ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2022, 7(2): 97-107 doi: 10.28978/nesciences.1159204

Length-Weight Relation of the Angular Rough Shark, *Oxynotus centrina* (Linnaeus, 1758) in the Mediterranean Sea

Hakan Kabasakal [1*] Elif Özgür Özbek [2]

[1] Ichthological Research Society, İstanbul, Turkey

[2] Turkish Marine Research Foundation, İstanbul, Turkey

Abstract

Oxynotus centrina is considered a rare or uncommon shark species throughout its distribution range. Because of this reason, it is one of the 46 uncommon elasmobranchs in the Mediterranean Sea, which requires filling the knowledge gaps, such as length-weight relations. Based on the analysis of 34 angular rough sharks, the length-weight relations (LWR) of males, females and combined sexes of *O. centrina* were described as $W = 0.216L^{2.686}$, $W = 0.134L^{3.041}$ and $W=0.102L^{3.173}$, respectively. Total lengths (TL) of females and combined sexes were strongly correlated with total weights (TW); while TL of males was moderately correlated with TW. The b values of LWRs of females and combined sexes (3.041 and 3.173, respectively) were not significantly different from 3.0 (t-test, $p>0.10$) and indicated positive allometric growth for the examined TL and TW range of *O. centrina* in the Mediterranean Sea.

Keywords:
Squaliformes, Oxynotus, size, growth, parameters, LWR

Article history:
Received 30 March 2022, Accepted 11 May 2022, Available online 08 August 2022

Introduction

The angular rough shark, *Oxynotus centrina* (Linnaeus, 1758) is a bottom dwelling squaliform shark of the family Oxynotidae, inhabiting continental shelves and upper slope at depths of 50 to more than 700 m (Ebert & Stehmann, 2013). It is commonly found on coralline algal and muddy bottoms, mostly deeper than 100 m depth (Ebert & Stehmann, 2013). The distribution range of *O. centrina* extends from north-to-southeastern Atlantic, and throughout the Mediterranean Sea, where the northernmost range extends to the Sea of Marmara (Ebert & Stehmann, 2013; Turan et al., 2018; Serena et al., 2020; Kabasakal, 2020).

[*]*Corresponding Author: Hakan KABASAKAL, E-mail*: *kabasakal.hakan@gmail.com*

Oxynotus centrina is considered as a rare or uncommon shark species throughout its distribution range (Ebert & Stehmann, 2013; Serena et al., 2020; Kabasakal, 2021; Mutlu et al., 2022). Mainly because of its rare occurrence, most of the studies on the life story parameters of *O. centrina* are based on the opportunistic observations of sporadic individuals (Geldiay & Mater, 1968; Megalofonou & Damalas, 2004; Dragičević et al., 2009; Kabasakal, 2009; Başusta et al., 2015; Yığın et al., 2016; Koehler, 2018), or specimen series, which were collected during very long sampling years (Capapé et al., 1999; Capapé, 2008; Kousteni & Megalofonou, 2016;).

In a recent study, Tsikliras & Dimarchopoulou (2021) emphasized that *Oxynotus centrina* is one of the 46 uncommon elasmobranchs in the Mediterranean Sea which requires filling the basic knowledge gaps, such as length-weight relations. It is, therefore, the aim of the present paper to provide length-weight relation (LWR) along with the growth parameters of *O. centrina*, based on individuals collected from several localities throughout the Mediterranean Sea.

Materials and Method

Length-weight data of *Oxynotus centrina* (n=34; Figure 1), that were examined in the present study, were obtained from the following sources: (1) unpublished morphometric measurements of the *O. centrina* individuals (n=17), which were recorded during the 1960 expedition of the former Meat and Fish Institution of the Republic of Turkey and donated to first author (HK) for analysis by Turkish Marine Research Foundation (TÜDAV); (2) length-weight measurements of the Mediterranean specimens of *O. centrina* (n=16), which were published in relevant references (Megalofonou & Damalas, 2004; Dragičević et al., 2009; İşmen et al., 2009; Barría et al., 2015; Başusta et al., 2015; Kousteni & Megalofonou, 2016; Yığın et al., 2016; Koehler, 2018) and (3) unpublished length-weight data of a gravid female (n=1), which is kept in the archives of second author (EÖÖ). The geographical distribution of the examined individuals of *O. centrina* throughout the Mediterranean Sea is shown in Figure 2.

Figure 1. Gravid female angular rough shark, *Oxynotus centrina*, captured from Antalya Bay (specimen no 22 in Table 1)

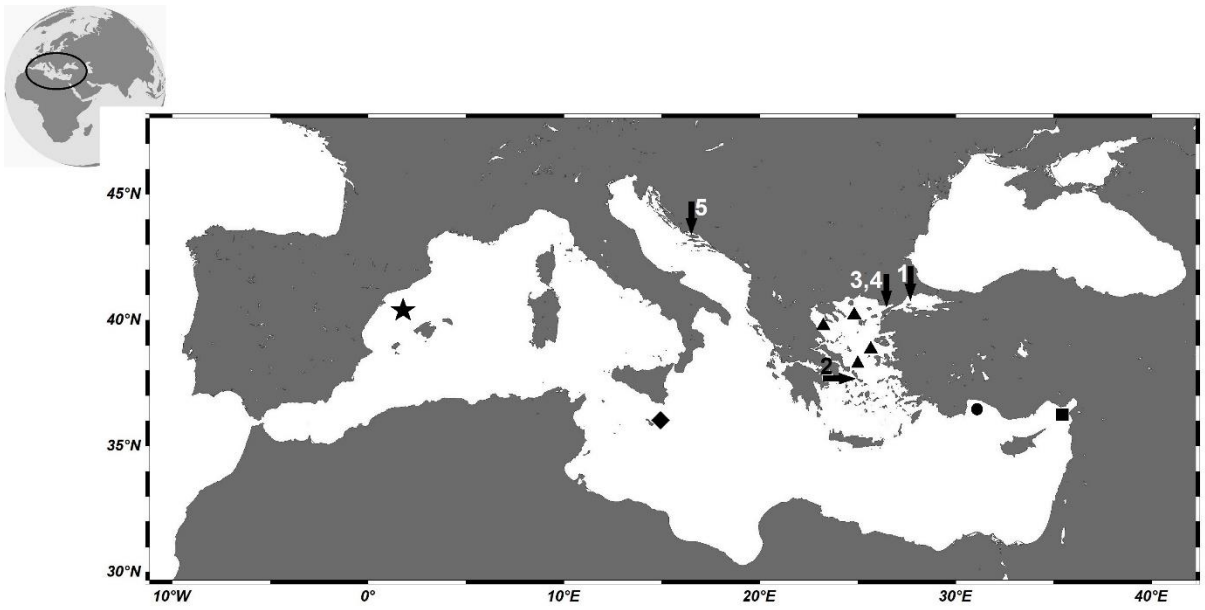

Figure 2. Capture localities of the individuals of *Oxynotus centrina* throughout the Mediterranean. (1↓), individuals captured from the Sea of Marmara in 1960 bottom trawl survey (specimen nos 1-17, in Table 1); (2→) Megalofonou & Damalas (2004; n=1); (3,4↓) İşmen et al. (2009; n=4), Yığın et al. (2016; n=1); (5↓) Dragičević et al. (2009; n=1); (▲) Kousteni & Megalofonou (2016; n=4); (◆) Koehler (2018; n=1); (●) unpublished data of gravid female captured in 2008 (specimen no 22, in Table 1; n=1); (■) Başusta et al. (2015; n=2); (★) Barría et al. (2015; n=2).

Base 10 logarithm transformed values of total length (TL) and total weight (TW) data were used to estimate the LWR of *O. centrina* based on the equation $W=aL^b$ (Ricker, 1975), where W is the weight of the fish, L is the total length, and *a* and *b* are constants. Regression analyses and t-test were computed on excel software analysis toolpak.

Results

Length and weight data of 34 individuals of *Oxynotus centrina*, captured in different regions of the Mediterranaean Sea, and adjacent seas (Adriatic, Aegean and Marmara Seas) were analysed. Eighteen out of 34 individuals (52.9%) were females and followed by 10 males (29.4%), while 6 individuals (17.6%) were sexed unknown. TL and TW data, sexes, capture localities of unpublished individuals together with same data of published individuals with relevant references, are presented in Table 1.

Table 1. General information of the examined individuals of *Oxynotus centrina*. (F) females; (M) males; (E) eastern; (NW) northwestern; (NE) northeastern; (CNT) central

No	TL (cm)	TW (g)	Sex	Depth (m)	Locality	Date	Reference
1	52	1600	F	52	Marmara	27.06.1960	Unpublished data
2	48	1700	F	52	Marmara	27.06.1960	Unpublished data
3	42	900	F	30-40	Marmara	28.06.1960	Unpublished data
4	48	1200	M	30-40	Marmara	28.06.1960	Unpublished data
5	47	1000	M	48	Marmara	29.06.1960	Unpublished data
6	52	1000	M	80	Marmara	27.07.1960	Unpublished data
7	53	1700	F	50	Marmara	29.07.1960	Unpublished data
8	46	900	M	70-76	Marmara	22.08.1960	Unpublished data
9	48	900	M	70-76	Marmara	22.08.1960	Unpublished data
10	48	900	M	70-76	Marmara	23.08.1960	Unpublished data
11	48	1200	F	70-76	Marmara	23.08.1960	Unpublished data
12	56	2600	F	?	Marmara	Spt. 1960	Unpublished data
13	47	1100	M	110	Marmara	Oct. 1960	Unpublished data
14	54	1800	F	110	Marmara	27.10.1960	Unpublished data
15	49	900	F	?	Marmara	Nov. 1960	Unpublished data
16	60	2200	F	?	Marmara	Nov. 1960	Unpublished data
17	56	2200	F	?	Marmara	Nov. 1960	Unpublished data
18	69	4000	F	100-200	Aegean Sea	Feb. 1999	Megalofonou & Damalas (2004)
19	80	7883	F	60	Adriatic Sea	7.07.2007	Dragičević et al. (2009)
20	53,3	1649	?	130	Aegean	Oct. 2007	Kousteni & Megalofonou (2016)
21	56,5	1703	?	130	Aegean	Oct. 2007	Kousteni & Megalofonou (2016)
22	74	2400	F	400-600	E Mediterranean	11.03.2008	Unpublished data
23	65,1	4652	F	65-75	Aegean	22.09.2008	Yığın et al. (2016)
24	49	530	M	5-500	Aegean	Mar. 2005-Jun. 2008	İşmen et al. (2009)

Table 1. Continued

25	55,3	1960	M	5-500	Aegean	Mar. 2005-Jun. 2008	İşmen et al. (2009)
26	29	260	F	5-500	Aegean	Mar. 2005-Jun. 2008	İşmen et al. (2009)
27	56	1752	F	5-500	Aegean	Mar. 2005-Jun. 2008	İşmen et al. (2009)
28	79	5020	?	180	Aegean	Jun. 2010	Kousteni & Megalofonou (2016)
29	67,4	3250	?	366-458	Aegean	1.05.2011	Kousteni & Megalofonou (2016)
30	38,8	650	?	40-2200	NW Mediterranean	Spt. 2011	Barría et al. (2015)
31	48	940	?	40-2200	NW Mediterranean	Jun. 2013	Barría et al. (2015)
32	56	2570	F	120-150	NE Mediterranean	14.05.2014	Başusta et al. (2015)
33	43,7	841	M	120-150	NE Mediterranean	14.05.2014	Başusta et al. (2015)
34	56,5	1864	F	60	CNT Mediterranean	13-14 May 2017	Koehler (2018)

Minimum, maximum and mean of TL and TW, and growth constants for males, females and combined sexes of the examined individuals of *Oxynotus centrina* are presented in Table 2. The *b* value of LWR of males (2.686) was significantly different than *b* values of females and combined sexes, and indicated negative allometric growth for the examined TL and TW range of males (t-test, $p<0.05$). The *b* values of LWR of females and combined sexes (3.041 and 3.173, respectively), were significantly larger from 3.0 (t-test, $p<0.05$) and indicated positive allometric growth for the examined TL and TW range of *O. centrina*. The LWRs of males, females and combined sexes of *O. centrina* were described as $W = 0.216L^{2.686}$, $W = 0.134L^{3.041}$ and $W=0.102L^{3.173}$, respectively. TLs of females and combined sexes were strongly correlated with TWs (correlation coefficients 0.936 and 0.923, respectively), while TL of males was moderately correlated with TW (correlation coefficient 0.534). LWR plots of males, females and both sexes are presented in Figure 3.

Table 2. LWR parameters for *Oxynotus centrina* in the Mediterranean Sea

Specimens	TL (mm)			TW (g)			Growth constants		±SE of b	R^2	Growth
	Min	Max	Mean±SD	Min	Max	Mean±SD	a	b			
Males (n=10)	43.7	55.3	48.40±3.22	530	1960	1033.10±370.71	0.216	2.686	0.127	0.285	Negative allometric
Females (n=18)	29	80	55.75±11.62	260	7883	2343.38±1731.92	0.134	3.041	0.114	0.876	Positive allometric
Combined sexes (n=34)*	29	80	53.84±10.78	260	7883	1933.06±1531.38	0.102	3.173	0.117	0.851	Positive allometric

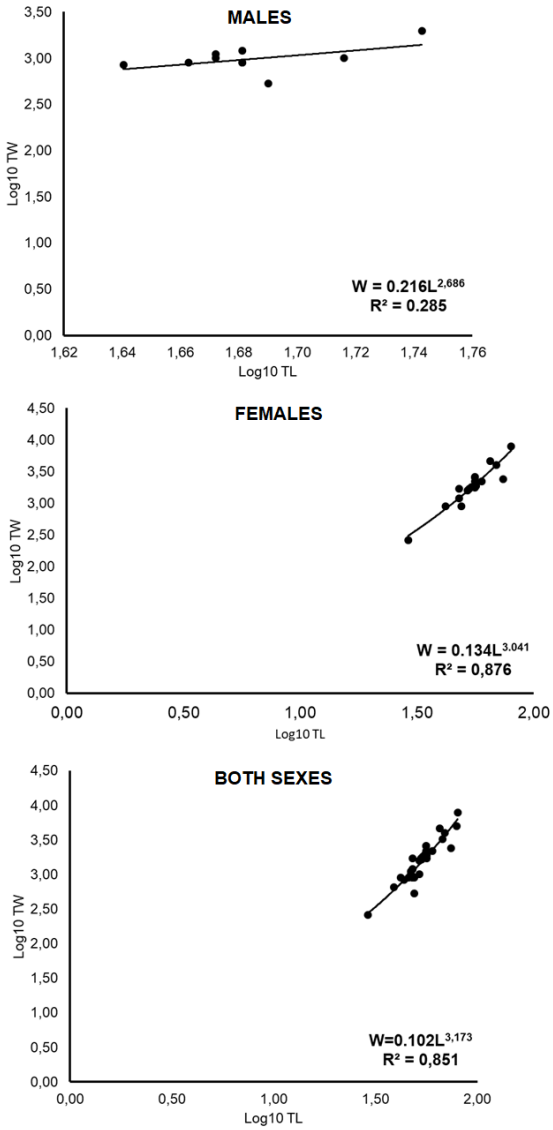

Figure 3. LWR plots of *Oxynotus centrina* for males, females and both sexes

Discussion

In one of the remarkable meta-analyses of LWRs, which focused on the 3929 LWRs of 1773 species of fishes, Froese (2006) concluded that across species median *b*=3.03 is significantly larger than 3.0, which indicates a tendency towards slightly positive-allometric growth, increasing relative body thickness or plumpness. The author also concluded that the expected range of $2.5 < b < 3.5$ is confirmed. The estimated *b* values of females and both sexes of the present study (3.041 and 3.173, respectively; Table 2), which were within the safe limits (Froese, 2006), indicate positive allometric growth for *Oxynotus centrina*. One of the well-known descriptive characteristics of *O. centrina* is "a species with high (or deep) and thick body" (Compagno, 1984; Quéro, 1984; Ebert & Stehmann, 2013), which is coinciding with the definition of positive-allometric growth (Froese, 2006). On the other hand, the *b* value of examined males (2.686) indicated a negative-allometric growth for the same species of shark (Table 2). According to Capapé et al. (1999), males of *O. centrina* reach sexual maturity between a TL range of 60 to 66 cm, while individuals smaller than this TL range are considered immature or maturing males. Therefore, TL ranges of the examined males in the present study (Table 2) coincide with immatures of *O. centrina*.

The LWR in fishes can be affected by a number of factors including season, habitat, gonad maturity, sex, stomach fullness and length ranges of the specimens captured (Kuriakose, 2017). Since fishes typically grow very rapidly in length in the first few months or years of life, until maturation (Moyle & Cech, 1988), the mature fish is typically heavier per unit of length than immature fish. The TL and TW ranges of the present males (Table 2) were restricted with the immature phase of *Oxynotus centrina*, which resulted in *b* lower than expected 3.0 and indicated a slimmer shark than the description of the species in this phase of its lifespan. This circumstance is also seen in the LWR plot of males (Figure 3), which depicts a slight inclination than the expected power graph of growth. However, the *b* values of the examined females and both sexes are slightly greater than 3.0 (Table 2), which is coincided with the "plumpness" of *O. centrina*, a well-known descriptive characteristic of the species. Furthermore, the resulted LWR plots of the examined females and combined sexes are representatives of the expected power graphs of growth (Figure 3). Therefore, LWR equations of the examined females and combined sexes ($W = 0.134L^{3.041}$ and $W=0.102L^{3.173}$, respectively) provided more assuring equations.

In the literature, the paucity of available information on the LWR and growth parameters of *Oxynotus centrina* is obvious. Capapé et al. (1999) reported LWR for males and females of *O. centrina,* as LnEW=3.579LnTL-15.406 and LnEW=3.579LnTL-15.291, respectively, where EW is the eviscerated body weight of fish. Authors also reported that LWRs for both sexes did not show a significant difference in slopes between sexes, in waters of the western Mediterranean and eastern tropical Atlantic. In a recent study of LWRs for 10 shark species from Saros Bay (northern Aegean Sea), İşmen et al. (2009) reported on the TL and TW of 4 individuals, but they did not give LWR equation for *O. centrina*, due to low number of sample size. Based on TL and TW data of 4

individuals (TL range 53.3-79 cm), Tsikliras & Dimarchopoulou (2021) reported *a* and *b* values for *O. centrina* as 0.0087 (range 0.0080-0.0093) and 3.04, respectively.

Considering the limitations of the present study, such as the sampling locations that are distributed throughout very wide area in the Mediterranean Sea, a low number of examined samples and narrow TL range of males, the estimated LWR of *Oxynotus centrina* is far from being complete for the moment. But, despite all these weaknesses, the present study provides a valuable contribution to a better understanding of the LWR of *O. centrina* in the Mediterranean Sea.

Acknowledgements

The authors would like to thank Prof. Dr. Bayram Öztürk for generously donating morphometric measurements of angular rough sharks, captured during the bottom trawl surveys, that were carried out in 1960. The authors also thank the crew of commercial trawler M/V Şentüer, for their friendly help during field surveys in 2008.

Author Contributions

Data analysis and manuscript writing were performed by the HK. Some parts of the field surveys and proof reading were carried out by the EÖÖ.

Conflict of Interest

The authors declares that no conflict of interest.

References

Barría, C., Navarro, J., Coll, M., Fernandez-Arcaya, U. & Sáez-Liante, R. (2015). Morphological parameters of abundant and threatened chondrichthyans of the northwestern Mediterranean Sea. *Journal of Applied Ichthyology*, 31(1), 114-119. https://doi.org/10.1111/jai.12499.

Başusta, N., Turan, C. & Başusta, A., (2015). New records of gravid female and adult male of the angular rough shark, *Oxynotus centrina* (Oxynotidae) from the northeastern Mediterranean. *Journal of Black Sea/Mediterranean Environment*, 21(1), 92-95.

Capapé, C., Seck, A. A. & Quignard, J.-P. (1999). Observations on the reproductive biology of the angular rough shark, *Oxynotus centrina* (Oxynotidae). *Cybium*, 23(3), 259-271.

Capapé, C. (2008). Diet of the angular rough shark *Oxynotus centrina* (Chondrichthyes: Oxynotidae) off the Languedocian coast (southern France, nortn-western Mediterranean). *Vie et Milieu*, 58(1), 57-61.

Compagno, L. J. V. (1984). Sharks of the world. An annotated and illustrated catalogue of sharks species known to date. Hexanchiformes to Lamniformes. FAO species catalogue. *FAO Fisheries Synopsis*, 125, Vol. 4(Part 1). FAO, Rome.

Dragičević, B., Dulčić, J. & Capapé, C. (2009). Capture of a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the eastern Adriatic Sea. *Journal of Applied Ichthyology*, 25(1), 56-59. https://doi.org/10.1111/j.1439-0426.2009.01265.x.

Ebert, D. A. & Stehmann, M. F. W. (2013). Sharks, batoids and chimaeras of the North Atlantic. *FAO Species Catalogue for Fishery Purposes*, No. 7. FAO, Rome.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4), 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x.

Geldiay, R. & Mater, S. (1968). Two species of fish found in the Aegean Sea (*Oxynotus centrina L.* and *Ophisurus serpens L.*). *Scientific Reports of the Faculty of Science*, Ege University, 52(33), 3-10.

İşmen, A., Yığın, C. Ç., Altınağaç, U. & Ayaz, A. (2009). Length-weight relationships for ten shark species from Saroz Bay (North Aegean Sea). *Journal of Applied Ichthyology*, 25(1), 109-112. https://doi.org/10.1111/j.1439-0426.2009.01263.x.

Kabasakal, H. (2009). Observations on a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), in the Sea of Marmara (north-western Turkey). *Pan-American Journal of Aquatic Sciences*, 4(4), 609-612.

Kabasakal, H. (2020). *A Field Guide to the Sharks of Turkish Waters*. Turkish Marine Research Foundation (TUDAV), Publication No: 55, Istanbul.

Kabasakal, H. (2021). A review of shark biodiversity in Turkish waters: updated inventory, new arrivals, questionable species and conservation issues. *ANNALES Series Historia Naturalis*, 31(2), 181-194.

Koehler, L. (2018). New records of angular rough sharks *Oxynotus centrina* in the coastal waters of Malta, with observations on post-capture resilience and release behaviour. *Journal of Fish Biology*, 92(6), 2039-2044. https://doi.org/10.1111/jfb.13641.

Kousteni, V. & Megalofonou, P. (2016). Observations on the biological traits of the rare shark *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the Hellenic Seas. *Journal of Fish Biology*, 89(3), 1880-1888. https://doi.org/10.1111/jfb.13077.

Kuriakose, S. (2017). Estimation of length weight relationship in fishes. pp. 215-220. In: A. Gopalakrishnan (Ed.), *Advanced Methods for Fish Stock Assessment and Fisheries Management*. ICAR-Central Marine Fisheries Research Institute, Kerala.

Megalofonou, P. & Damalas, D. (2004). Morphological and biological characteristics of a gravid angular rough shark (*Oxynotus centrina*) and its embryos from the eastern Mediterranean Sea. *Cybium*, 28(2), 105-110.

Moyle, P. B. & Cech, J. J. (1988). Fishes–An Introduction to Ichthyology. Prentice Hall, New Jersey.

Mutlu, E., Deval, M. C., Miglietta, C., Saygu, İ. & de Meo, I. (2022). Biometrical distribution of sharks in a low elasmobranchs-diversified shelf, the eastern Mediterranean Sea. *Acta Biologica Turcica*, 35(2), 1-23.

Quéro, J. –C. (1984). Oxynotidae. pp. 126-127. In: P. J. P. Whitehead, M. –L. Bauchot, J. –C. Hureau, J. Nielsen & E. Tortonese (Eds.). *Fishes of the North-eastern Atlantic and the Mediterranean*. UNESCO, Paris.

Ricker, W.E. (1975). Computation and Interpretation of Biological Statistics of Fish Populations. *Bulletin of the Fisheries Research Board of Canada* 191, Ottawa.

Serena, F., Abella, A. J., Bargnesi, F., Barone, M., Colloca, F., Ferretti, F., Fiorentino, F., Jenrette, J. & Moro, S. (2020). Species diversity, taxonomy and distribution of Chondrichthyes in the Mediterranean and Black Sea, *The European Zoological Journal*, 87(1), 497-536. https://doi.org/10.1080/24750263.2020.1805518.

Tsikliras, A. C. & Dimarchopoulou, D. (2021). Filling in knowledge gaps: Length-weight relations of 46 uncommon sharks and rays (Elasmobranchii) in the Mediterranean Sea. *Acta Ichthyologia et Piscatoria*, 51(3), 249-255. https://doi.org/10.3897/aiep.51.65858.

Turan, C., Gürlek, M., Başusta, N., Uyan, A., Doğdu, S. A., & Karan, S. (2018). A checklist of the non-indigenous fishes in Turkish marine waters. *Natural and Engineering Sciences*, 3(3), 333-358. https://doi.org/10.28978/nesciences.468995.

Yığın, C. Ç., İşmen, A. & Önal, U. (2016). Occurrence of a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), from Saros Bay, North Aegean Sea. *Journal of the Black Sea/Mediterranean Environment*, 22(1), 103-109.