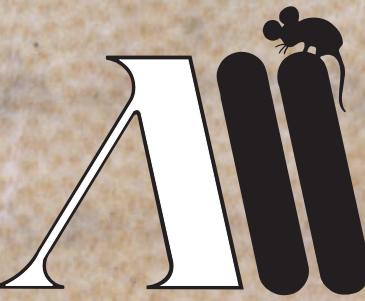


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AGE AND GROWTH PARAMETERS OF THE RED MULLET *MULLUS BARBATUS* (MULLIDAE) FROM NORTHERN TUNISIA (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

*The paper presents the results of a study of age and growth of the red mullet *Mullus barbatus Linnaeus, 1758* from the northern coast of Tunisia, based on otolith readings. The age composition ranged from 1 to 5 years, but the majority of specimens belonged to the one-year group, in both females and males. Females significantly outnumbered males in size classes larger than 150 mm, whereas males significantly outnumbered females in smaller size classes. Additionally, the growth patterns were similar up the age of 1 for both sexes, after which females grew faster and reached a greater maximum weight than males. The length-weight relationship was $W = 0.0044 * TL^{3.1311}$ ($R^2 = 0.9582$) for all specimens. Estimated growth parameters were $L_\infty = 24.23$, $K = 0.307$ and $to = -0.983$ for males, and $L_\infty = 27.65$, $K = 0.284$ and $to = -0.687$ for females. Estimates for all specimens display the following value: $L_\infty = 25.96$, $K = 0.291$ and $to = -0.824$.*

Key words: *Mullus barbatus*, age, growth parameters, length-weight relationship, Tunisia

ETÀ E PARAMETRI DI CRESCITA DELLA TRIGLIA DI FANGO *MULLUS BARBATUS* (MULLIDAE) DELLA TUNISIA SETTENTRIONALE (MEDITERRANEO CENTRALE)

SINTESI

*L'articolo presenta i risultati di uno studio sull'età e la crescita della triglia di fango, *Mullus barbatus Linnaeus, 1758*, proveniente dalla costa settentrionale della Tunisia, basato sulla lettura degli otoliti. I risultati indicano che l'età degli esemplari varia da 1 a 5 anni, ma la maggior parte degli individui studiati appartiene al gruppo di un anno, sia le femmine che i maschi. Le femmine superano significativamente i maschi nelle classi di dimensioni superiori a 150 mm, mentre i maschi superano significativamente le femmine nelle classi di dimensioni inferiori. Inoltre, i modelli di crescita sono simili fino all'età di un anno per entrambi i sessi, dopo di che le femmine crescono più velocemente e raggiungono un peso massimo maggiore ai maschi. La relazione lunghezza-peso è $W = 0,0044 * TL^{3,1311}$ ($R^2 = 0,9582$) per tutti gli esemplari. I parametri di crescita stimati sono $L_\infty = 24,23$, $K = 0,307$ e $to = -0,983$ per i maschi, e $L_\infty = 27,65$, $K = 0,284$ e $to = -0,687$ per le femmine. Le stime per tutti gli esemplari mostrano il seguente valore: $L_\infty = 25,96$, $K = 0,291$ e $to = -0,824$.*

Parole chiave: *Mullus barbatus*, età, parametri di crescita, rapporto lunghezza-peso, Tunisia

INTRODUCTION

The red mullet, *Mullus barbatus* Linnaeus, 1758 is a very important component of demersal fisheries in Tunisia (Chérif et al., 2007; Chérif et al., 2013). The species is commonly caught by trawl fleet and small-scale fishing vessels using trammel nets and gillnets, with this type of gear accounting for about 10% of catches (Chérif et al., 2013). During the last 10 years, the total annual landings stood at an average value of 2220 metric tons, representing 9.5% of total demersal catches (Anonymous, 2018). Despite the relative importance and economic value of the red mullet, the data on age and growth of this species in Tunisian waters, as opposed to other areas, are deficient. Gharbi (1980) studied the growth and age of *M. barbatus* based on an analysis of scale annuli, suggesting that the age determination from scales might be a source of errors in age-structured calculations and pointing out the need for the evaluation of age and growth using otolith microstructure analysis. Such opinion was in total accordance with similar studies of *M. barbatus* showing that otolith constitutes the most suitable structure for age estimation. While otolith readings are a reliable and valid method for age determination, the use of scales has been criticized mainly because the age in older specimens is frequently underestimated (Beamish & McFarlane, 1983; Carlander, 1987). Therefore, the main goal of this study is to present *M. barbatus* growth mark patterns based on an analysis of otolith microstructures.

MATERIAL AND METHODS

This study is based on material collected monthly from northern Tunisia (Fig. 1) between January 2005 and Decem-

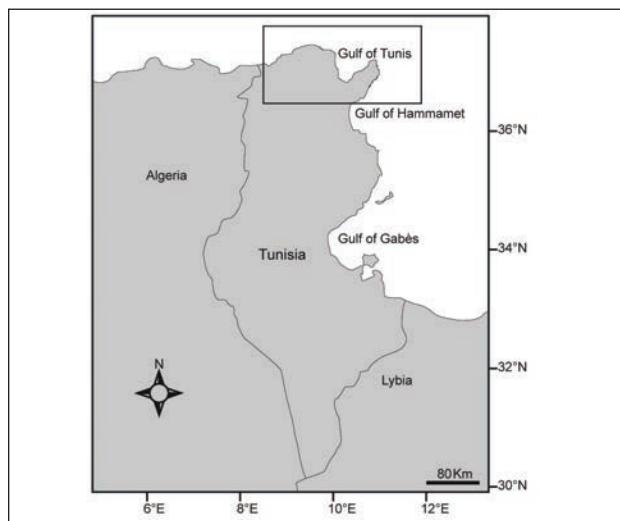


Fig. 1: Map of the Tunisian coast with the rectangle indicating the sampling area of *Mullus barbatus*.
Sl. 1: Zemljevid tunizijske obale z vzorčevalnim predelom (pravokotnik), kjer so vzorčili primerke bradačev *Mullus barbatus*.

ber 2007 by commercial trawlers using the Tunisian shrimp trawl with a stretched-mesh size of 52 mm in the wing and 40 mm in the cod end (Chérif et al., 2007). After landing, all specimens were measured for total length to the nearest millimeter, and for total body weight to the nearest gram. Additionally, they were sorted by sex. All sagittal otoliths were removed, cleaned and put in labeled envelopes. All otoliths were placed in a concave black dish and examined using the reflected light of a binocular microscope at a magnification of 10 X. The age estimates were obtained by each otolith being read at least twice by the same person. If the two age estimates did not coincide, a third reading was performed. When the three readings differed by one year, their median age was considered. However, when all three readings differed by more than one year, the otolith was discarded. In conclusion, the specimens examined in the present study ranged between 1 and 5 years of age.

The length-weight relationship was described by the form proposed by Ricker (1973): $W = aTL^b$, where (W) is the weight in grams, (TL) the total length in mm, (b) the growth exponent, and (a) is a constant. The hypothesis of isometric growth was tested using a *t*-test (Zar 1999).

Growth was expressed in terms following the von Bertalanffy equation (Beverton & Holt, 1957, Sparre & Venema, 1992): $L_t = L_\infty (1 - e^{-k(t-t_0)})$, where (L_∞) is the asymptotic total

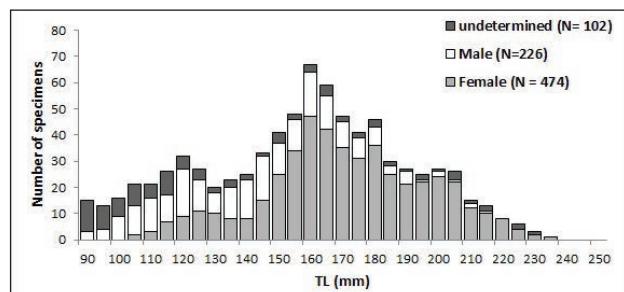


Fig. 2: Length frequency distribution in the *Mullus barbatus* caught from the northern coast of Tunisia.
Sl. 2: Frekvenčna porazdelitev dolžine primerkov vrste *Mullus barbatus*, ujetih ob severni tunizijski obali.

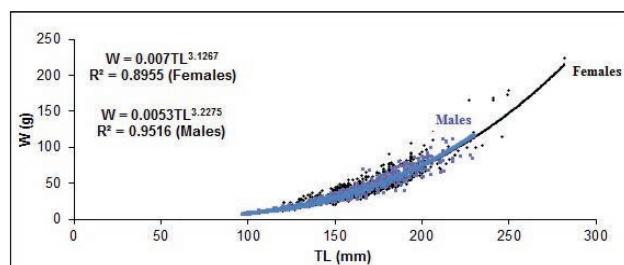


Fig. 3. Length-weight relationship in the *Mullus barbatus* caught from the northern coast of Tunisia.
Sl. 3: Odnos med dolžino in težo pri vrsti *Mullus barbatus*, ujeti ob severni tunizijski obali.

Tab. 1: Parameters of length-weight relationship for the *Mullus barbatus* caught from the northern coast of Tunisia.
Tab. 1: Parametri odnosa med dolžino in težo za primerke vrste *Mullus barbatus*, ujetih ob severni tunizijski obali.

Equations	Sex	a	b	R ²	t-test	Growth
W = aTL ^b	♀	0.0070	3.1267	0.8955	4.51	+
	♂	0.0053	3.2275	0.9516	7.99	+
	combined sexes	0.0044	3.1311	0.9582	20.02	+

Tab. 2: Age and growth parameters in the *Mullus barbatus* caught from the northern coast of Tunisia.
Tab. 2: Starost in rastni parametri pri vrsti *Mullus barbatus*, ujeti ob severni tunizijski obali.

Age (years)	Males (N = 132)	Females (N = 289)	All individuals (N = 488)
	TL (cm) (Average + SD)	TL (cm) (Average + SD)	TL (cm) (Average + SD)
I	11.16±0.9	11.32±1.3	11.25±0.4
II	14.30±1.1	15.44±1.7	14.87±0.9
III	17.25±1.4	19.40±0.9	18.32±1.0
IV	19.18±0.8	20.69±1.9	19.39±2.1
V	20.25±1.2	23.13±1.5	21.69±1.8
Growth parameters (L_∞, W_∞, K and t₀)			
L _∞ (cm)	24.23	27.65	25.96
K	0.307	0.284	0.291
t ₀	-0.983	-0.687	-0.824
W _∞ (gr)	148.88	240.72	198.64

length, (*L_t*) the total length at age (*t*), (*K*) the growth curvature parameter, and (*t₀*) is the theoretical age of the fish at zero total length. For the growth in weight, the same function was used: $W_t = W_{\infty} (1 - e^{-K(t-t_0)})$, where (*W_t*) is the total weight, (*W_∞*) is the asymptotic weight, and (*b*) is the power constant of the length-weight relationship. The Fishparm software including the non-linear estimation method was used to estimate the growth parameters (Saila et al., 1988).

RESULTS

Length and weight distribution

Of the 802 fish examined, 226 were males, 474 females, and 102 unidentified (67 were immature and 35 damaged). The c₂ test revealed that the difference between the sexes was significant (c₂ = 17.33; d.f. = 1; P < 0.05).

The length and weight of the red mullet ranged from 94 mm to 237 mm in total length (TL) and from 7.64 grams to 148.17 grams in total weight (TW). The total length ranged between 103 mm in 237 mm (9.94 grams to 148.17 grams) in females and between 94 mm and 216 mm (7.64 grams to 110.24 grams) in males.

The dominant length group was 100–130 mm (23.2%), followed by 140–210 mm (69.4%). Females dominated size classes larger than 150 mm, whereas males significantly outnumbered females in smaller size classes (c₂ = 6.09; d.f. = 1; P < 0.05). Evidently, the larger specimens caught were females (Fig. 2).

Length-weight relationship

The relationship between total weight and total length is presented in Table 1 and Figure 3. The value of (*b*) for males, females, and all specimens was significantly different from 3 (t-test, P < 0.05), indicating that the body shape displays positive allometric growth. In addition, the (*R²*) values for relationships among males, females, and all fish indicated a good correlation between length and weight.

Age and growth parameters

The results of otolith readings for all fish, and separately for each sex are presented in Table 2 and Figure 4. Age was determined in 488 specimens (60.84% of total specimens). Five age classes were identified in each sex.

In females, age classes I (42.6%) and II (33.9%) were dominant, followed by age class III (15.3%). In males, the most dominant age class was I (1 year old) standing at 46.8%, followed by age class II (2 years old) at 37.3%. Length-at-age data obtained were used to calculate the von Bertalanffy growth parameters as follows (Fig. 3):

$$\text{Males: } Lt = 24.23 [1 - e^{-0.307(t+0.983)}]$$

$$\text{Females: } Lt = 27.65 [1 - e^{-0.284(t+0.687)}]$$

$$\text{Sexes combined: } Lt = 25.96 [1 - e^{-0.291(t+0.824)}]$$

Additionally, the growth patterns by sex were similar up to the age of 1 year (class I), after that age, the females grew faster and attained a greater maximum weight than males (Fig. 5).

DISCUSSION

Sagittal otoliths were used for age determination, showing that the age composition of the red mullet caught in the northern area of Tunisia ranged from 1 to 5 years. This result was in agreement with those of previous studies from different regions of the Mediterranean Sea (Jabeur, 1999; Çiçek, 2015). In the eastern and central Mediterranean Sea, the growth pattern was substantially different; the maximum observed life span for the red mullet was 9 years for all specimens (Genç, 2000; Carbonara et al. 2018). Furthermore, for the Black Sea, Aydin & Karadurmüş (2013) determined the age span to be between 1 and 7 years, while Sahin & Akbulut (1997) reported a maximum age of 6 years. Such differences are probably due to age estimation criteria, age estimation schemes, and material used, otolith or scale (Carbonara et al., 2018).

In this study the majority of the specimens belonged to classes I and II indicating that the local *M. barbatus* population mostly included juvenile specimens. The lower proportions of adult specimens can be explained by the sampling method or by the fact that only some specimens

are able to reach the maximum age. The (*b*) values of the length-weight relationship of *M. barbatus* differed largely according to localities (Table 3). These differences may be attributed to food availability (quantity, quality, and size), environmental conditions (temperature, salinity), sex, and stage of maturity (Ricker 1973; Pauly 1984; Sparre & Venema 1992; Chérif et al., 2007; Yıldız & Karakulak, 2016; Carbonara et al., 2018). Also, the sampling methods (commercial or survey), the different size structures, and the number of observed specimens in the studies could account for such differences of (*b*) values (Zorica et al., 2006, Orhan & Genç, 2013; Carbonara et al., 2018). A comparison of growth parameters of *M. barbatus* from the northern Tunisian coast with those from other areas of the world reveals significant differences (Tab. 3). The differences in growth rates between areas were probably due to differences in the methods of investigation, as well as latitudinal differences.

The present study seems to suggest that females grow slightly faster than males. This differential growth with respect to sex, displaying higher mean weights with age, may be explained by the distinct metabolisms of the two sexes (Pauly, 1994). Females accumulate hepatic lipids for metabolic functions, such as gonadic products, the phenomenon being more evident during vitellogenesis and egg production. Therefore, the difference in growth between males and females may be due to different stages in ontogenetic development, such as differences in condition and gonad maturity (Ricker, 1975; Morey et al., 2003).

In conclusion, recent studies note that stocks of *M. barbatus* have decreased off northern Tunisia (UNEP-MAP-RAC/SPA, 2014). Such patterns are probably due to overfishing and interspecific pressure for food. The results herein presented have shown that the most dominant age groups in the catches were between one and two years old. This indicates that the population was composed mostly by juvenile specimens, and faced a poor recruitment. Therefore, to prevent and avoid collapse in a long-term, the stocks of *M. barbatus* should be managed and exploited with care, being regularly restored in order to keep the presence of a viable population in the region.

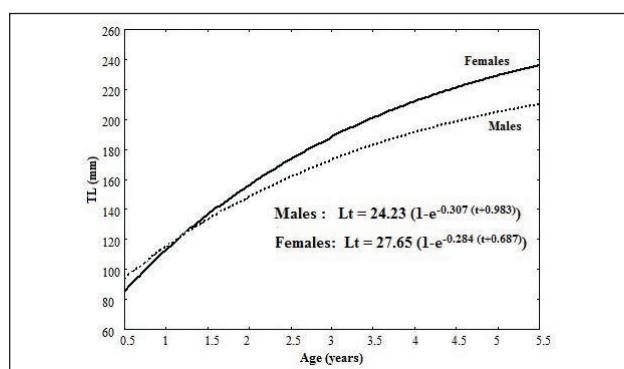


Fig. 4. Von Bertalanffy growth curve for the *Mullus barbatus* caught from the northern coast of Tunisia.
Sl. 4: Von Bertalanffyeva rastna krivulja za primerke bračev *Mullus barbatus*, ujetih ob severni tunizijski obali.

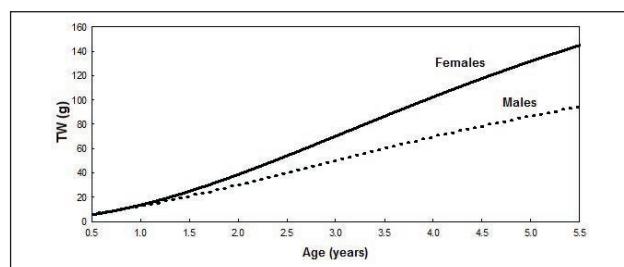


Fig. 5. Growth patterns by sex for the *Mullus barbatus* caught from the northern coast of Tunisia.
Sl. 5: Rastni vzorci glede na spol pri vrsti *Mullus barbatus*, ujeti ob severni tunizijski obali.

Tab. 3: Growth parameters (L_∞ , t_0 and k) and length-weight relationship (a and b) for *Mullus barbatus* from different localities.**Tab. 3: Rastni parametri (L_∞ , t_0 in k) in odnos med dolžino in težo (a in b) za primerke vrste *Mullus barbatus* iz različnih lokalitet.**

Area	L_∞ (cm)	t_0	K	a	b	Reference
South-West Adriatic	19.7 TL	-1.180	0.36	0.008	3.09	Ungaro et al., 1994
Adriatic Sea	27.49 TL	-0.25	0.5	-	-	Scaccini, 1947
Ionian Sea	25.20	-1.710	0.260	-	-	Tursi et al., 1994
Izmir Bay	27 TL	-1.506	0.183	0.0063	3.363	Akyol et al., 2000
Spanish coasts	33 TL	-0.07	0.38	-	-	Sanchez et al., 1995
Northern Spain	33 TL	-0.001	0.33	0.006241	3.1597	Fernández et al., 2005
Tunisian coasts	20.25 SL	-0.02	0.513	-	-	Gharbi, 1980
Greece waters	23.5 TL	-0.86	0.51	-	-	Vrantzas et al., 1992
Izmyr Bay	19.036 FL	-0.77	0.438	0.0070	3.29	Kinacigil et al., 2001
Aegean sea	24.2 TL	-5.61	0.105	0.0071	3.321	Özvarol et al., 2006
South-West Mediterranean	27 TL	-0.09	0.439	0.00009	3.031	Layachi, 2007
İskenderun Bay	21.98 TL	-0.194	1.168	0.0072	3.162	Çiçek, 2015
Cyprus waters	28.4 TL	-1.100	0.18	0.01288	2.94	Livadas, 1988
Gulf of Tunis	-	-	-	0.0072	3.1045	Cherif et al., 2007
Gulf of Tunis	-	-	-	0.005	3.23	Cherif et al., 2008
Saranikos Gulf	23.5 TL	-0.860	0.51	-	-	Vrantzas et al., 1992
Adriatic Sea	29.008 TL	-1.189	0.194	-	-	Carbonara et al., 2018
Western Black Sea	-	-	-	0.0059	3.21	Türker & Bal, 2018
Middle Black Sea	-	-	-	0.0111	2.96	Kalaycı et al., 2007
Western Black Sea	24.10 TL	-1.981	0.171	0.0109	2.9886	Yıldız & Karakul, 2016
Turkish coasts	24.4 TL	-0.716	0.450	0.01	3.001	Bingel, 1987
Aegean sea	19.13 TL	-1.56	0.382	0.0060	3.219	Tüzün et al., 2019
Aegean sea	18.4 TL	-0.910	0.620	0.0100	3.201	Kurtul & Özaydın, 2017
Aegean Sea	28.75	-1.920	0.155	0.0084	3.077	Arslan & İşmen, 2014
Aegean Sea	26.08	-3.535	0.127	0.0157	2.981	Çelik & Torcu, 2000
Aegean Sea	19.04	-0.777	0.438	0.0071	3.290	Kınacigil et al., 2001
İskenderun Bay	24.2	-0.569	0.63	-	-	Gücü, 1995
Black Sea	27.40	-2.351	0.140	0.0088	3.034	Aydın & Karadurmüş, 2013
Algerian Sea	25.09	-0.185	0.490	0.0172	2.842	Talet et al., 2016
Northern Tunisia coasts	25.96 TL	-0.824	0.309	0.0044	3.131	This study

STAROSTNI IN RASTNI PARAMETRI PRI NAVADNEM BRADAČU *MULLUS BARBATUS* (MULLIDAE) IZ SEVERNE TUNIZIJE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o izsledkih raziskave o starostnih in rastnih parametrih pri navadnem bradaču *Mullus barbatus* Linnaeus, 1758 iz severne tunizijske obale na podlagi analize otolitov. Starostna struktura je bila med 1 in 5 leti, večina primerkov, tako samcev kot tudi samic, pa je pripadala skupini prvoletnih rib. Samice so značilno prevladovale v velikostnih razredih večjih od 150 mm, samci pa so bili pogosteje v manjših velikostnih razredih. Vzorci rasti so bili pri obeh spolih podobni do starosti enega leta, potem pa so samice rasle hitreje in dosegle večjo maksimalno dolžino kot samci. Odnos med dolžino in težo za vse primerke je bil $W = 0,0044 * TL^{3,1311}$ ($R^2 = 0,9582$). Ocjenjeni rastni parametri pri samicah so bili $L_\infty = 24,23$, $K = 0,307$ in $to = -0,983$, pri samicah pa $L_\infty = 27,65$, $K = 0,284$ in $to = -0,687$. Ocene rastnih parametrov za vse primerke so bile $L_\infty = 25,96$, $K = 0,291$ in $to = -0,824$.

Ključne besede: *Mullus barbatus*, starost, rastni parametri, odnos med dolžino in težo, Tunizija

REFERENCES

- Arslan M. & A. Ismen (2014):** Age, growth, reproduction and feeding of *Mullus barbatus* in Saros Bay (North Aegean Sea). J. Black Sea/Medit. Environ., 20(3), 184-199.
- Akyol, O., Z. Tosunoglu, & A. Tokaç (2000):** Investigations of the growth and reproduction of red mullet (*Mullus barbatus* Linnaeus, 1758) population in the Bay of Izmir (Aegean Sea). Anadolu Univ. J. Sci. Tech., 1(1), 121-127.
- Anonymous (2018):** Annuaires des statistiques des produits de la pêche en Tunisie. Direction Générale à la Pêche et à l'Aquaculture (DGPA), 128 pp.
- Aydin, M. & U. Karadurmus (2013):** An Investigation on age, growth and biological characteristics of red mullet (*Mullet barbatus ponticus*, Essipov 1927) in the Eastern Black Sea. Iran. J. Fish. Sci., 12(2), 277-288.
- Beamish, R.J. & G.A. McFarlane (1983):** The forgotten requirement for age validation in fisheries biology. Trans. Am. Fish. Soc., 112(6), 735-743.
- Beverton, R.J.H. & S.J. Holt (1957):** On the dynamics of exploited fish populations. U. K. Min. Agric. Fish., Fish. Invest., ser. 2(9), 533 pp.
- Bingel, F. (1987):** Final report of the quantitative fishery project in the coastal fishing grounds of the NorthEastern Mediterranean. Project No: 80070011, Içel, Turkey. 312 pp.
- Carbonara, P., S. Intini, J. Jerina, J. Kolitari, A. Joksimović, N. Milone, G. Lembo, L. Casciaro, L. Bitetto, W. Zupa, M.T. Spedicato & L. Sion (2018):** A holistic approach to the age validation of *Mullus barbatus* L., 1758 in the Southern Adriatic Sea (Central Mediterranean). Sci. Rep., 8, 13219. <https://doi.org/10.1038/s41598-018-30872-1>.
- Carlander, K.D. (1987):** A history of scale age and growth studies of North American freshwater. In Age and Growth of Fish. In RC Summerfelt & GE Hall (Editors), pp. 3-14, Iowa State University Press, Ames.
- Çelik, Ö. & H. Torcu (2000):** Investigations on the Biology of red mullet (*Mullus barbatus* L., 1758) in Edremit Bay. Aegean Sea. Turkey. Turk. J. Veterin. Anim. Sci., 24(3), 287-295.
- Genç, Y. (2002):** Reproduction of Five Important Demersal Fishes in the Eastern Black Sea. CFRI Yunus Res. Bull., 2(4), 9-10.
- Chérif, M., R. Zarrad, H. Gharbi, H. Missaoui, & O. Jarboui (2007):** Some biological parameters of the red mullet, *Mullus barbatus* (L., 1758) from the Gulf of Tunis, Acta Adriat., 48(2), 131-144.
- Chérif, M., R. Zarrad, H. Gharbi, H. Missaoui & O. Jarboui (2008):** Length-weight relationships for 11 fish species from the Gulf of Tunis (SW Mediterranean Sea, Tunisia). Pan-Amer. J. Aquat. Sci., 3, 1-5.
- Chérif, M., R. Benmassaoud, H. Missaoui & C. Capapé (2013):** The mullid species from Tunisian waters (Central Mediterranean Sea). Inter. J. Eng. Appl. Sci., 4(2), 62-65.
- Çiçek, E. (2015):** Age, growth and mortality parameters of *Mullus barbatus* Linnaeus, 1758 (Perciformes: Mullidae) in İskenderun Bay, northeastern Mediterranean. Iran. J. Ichthyol., 2(4), 262-269.
- Fernández, A.M., M. García-Rodríguez, J.L. Pérez Gil, A. Esteban, M. González & E. Barcala (2005):** Stock Assessment of red mullet *Mullus barbatus* from the trawl fishery off the geographical sub-area Northern Spain. Working Document to the G.F.C.M. SAC Working Group on Demersal species Rome, 26-30 September 2005, 17 pp.
- Gharbi, H. (1980):** Contribution à l'étude biologique et dynamique des rougets (*Mullus barbatus* Linnaeus, 1758 et *Mullus surmuletus* Linnaeus, 1758) des côtes tunisiennes. PhD Thesis, University of Tunis, Tunisia, 100 pp.
- Gonçalves J.M.S., L. Bentes, R. Coelho, C. Correia, P.G. Lino, P. Monteiro, J. Ribeiro & K. Erzini (2003):** Age and growth, maturity, mortality and yield-per-recruit for two banded bream (*Diplodus vulgaris* Geoffr.) from the south coast of Portugal. Fish. Res., 62, 349-359.
- Güçü, A.C. (1995):** A box model for the basic elements of the northeastern Mediterranean Sea trawl fisheries. Isr. J. Zool., 41, 551-567.
- Jabeur, C. (1999):** La pêche dans le golfe de Gabès: interaction techniques entre les métiers et exploitation partagée du rouget (*Mullus surmuletus* L., 1758). PhD Thesis, Université de Bretagne Occidentale Brest, France, 161 pp.
- Kalaycı, F., N. Samsun, S. Bilgin, & O. Samsun (2007):** Length-weight relationship of 10 fish species caught by bottom trawl and midwater trawl from the Middle Black Sea, Turkey. Turk. J. of Fish. Aquat. Sci., 7(1), 33-36.
- Kinacigil, H., T. İlkyaz, O. Akyol, G. Mettin, E. Cira, & A. Ayaz (2001):** Growth parameters of red mullet (*Mullus barbatus* L., 1758) and seasonal codend selectivity of traditional bottom trawl net in Izmir Bay (Aegean Sea). Acta Adriat., 42(1), 113-123.
- Landa, J., P. Pereda, R. Duarte & M. Azevedo (2001):** Growth of anglerfish (*Lophius piscatorius* and *L. budegassa*) in Atlantic Iberian waters. Fish. Res., 51, 363-376.
- Layachi, M., M. Melhaoui, A. Srour & M. Ramdani (2007):** Contribution à l'étude de la reproduction et de la croissance du Rouget-barbet de vase (*Mullus barbatus* L., 1758) de la zone littorale méditerranéenne de Nador (Maroc). Bull. Inst. Sci., Rabat, sect. Sci. Vie, 29, 43-51.
- Livadas, R.J. (1984):** A study of the biology and population dynamics of red mullet (*M. barbatus* L.) family Mullidae, in Cyprian waters. Ministry of Agriculture & Natural Resources (Department of Fisheries), 36 pp.
- Livadas, R.J. (1988):** A study of the growth and maturity of striped mullet (*Mullus barbatus* L.), in waters of Cyprus. FAO Fish. Rep., 412, 44-51.

- Morey G., J. Moranto, E. Massuti, A. Grau, F. Riera & B. Morales-Nin (2003):** Weight-length relationships of littoral to lower slope fishes from the western Mediterranean. Fish. Res., 62, 89–96.
- Orhan, A.K & Y. Genç, (2013):** Growth and reproduction of the greater weever (*Trachinus draco* L., 1758) along the eastern coast of the Black Sea. J. Black Sea/Medit. Environ., 19(1), 95–110.
- Özvarol, Z.A.B., B.A. Balci, M. Özba, M. Gökgolu, H. Gülyavuz, A. Tagli, M. Pehlivian & Y. Kaya (2006):** An investigation on the growth properties of red mullet (*Mullus barbatus* L., 1758) in Antalya Bay. Ege J. Fish. Aquat. Sci., 23, 113–118.
- Pauly, D. (1984):** Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators. ICLARM Studies and Reviews 8. International Center for Living Aquatic Resources Management, Manila, Philippines, 325 pp.
- Pauly, D. (1994):** On the Sex of Fish and the Gender of Scientists: Essays in Fisheries Science, London, Chapman & Hall, 250 pp.
- Ricker, W.E. (1973):** Linear regressions in fishery research. J. Fish. Res. Board Canada, 30, 409–434.
- Ricker, W.E. (1975):** Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd Can., 191, 382 pp.
- Sahin, T. & B. Akbulut (1997):** Some biological characteristics of *Mullus barbatus poncticus* Essipov, 1927 in the Eastern Black Sea Coast of Turkey. Turk J. Zool., 21, 179–185.
- Saila, S.B., C.W. Recksiek & M.H. Prager (1988):** Basic Fishery Science Programs. A Compendium of Microcomputer Programs and Manual of Operation. Amsterdam; Elsevier, 230 pp.
- Sanchez, P., F. Alvarez, S. De Ranieri & P. Sartor (1995):** Evaluation and analysis of the interaction of fishing gears in the demersal fisheries of Western Mediterranean. Final Report. Research Programme Studies in the Fishing Sector. MED92/009. (Mimeo), 333 pp.
- Scaccini, A. (1947):** L'accrescimento e la proporzione dei sessi nella popolazione Adriatica di *Mullus barbatus*. Vol. 1 Note Lab. Biol. Mar. Fano, 3, 17–24.
- Sparre, P. & S.C. Venema (1992):** Introduction to Tropical Fish Stock Assessment. Part 1. Manual, FAO Fisheries Technical Paper, 306. No. 1, Review 1, FAO, Rome, 376 pp.
- Talet, L.B., A.B. Talet & Z. Boutiba (2016):** Population dynamic parameters of the red mullet *Mullus barbatus* (Mullidae) in the Arzew Gulf, Algeria. Int. J. Aquat. Biol., 4(1), 1–10.
- Tursi, A., A. Matarrese, G. D'Onghia, & L. Sion (1994):** Population biology of red mullet (*Mullus barbatus* L.) from the Ionian Sea. Mar. Life, 4, 33–43.
- Tüzün, S., C. Dalyan & L. Eryilmaz (2019):** Age and growth of the red mullet *Mullus barbatus* in the north Aegean Sea. J. Ichthyol., 59(4), 572–582.
- UNEP-MAP & RAC/SPA (2014):** Status and conservation of fisheries in the Sicily Channel/ Tunisian Plateau. By H. Farrugio & Alen Soldo. Draft internal report for the purposes of the Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Malaga, Spain, 7–11 April 2014, 64 pp.
- Ungaro, N., E. Rizzi & C.A. Marano (1995):** Utilizzo del modello di B everton e Holt, "rendimento per recluta (Y/R)", per la risorsa *Mullus barbatus* L., nell'Adriatico pugliese. Biol. Mar. Medit., 1(1), 317–318.
- Vrantzas, N., M. Kalagia & C. Karlou (1992):** Age, growth and state of stock of red mullet (*Mullus barbatus* L. 1758) in the Saronikos Gulf of Greece. FAO Fish. Rep., 477, 51–67.
- Yıldız, T. & F. Saadet Karakulak (2016):** An investigation of age, growth and mortality of the red mullet *Mullus barbatus* Linnaeus, 1758 in the western Black Sea. Cah. Biol. Mar., 57(4), 415–425.
- Zar, J.H. (1999):** Biostatistical Analysis, 4th edn. Prentice-Hall, Newark, NJ. p + App. 663 pp.
- Zorica, B., G. Sinović, A. Pallaoro & V. Čikeš Keč (2006):** Reproductive biology and length-weight relationship of painted comber, *Serranus scriba* (Linnaeus, 1758), in the Trogir Bay area (middle-eastern Adriatic). J. Appl. Ichthyol., 22(4), 260–263.