.70 ± 0.28 (13.50–13.90)	25.87 ± 0.07 (25.37–26.36)	1.01 ± 0.04 (0.98–1.03)

Min, minumum total length at age; Max, maximum total length at age.

mean age calculated for the *j*th fish (Beamish & Fournier, 1981). A von Bertalanffy growth function (von Bertalanffy, 1938):

$$TL_t = TL_\infty (1 - e^{-k(t-t_0)})$$

was fitted through a non-linear least square technique (Prager, Saila, & Recksiek, 1989).

where, TL_t is the expected total length at age *t* years, TL_∞ is the asymptotic average maximum total length, *k* is the growth coefficient, and t_0 is the theoretical age at zero length.

Length–weight relationships were calculated using the equation:

$$W = a \times TL^b$$

where, *W* is total weight, TL is the total length, *a* is the intercept of the regression line and *b* is the regression coefficient. The *b* values of both sexes were compared by using the Kolmogorov–Smirnov two-sample test, and the *b* value variation from 3 was tested with the one sample *t* test. Individual values of Fulton's condition factor (*K*) were obtained with the formula:

$$K = (W/TL^b) \times 100$$

where, *W* is total weight; TL is total length and *b* is the coefficient of allometric of relationship (Bagenal & Tesch, 1978).

Data were subjected to statistic analyses using the IBM SPSS Statistics vers. 22.0 for Windows.

3 | RESULTS

In this study, a total of 1,707 spiny gurnard (924 females, 783 males) were used. Sex ratio was biased to females (1.2:1) and found significantly different from 1:1 ratio (chi-square test, $p < .05$). Although the age of *Lepidotrigla dieuzeidei* ranged from 3 to 11 years, most were ages 5 and 6 (Table 1). The index of the average percentage error (IAPE) for spiny gurnard was 7.8%. According to age groups, total lengths, weights and condition factors of male and female populations of spiny gurnard are given in Table 1.

The total length–weight relationships of sexes combined, male and female populations of *L. dieuzeidei* in the northeastern Mediterranean are given in Figure 1. All relationships were logarithmic and "*b*" values were higher than 3 (see Figure 1). Comparisons of *b* values between males and females were not found to be significant ($p > .05$).

In this study, 95% confidence intervals of $b = 3.525–3.633$ for combined sexes, 3.474–3.627 for males and 3.526–3.678 for females ($p < .001$) were determined. According to these values, the growth type of this species was isometric for females, males and sexes combined (Table 2).

Regression analysis shows that fish length has a significant correlation with weight ($r^2 = .909$, F1, 1,705 = 17,012.516, $p < .001$ for sexes combined; $r^2 = .914$, F1, 781 = 8,300.241, $p < .001$ for males; $r^2 = .904$, F1, 922 = 8,713.045, $p < .001$ for females, and that a 91% increase in weight was due to length increase. Furthermore, when the *t* test results were analyzed for the significance of regression coefficients (*t* test = 130.432, $p < .001$ for sexes combined; *t* test = 91.106, $p < .001$ for males; *t* test = 93.344, $p < .001$ for females), it was found that fish-length data could be used with high accuracy to predict fish weight.

Age: total length relationships for combined sexes, males and females of spiny gurnard population in the Northeastern Mediterranean

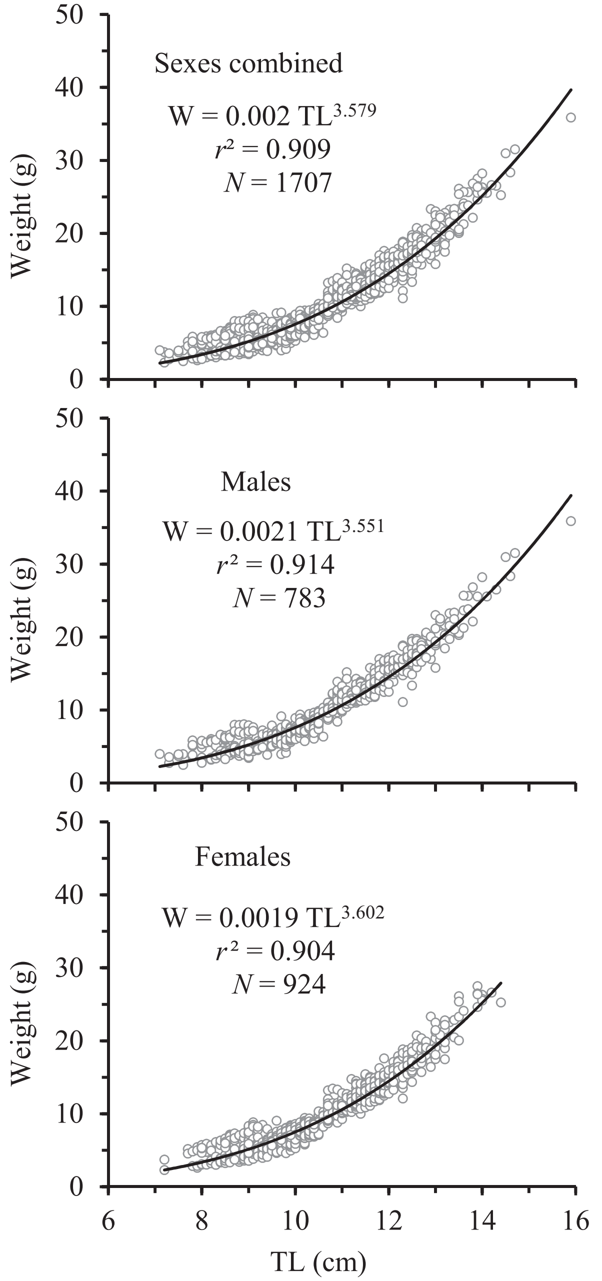

FIGURE 1 Total length–weight relationship for combined sexes, as well as male and female *L. dieuzeidei*, Northeastern Mediterranean: equations, coeffcients of determination (r^2) and number of specimens (N)

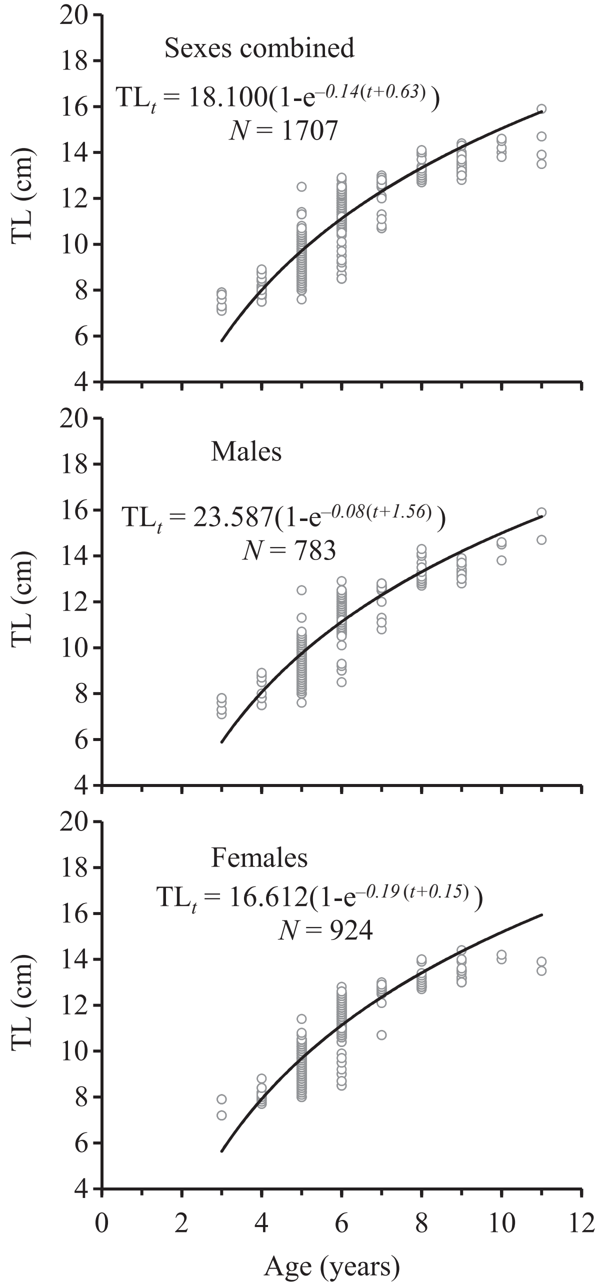

FIGURE 2 Von Bertalaffy growth curves and equations fitted on total length (TL)-at-age data for combined sexes, as well as male and female *L. dieuzeidei*, Northeastern Mediterranean

TABLE 2 Descriptive statistics and estimated parameters of total length–weigth relationships (LWRs) for *L. dieuzeidei*, northeastern Mediterranean

		Total length (cm)		Weigth (g)		Regression parameter				
	N	Min–max	Mean ± *SD*	Min–max	Mean ± *SD*	*a*	*b*	*SE* (*b*)	%95CI (*b*)	r^2
CS	1,707	7.10–15.90	10.47 ± 1.40	2.28–35.88	9.75 ± 5.03	0.0020	3.579	0.027	3.525–3.633	.909
M	783	7.10–15.90	10.53 ± 1.43	2.47–35.88	10.03 ± 5.19	0.0021	3.551	0.039	3.474–3.627	.914
F	924	7.20–14.40	10.43 ± 1.35	2.28–27.50	9.55 ± 4.88	0.0019	3.602	0.039	3.526–3.678	.904

CS, combined sexes; M, male; F, female; *N*, number of specimens; *SD*, standard deviation; *a*, intercept of the relationship; *b*, slope of the relationship; *SE* (*b*), standar error of *b*; 95% CI (*b*), confidence limits of *b*; r^2, coefficient of determination.

TABLE 3 Total lengths-at-age, TL (cm), measured and predicted by von Bertalanffy equation calculated from observed data for *L. dieuzeidei*, northeastern Mediterranean, 2012–2013 fishing seasons

	L_∞ (cm)	K (year^{-1})	t_0 (year^{-1})	N
Males	23.59	0.08	−1.56	783
Females	16.61	0.19	−0.15	924
Sexes combined	18.10	0.14	−0.63	1,707

Age groups	Males		Females		Sexes combined	
	Predicted TL (cm)	Measured TL (cm)	Predicted TL (cm)	Measured TL (cm)	Predicted TL (cm)	Measured TL (cm)
3	7.40	7.48	7.08	7.55	7.05	7.51
4	8.68	7.89	8.57	8.06	8.45	8.10
5	9.86	9.53	9.80	9.50	9.68	9.52
6	10.95	11.48	10.82	11.48	10.75	11.48
7	11.95	12.35	11.65	12.50	11.68	12.47
8	12.87	13.06	12.34	13.12	12.50	13.12
9	13.72	13.24	12.92	13.41	13.21	13.38
10	14.50	13.62	13.39	14.10	13.83	14.22
11	15.22	13.57	13.78	13.70	14.37	14.50

TABLE 4 Growth parameters of some triglid species

Species	Sex	L_∞	k	t_0	Reference
Aspitrigla cuculus	Male	20.4	0.51	—	Papaconstantinou (1983)
Aspitrigla cuculus	Female	27.6	0.22	—	Papaconstantinou (1983)
Aspitrigla cuculus	Male	23.4	0.59	−0.38	Colloca, Cardinale, Marcello, and Ardizzone (2003)
Aspitrigla cuculus	Female	24.2	0.74	−0.07	Colloca et al. (2003)
Chelidonichthys lucerna	All	40.9	0.14	−2.26	Altun, Göksu, Türeli, and Erdem (1997)
Chelidonichthys lucerna	All	45	0.22	−0.58	Işmen et al. (2004)
Chelidonichthys lucerna	All	61.3	0.17	−0.04	Eryilmaz and Meriç (2005)
Chelidonichthys lucerna	Male	40.26	0.06	−1.32	Boudaya et al. (2008)
Chelidonichthys lucerna	Female	46.16	0.05	−3.03	Boudaya et al. (2008)
Lepidotrigla dieuzeidei	All	18.100	0.14	−0.63	In this study
Lepidotrigla dieuzeidei	Male	23.587	0.08	−1.56	In this study
Lepidotrigla dieuzeidei	Female	16.612	0.19	−0.15	In this study

—, not determined.

are given Figure 2. The von Bertalanffy Growth Functions (VBGF) are also shown in Figure 2.

4 | DISCUSSION

This is the first study on age and growth characteristics of spiny gurnard in the northeastern Mediterranean. The results were compared to the studies of other species from the Triglidae family in the Mediterranean Sea.

Total lengths of *L. dieuzeidei* in this study were between 7.15–16.20 cm, which was similar to *L. dieuzeidei* from the southern Aegean Sea (range 8.7–14.1 cm (Bilge, Yapici, Filiz, & Cerim, 2014)), Portugal coasts, Atlantic Ocean (range 6.8–16.2 cm (Olim & Borges, 2006)) but larger than those from the Adriatic Sea (range 7.4–13.7 cm (Valisneri et al., 2010)). However, lengths of *L. dieuzeidei* from the Tyrrhenian Sea were between 5.0–19.0 cm (Voliani, Mannini, & Auteri, 2000), which might be attributed to the differences of catch time, catch equipments and the number of fish sampled.

The female: male ratio of *L. dieuzeidei* in the present study was 1.2:1. This ratio was 1.55:1 for *Trigliporus lastoviza*, 1.29:1 for *Lepidotriglia cavillone*, 1.26:1 for *Triglia lucerne*, and 1.87:1 for *Triglia lyra* from Edremit Bay, Aegean Sea, Turkey (Uçkun, 2005). Sex ratio of *L. dieuzeidei* shows a similarity to that of *L. cavillone* and *T. lucerna*.

Age of *L. dieuzeidei* in the present study ranged between 3 and 11 years. However, the ages of other species belonging to the Triglidae family were between 0 and 16 (Uçkun, 2005). The reason for this difference might be that young fishes were predominant in our study.

Length–weight relationships of the spiny gurnard population for females, males, and sexes combined were isometric and strong (correlation coefficients very close to 1) and it can be stated that a 91% increase in weight was due to length increase. Similar values were observed in *L. dieuzeidei* on the Atlantic Ocean coast of Portugal (Olim & Borges, 2006) and the Adriatic Sea (Valisneri et al., 2010). In general, the number of females was higher than that of males in triglids population of the northeastern Mediterranean according to results of most studies. We have found that lengths and weights of triglids populations in the northeastern Mediterranean increased with the age of the fish. Similar results were also found for other species of Triglidae (Işmen et al., 2004; Uçkun, 2005).

As can be seen in Table 3, the calculated and measured lengths were very close to each other. Males reach a larger asymptotic total length (TL_∞ = 23.59 cm) than females (TL_∞ = 16.61 cm) and grow more slowly (k = 0.08 year^{-1}, t_0 = −1.56 for males and k = 0.19 year^{-1}, t_0 = −0.15 for females).

This study provides baseline information on growth parameters for *L. dieuzeidei* from the northeastern Mediterranean. This information will be useful for researchers and fishery managers in the future.

REFERENCES

Altun, A., Göksu, M. Z. L., Türeli, C., & Erdem, Ü. (1997). An investigation on some biological characteristics of sole (*Solea vulgaris*, Quensel, 1806) and Mediterranean gurnard (*Trigla lucerna* Linnaeus, 1758) in the Yumurtalık Bay. *XIII International Biology Congress, Istanbul, Turkey*, 5, 147–158.

Bagenal, T. B., & Tesch, F. W. (1978). Age and growth. In T. B. Bagenal (Ed.), *Methods for assessment of fish production in freshwater* (3rd ed., pp. 101–136). Oxford, UK: Blackwell Scientific Publication.

Başusta, A., Başusta, N., Calta, M., Özer, Eİ., & Girgin, H. (2013). Length–weight relationship and condition factor of spiny gurnard (*Lepidotrigla dieuzeidei* Blanc and Hureau, 1973) inhabiting northeast Mediterranean Sea. *Journal of Animal and Veterinary Advances*, *12*(2), 212–214.

Başusta, A., Özer, Eİ., & Girgin, H. (2013). Relationship between fish length and otolith dimensions in the population of *Lepidotrigla dieuzeidei* (Blanc & Hureau, 1973) from Mediterranean. *Yunus Research Bulletin*, *3*, 3–9.

Beamish, R. J., & Fournier, D. A. (1981). A method for comparing the precision of a set of age determinations. *Canadian Journal of Fisheries and Aquatic Science*, *38*, 982–983.

von Bertalanffy, L. (1938). A quantitative theory of organic growth (Inquiries on growth laws. II). *Human Biology*, *10*, 181–213.

Bilge, G., Yapici, S., Filiz, H., & Cerim, H. (2014). Weight–length relations for 103 fish species from the southern Aegean Sea, Turkey. *Acta Ichthyologica Et Piscatoria*, *44*(3), 263–269.

Boudaya, L., Neifar, L., Rizzo, P., Badalucco, C., Bouain, A., & Fiorentino, F. (2008). Growth and reproduction of Chelidonichthys lucerna (Linnaeus) (Pisces: Triglidae) in the Gulf of Gabes, Tunisia. *Journal of Applied Ichthyology*, *24*, 581–588.

Chugunova, N. L. (1963). *Age and growth studies in fish* (132 pp.). Jerusalem: National Science Foundation.

Colloca, F., Cardinale, M., Marcello, A., & Ardizzone, G. D. (2003). Tracing the life history of red gurnard (*Aspitrigla cuculus*) using validated otolith annual rings. *Journal of Applied Ichthyology*, *19*, 1–9.

Eryilmaz, L., & Meriç, N. (2005). Some biological characteristics of the tub gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) in the Sea of Marmara. *Turkish Journal of Veterinary and Animal Sciences*, *29*, 367–374.

Golani, D., Oztürk, B., & Başusta, N. (2006). *Fishes of the eastern Mediterranean* (259 pp.). Istanbul, Turkey: Turkish Marine Research Foundation.

Işmen, A., Işmen, P., & Başusta, N. (2004). Age, growth and reproduction of tub gurnard (*Chelidonichthyes lucerna* L.1758) in the İskenderun Bay, eastern Mediterranean. *Turkish Journal of Veterinary and Animal Sciences*, *28*, 289–295.

Olim, S., & Borges, T. C. (2006). Weight–length relationships for eight species of the family Triglidae discarded on the south coast of Portugal. *Journal of Applied Ichthyology*, *22*, 257–259.

Papaconstantinou, C. (1983). Obervations on the ecology of gurnards (Pisces: Triglidae) of the Greek Seas. *Cybium*, *7*(4), 71–88.

Prager, M. H., Saila, S. B., & Recksiek, C. W. (1989). FISHPARM: amicrocomputer program for parameter estimation of non-linearmodels in fishery science (pp. 87–100). Old Dominion Univ. Oceanogr. Tech. Rep.

Secor, D. H., Dean, J. M., & Laban, E. H. (1991). *Manual for otolith removal and preparation for microstructural examination* (85 pp.). Palo Alto, CA: Electric Power Research Institute and Belle W. Baruch Institute for Marine Biology and Coastal Research.

Uçkun, D. (2005). Investigation of the age and growth characteristics of the species belonging to the family Triglidae in Edremit Bay. *European Journal of Fisheries and Aquatic Sciences*, *22*(3–4), 363–369.

Uçkun, D., & Toğulga, M. (2007). Age, growth and reproduction of tub gurnard *Chelidonichthys lucernus* Linnaeus, 1758 (Osteichthtyes: Triglidae) from İzmir Bay, Aegean Sea, Eastern Mediterranean. *Acta Adriatica*, *48*(2), 173–184.

Valisneri, M., Montanini, S., & Stagioni, M. (2010). Length–weight relationship for the family Triglidae in the Adriatic Sea, northeastern Mediterranean. *Journal of Applied Ichthyology*, *26*, 460–462.

Voliani, A., Mannini, P., & Auteri, R. (2000). Distribution and biology of *Lepidotriglia cavillone* (Lacépède) and *L. dieuzeidei* (Blanc & Hureau) in Tuscan archipelago. *Biologia Marina Mediterranea*, *7*, 844–849.

How to cite this article: Başusta A, Başusta N, Calta M, Ozcan EI. A study on age and growth characteristics of spiny gurnard (*Lepidotrigla dieuzeidei* Blanc & Hureau, 1973), northeastern Mediterranean Sea. *J Appl Ichthyol*. 2017;33:966–970. https://doi.org/10.1111/jai.13384