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AGE AND GROWTH OF THE POUTING *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) FROM MOROCCAN CENTRAL ATLANTIC WATERS

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ABSTRACT

This investigation, aimed to access the age and growth characteristics of the pouting, Trisopterus luscus *in the central Atlantic Moroccan coastal area, is based on otolith analysis. Age and growth of the population of* T. luscus *were studied on a total sample of 2210 individuals collected during monthly sampling from January 2018 to December 2019. The growth curves (length and weight) based on age estimates from otolith readings show that the greatest growth occurs during the first two years of life. The maximum age using the von Bertalanffy model is estimated to be 6 years (for both male and female pouting). The largest fish sampled (female) was 316 mm long. Different growth rates between males and females are shown; the average total length in females was equal to or greater than that in males, and the weight in female fish was always higher than that in males of the same year group.*

Key words: Age, growth, otoliths, *Trisopterus luscus,* Atlantic Moroccan coast

ETÀ E CRESCITA DELLA BUSBANA BRUNA, *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) DELLE ACQUE MAROCCHINE DELL'ATLANTICO CENTRALE

SINTESI

La ricerca, volta a studiare le caratteristiche di età e crescita della busbana bruna, Trisopterus luscus*, nella zona costiera atlantica centrale del Marocco, si basa sull'analisi degli otoliti. L'età e la crescita della popolazione di* T. luscus *sono state studiate su un campione totale di 2210 individui raccolti durante il campionamento mensile da gennaio 2018 a dicembre 2019. Le curve di crescita (lunghezza e peso) basate sulle stime di età dalle letture degli otoliti mostrano che la crescita maggiore si verifica durante i primi due anni di vita. L'età massima utilizzando il modello di von Bertalanffy è stimata a 6 anni (sia per il maschio che per la femmina). Il più grande pesce campionato (femmina) era lungo 316 mm. Sono stati evidenziati diversi tassi di crescita tra maschi e femmine; la lunghezza totale media nelle femmine era uguale o superiore a quella dei maschi, e il peso nelle femmine era sempre superiore a quello dei maschi dello stesso gruppo d'età.*

Parole chiave: età, crescita, otoliti, *Trisopterus luscus*, costa atlantica del Marocco

INTRODUCTION

Trisopterus luscus (Linnaeus, 1758) is a benthopelagic marine teleost living mostly in the outer Atlantic shelf area at depths about 100 m, but inshore shoals generally occupy depths up to 50 m and usually less in the spawning areas that include estuaries. Immature fish typically form large schools above sandy bottoms (Ballerstedt, 2008; Froese & Pauly, 2021). Distribution of the species extends from the Northeastern Atlantic – from Norway, along the coasts of Ireland and Britain, in the English Channel, in the North Atlantic coasts of France, Spain, Portugal, and the Atlantic Moroccan coast – to all parts of the western Mediterranean (62°N–25°N, 19°W–16°E) (Muus & Nielsen, 1999; Froese & Pauly, 2021).

Published data available on the growth of this fish species began with Chevey (1929) and Oliver (1949) in Chaves & Cardador (2004) and Froese & Pauly (2021). However, these studies were made using scales for estimating growth. Quadros Benvegnu (1971) researched biological aspects of the species on the Cantabrian coast, and Labarta & Ferreiro (1982) did similarly for Galicia. Gherbi Barre (1983), Desmarchelier (1986) and Puente (1988) provided information on the fish's general biology in the French seas. An age and growth study of *Trisopterus luscus* was also conducted off the coast of Asturias by Merayo (1994) and the species was also studied in Portuguese waters (Cardoso *et al.*, 2004). However, there is no information on the age and growth of the pouting in the Moroccan Atlantic, the southern limit of *Trisopterus luscus* in the eastern Atlantic (e.g., Chaves & Cardador 2004). The present biological study of growth in the pouting is the first related to the Atlantic Moroccan zone. Pouting are currently landed as bycatch by trawlers but they represent a significant share (in tonnage) of fish landed in the coastal ports of the Moroccan Atlantic, averaging about 1000 tons annually.

The purpose of this work is to establish the growth parameters of the sampled coastal population using linear, relative absolute weight growth analysis. A combination of these growth parameters together and the factors concerning reproduction and stock exploitation will help establish management measures for a rational stock exploitation to be proposed.

MATERIAL AND METHODS

Study Area

The study area (Moroccan Central Atlantic) extends from Essaouira in the north to Sidi Ifni to the south (Fig. 1) and includes the geographical south limit of the pouting stock distribution.

Biological sampling of the pouting stock made use of commercial catches of trawlers, long liners, and fishing canoes. Sampling was carried out over a 2-year period (2018 and 2019) at the main port in the Moroccan Central Atlantic region, the port of Agadir, where most of the fish catch in this area is landed. Sampling covered almost the entire size range of each pouting catch, which ranged between 11 and 31.6 cm in total length.

After extraction from the measured fish in the laboratory, otolith pairs were placed in labeled preservative tubes. The calcified parts were fixed within resin then cut using a small chainsaw and placed in numbered cells (Bedford, 1983; Merayo & Villegas, 1994; Cardoso *et al.*, 2004).

Age readings of the prepared otoliths were made under a binocular microscope (objective GR: X50) (Fig.2), using the whole otolith growth record (Holden & Raitt, 1975; Bedford, 1983).

Growth parameters were estimated using the von Bertalanffy (1938) model, Bertalanffy growth equation for length (mm): $\mathbf{Lt = L\infty\ (1\text{-}exp^{(-k\ (t-t0))})}$, where Lt = the fish length according to the age at time t; L∞ = asymptotic length that would be reached by the fish at the infinite theoretical age; k = growth coefficient characterizing the speed with which the species grows towards its asymptotic size; t_0 = theoretical age for zero length.

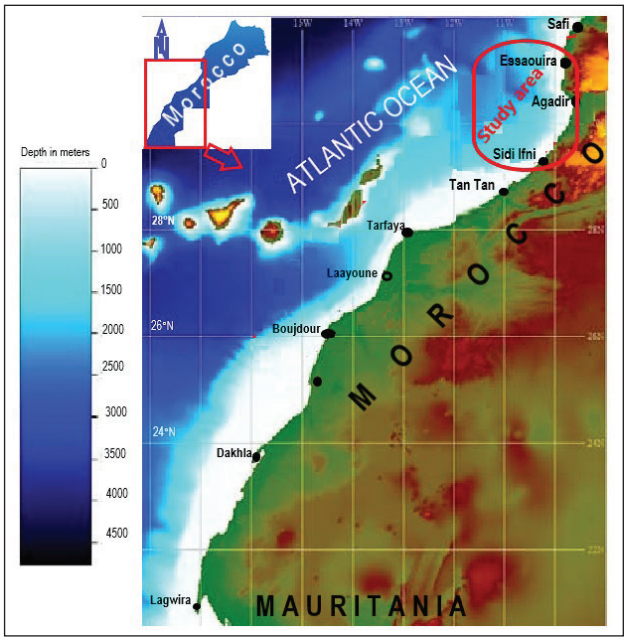

Fig. 1: Essaouira-Sidi Ifni sampling area and key fishing ports in the center and south Moroccan Atlantic regions. Sl. 1: Vzorčevalni predel Essaouira-Sidi Ifni s ključnimi ribiškimi pristanišči v osrednjem in južnem delu maroške atlantske obale.

Tab. 1: Parameters of the von Bertalanffy equation for linear growth of** Trisopterus luscus **in the area of the Central Atlantic Moroccan coast.
Tab. 1: Parametri von Bertalanffyijeve enačbe za linearno rast francoskega moliča** Trisopterus luscus **na predelu osrednje atlantske maroške obale.

Parameters					Lenght	
Sex	**L∞**	**k**	**t0**	**Ø'**	**Lmin**	**Lmax**
Females	329.10	0.127	-4.02	4.14	131	316
Males	356.99	0.082	-5.21	4.02	113	278
Combined	359.69	0.105	-3.76	4.14	113	316

The von Bertalanffy growth equation for weight (g): $\mathbf{Wt = W\ (1\text{-}exp^{(-k(t-t0))})}$, where Wt = fish weight at the age of t (g); and W = asymptotic weight that would be reached by the fish at the infinite theoretical age.

The phi-prime test Ø' (performance index) was used to compare the estimated linear growth parameters L∞ and k for both sexes and separated sexes, like in other studies.

The data used to determine the size-weight relationship of the pouting fish are total length (to the nearest millimeter) and weight (g). For the pouting, the mathematical formulation of the growth equation, expressing the evolution of average weights as a function of time, consists in simply combining the length-weight relationship with the size growth equation.

The expression of the length-weight relationship is exponential, as follows: $\mathbf{W = a\ L^b}$, where W = weight of fish in (g); L = total length of fish in (mm); a = proportionality constant (intercept) and, b = regression coefficient (slope). The association between total length (L) and total weight (W) was calculated by the correlation coefficient (r^2). Value of the exponent b provides information on fish growth. When b = 3, the increase in weight is isometric, otherwise it is allometric (major allometry if b > 3, minor allometry if b < 3). This size-to-weight relationship was calculated as logarithmic coordinates for both sexes taken together and for all individuals in the samples.

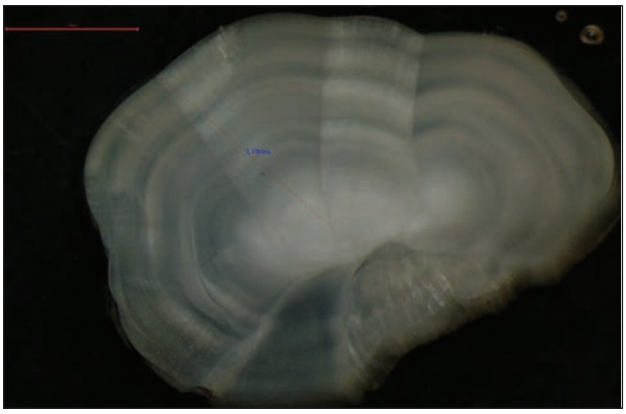

Fig. 2: Otolith of a** Trisopterus luscus **from the Moroccan Central Atlantic waters (scale = 1 mm).
Sl. 2: Otolit vrste** Trisopterus luscus **iz osrednje atlantske maroške obale (merilo = 1 mm).

Statistical analyses:

- The test "χ^2" was used for a comparison of growth in males and females;
- The test used to compare the growth parameters of the same species from the same stock or different stock is the phi-prime test (Ø') (Munro & Pauly, 1983; Pauly & Munro, 1984) referred to as: Ø' (phi prime) = log (K) + 2.log (L∞);
- The reliability of allometry was studied by the Student (t) test (Snedcore & Cochran, in Arneri *et al.*, 2001): t = (b – 3)/ (b); (b = allometric coefficient, (b) = standard deviation of b). The value of 't' obtained is compared to the theoretical 't' at the 5% threshold. A value greater than 't' theoretical indicates that there is allometry (b ≠ 3). If not, we have an isometry.

RESULTS

Length Growth

The linear growth of the pouting, according to the model of von Bertalanffy (1938), used the linear growth equation (L∞, k and t_0) and was estimated by the Gulland and Holt method considering the data for male and female fish separately and as a combination of both sexes (Choat *et al.*, 2006; Williams *et al.*, 2009). Consequently, the parameters for the linear growth equation of von Bertalanffy were also selected using data for both sexes of the pouting combined

Tab. 2: Statistical parameters for the comparison of the growth of** Trisopterus luscus **male-female in the area of the Central Atlantic Moroccan coast.
Tab. 2: Statistični parametri za primerjavo rasti samcev in samic francoskega moliča** Trisopterus luscus **na predelu osrednje atlantske maroške obale.

	χ^2 calculated	n	α	df	χ^2 observed
Male + Female	0.17	914	5%	6	1.64

*χ^2: chi-squared test; n: total numbers of individuals in the sample; α: alfa level 0.05 (5%); df: degree of freedom; χ^2 calcal = test χ^2 calculated; χ^2 observed = test χ^2 observed.

and for females and males separately (Tab. 1–3). The asymptotic lengths (to the nearest mm) obtained for the male and female pouting were 357 mm and 329 mm respectively, a difference of 27 mm. The asymptotic length (L∞) of males was larger than that of the females and the growth constant (k) for the females was larger than those of the males.

Using the Von Bertalanffy equation (1938) for both sexes and for the sexes combined, theoretical size/age data pairs or size-age keys were calculated. These data pairs were used to draw a graphical representation of the length growth curve (Fig. 3). In general, the growth curve of a fish is asymptotic as described in the von Bertalanffy (1938) model. In our case, the lengths calculated by this model coincide with those observed (with slight differences). This suggests that the sample is representative of the size range of pouting present in the Moroccan Central Atlantic.

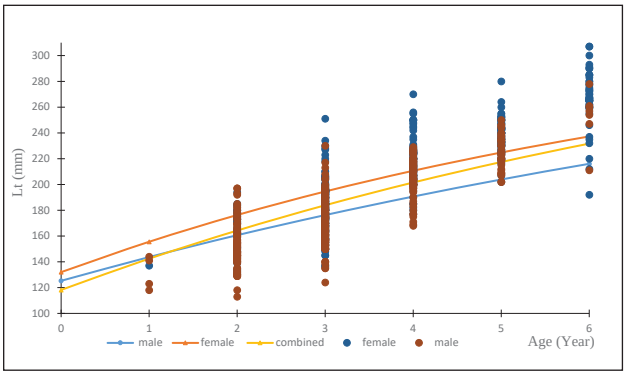

Fig. 3: Von Bertalanffy curves for the linear growth of the** Trisoprterus luscus **in the Central Atlantic Moroccan coast with data for male and female fish shown as colored points.
Sl. 3: Von Bertalanffyjeve krivulje linearne rasti francoskega moliča** Trisoprterus luscus **iz osrednje atlantske maroške obale. Samci in samice so označeni z barvnimi krogci.

Tab. 3: Age-length key obtained for** Trisopterus luscus **in the study area of the Central Atlantic Moroccan coast, for females, males and the two sexes combined.
Tab. 3: Starostno-dolžinski podatki za samce in samice ter za oba spola francoskih moličev na vzorčenem predelu osrednje atlantske maroške obale.

Sex t(year)	Male (mm)	Female (mm)	Combined (mm)
0	125.28	132.01	118.21
1	143.70	155.56	142.45
2	160.65	176.30	164.26
3	176.26	194.56	183.88
4	190.63	210.63	201.53
5	203.,86	224.79	217.41
6	216.03	237.25	231.70

This curve allowed us to conduct a comparative examination of the growth of each sex. It shows that there is a significant difference between the male and female pouting in favor of the former in age group 0 (less than one year) (Tab. 3), beyond which the growth rate is reversed, in fact, the theoretical length at the same age is greater in females than in males during most of the life of the species. The age of the largest females and males observed in the study area was 6 years.

The linear growth curves for females, males, and both sexes of the pouting combined are shown in the graph (Fig. 3). The graph (Fig. 3) indicate that males initially grow faster than females. However, this difference only manifests itself in the first year of life and then always remains in favor of the females until theoretical year 9. The representation of von Bertalanffy's equations for the linear growth of the males and females of the pouting, on the same graph (Fig. 3) shows that the growth in length of the females is clearly faster than that of the males from the end of the first year of life. The length of female is then greater than that of the male.

Relative weight growth

In the 914 specimens of pouting caught in the Moroccan Central Atlantic during the study period of two years, the total length (L) varied between 113 mm (min. size) and 316 mm (max. size). The minimum weight in males was 14.3 g for a minimum size fish of 113 mm, in females it was 26.07 g for a

Tab. 4: Length-weight equation parameters in males and females of** Trisopterus luscus **from the area of the Central Atlantic Moroccan coast.
Tab. 4: Dolžinsko-masni odnos pri samicah in samcih francoskega moliča** Trisopterus luscus **iz predela osrednje atlantske maroške obale.

Sex	a	b	σ^2	r^2	n	L_{min} (mm)	L_{max} (mm)
Female	0.000008	3.0675	1.35	0.9656	512	131	316
Male	0.00001	2.9748	1.27	0.9612	402	113	278
Combined	0.000008	3.067	1.35	0.9678	914	113	316

*σ^2 = Variance

Tab. 5: Parameters for growth comparison in** Trisopterus luscus **male-female (Student t-test).
Tab. 5: Parametri za primerjavo rasti pri samicah in samcih francoskega moliča** Trisopterus luscus **(Studentov t-test).

Equation	Sex	a	b	r^2	n	χ^2 observ	Th(n-2) α =5%	Type of allometry
$W = a.L^b$	Female	0.000008	3.0675	0.9656	512	0.0497	2.02	Isometric
	Male	0.00001	2.9748	0.9612	402	-0.0198	2.02	Isometric
	Combined	0.000008	3.067	0.9678	914	0.0494	2.02	Isometric

*σ^2 = Variance

min fish size of 131 mm. The maximum total weight (Pt) was 430.49 g for a 316 mm female, compared to 303.84 g for a 278 mm male.

In order to determine the weight corresponding to all the calculated lengths, the size-weight relationships were determined for males, females, and the two sexes combined. We considered all couples, without prior grouping during the two cycles (2018/2019).

Figures 4 and 5 represent respectively the results of the variations in the relationship between total weight and total length for each sex and for all the individuals of the combined fish sample collected from the Moroccan Atlantic coast.

Tables 4 and 5 show the number of specimens collected, the minimum and maximum values of size, the estimated parameters a and b, as well as the correlation coefficient for the total weights. Irrespective of the size of the fish, the length and weight points are not dispersed, this indicates that the length-mass relationship is governed by the same correlation for all sizes. The R-correlation coefficients are very close to 1, reflecting a strong positive correlation between the two variables of size and weight.

The relationship between length (total length in mm) and body weight (g) was studied for the two sexes separately and combined (Tab. 5). The parameters of the equation are $W = a\ L^b$ (Ricker, 1980).

The estimated values of b are close to 3 regardless of sex (Tab. 6) and the Student t-test returns values below the 2.02 threshold, corresponding to a 95% degree of safety. This would suggest that in the pouting of either sex, as characterized by the isometric growth between the total weight and length, that body shape does not change significantly and that body development (weight growth) is proportional in both sexes.

The value of b (Tab. 6) is consistent and corresponds with the literature, which locates this value between 2.5 and 3.5 (Pauly,1997) for the size-weight relationships. The b parameter of the full-length-to-weight relationship, calculated for the two sexes of the pouting combined and separately, is roughly equal to 3, which shows a relative growth isometry. For males, the Student statistical test shows that factor b is less than '3,' and therefore, the relative growth in the male and female pouting examined in the sample follows an isometric allometry function, meaning that weight and length increase proportionally.

The length-weight equations for the pouting examined are graphically represented in Fig. 4, for males, females, and the two sexes combined.

A comparison of equations from the length-to-weight relationship of males and females (Fig. 5) shows that at the same size, the full weight of the females is always greater than that of the males. The difference in weight in females compared to that in males is clearly observed above the size of around 180 mm total length, and is likely due to gonadal development, which is greater in females.

Absolute weight growth

The theoretical weight growth curves result from a combination of the linear growth equation $Lt = L_{\infty}(1 - e^{-k(t-to)})^b$ and the size-weight relationship ($W = a.L^b$). Applying the linear growth equation and the size-weight relationship, we follow the weight growth equation of Von Bertalanffy: $Wt = W_{\infty}(1-e-k^{(t-to)})^b$, where W, Asymptotic weights were established for both sexes separately and combined (Tab. 7). Parameters k and t_0 are identical to those calculated from the linear growth equation.

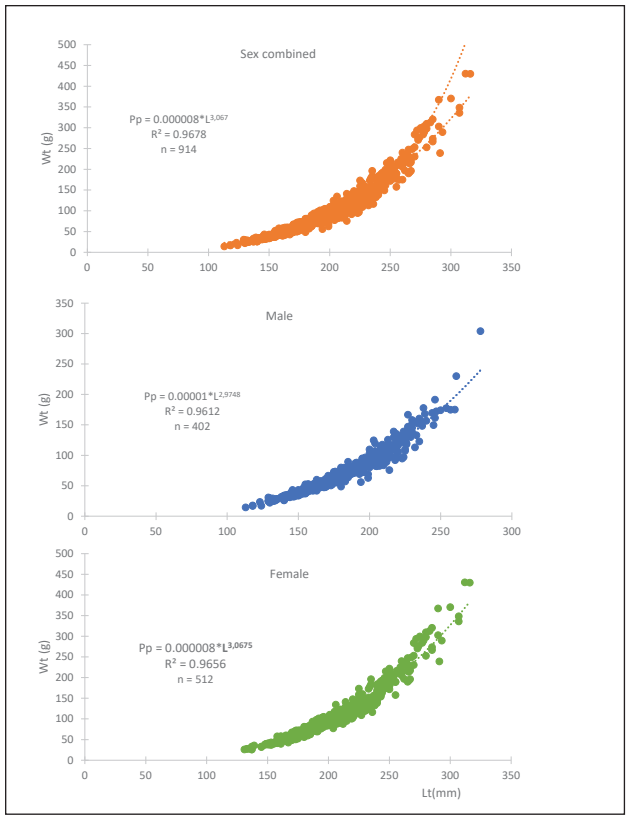

Fig. 4: Full (Pp) length (mm) – weight (g) relationship in** Trisopterus luscus **from the Moroccan Central Atlantic coast stock for the two sexes combined (top), males (center), and females (bottom).
Sl. 4: Celotni masno-dolžinski odnos pri francoskem moliču** Trisopterus luscus **iz osrednje atlantske maroške obale za oba spola (zgoraj), samce (sredina) in samice (spodaj).

The weight growth in females trends to an asymptotic value of 414.78 g, whereas in males the asymptotic weight is 385.04 g (Tab. 7 and Fig. 6). The asymptotic weights of females are comparatively much higher than those of males. Age-weight keys for females, males, and the sexes combined were calculated as the average weights for each category in years 0–1 to 6 (Tab. 8).

The average age-weight data are shown in the graph in Fig. 6 were weight growth in females is substantially greater than that of males, even in the age weight group of less than one year. The difference increases steadily to a maximum in individuals of the 6-year age group.

DISCUSSION

The linear growth of the Atlantic Moroccan pouting was studied using the modal progression method to demonstrate the distribution of length and weight data du-

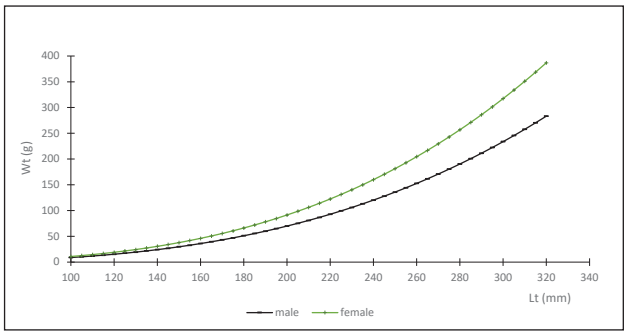

Fig. 5: Comparison of length equation curves – weight (g) of male and female** Trisopterus luscus **from the Central Atlantic Moroccan coast stock.
Sl. 5: Primerjava krivulj na podlagi odnosa med dolžino in težo (g) samcev in samic francoskih moličev** Trisopterus luscus **iz osrednje atlantske maroške obale.

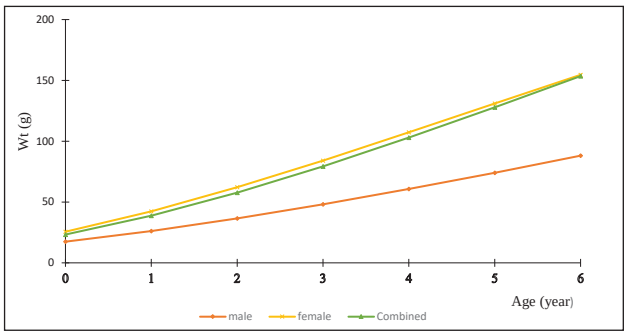

Fig. 6: Theoretical curves of the absolute weight growth of** Trisopterus luscus **in the area of the Central Atlantic Moroccan coast.
Sl. 6: Teoretične krivulje za absolutno rast mase francoskih moličev** Trisopterus luscus **na predelih osrednje atlantske maroške obale.

Tab. 6: Student t-test in length-weight allometry for the** Trisopterus luscus **of the area of the Central Atlantic Moroccan coast.
Tab. 6: Vrednosti Studentovega t-testa za dolžinsko-masno alometrijo pri francoskem moliču** Trisopterus luscus **na predelu osrednje atlantske maroške obale.

Sex	b	t. calcul	Allometry
Female	3.0675	0.0497	Isometric
Male	2.9748	-0.0198	Isometric
Combined	3.067	0.0494	Isometric

Tab. 7: Parameters of the absolute weight growth of** Trisopterus luscus **in the area of the Central Atlantic Moroccan coast.
Tab. 7: Parametri absolutne rasti mase francoskega moliča** Trisopterus luscus **na predelu osrednje atlantske maroške obale.

Sex	b	W∞(g)	k	t0
Combined	3.067	415.82	0.105	-3.76
Male	2.9748	385.04	0.082	-5.21
Female	3.0675	414.78	0.127	-4.02

ring the years 2018–2019. The von Bertalanffy equation is well suited for displaying linear growth trends in the separated and combined sexes of this fish in Moroccan Atlantic stocks.

This study revealed that growth rates for each sex decreased with age; they were highest at small sizes (2–3 years), while after 3 years of rapid growth of young individuals the rates declined, with the fish approaching asymptotic size and weight. The observations show that after the first year of growth, the female is always larger than the male and the rate of increase, be it weight or linear, is always higher in females than in males.

The difference in growth rate between the two sexes allows females to reach larger sizes than males at the same ages. Adjustment of growth parameters to von Bertalanffy's growth model (1938) shows that the growth constant values (k) for females are higher than those for males, while the females' asymptotic sizes (L∞) are smaller than the males'. Similar results were obtained by Puente (1988) in France.

Several hypotheses have been made to explain the dominance of females at larger sizes, including considerably higher mortality rates for males compared to those for females at the same ages, furtherly, but to a lesser extent, the difference in the growth rate between the two sexes, as well as access to fishing gear, and male vulnerability to environmental factors (Piñeiro & Sainza, 2003).

The phi-prime test Ø′ (performance index) was used to compare the estimated linear growth parameters L∞ and k for the combined sex and separated sex groups with those obtained in other studies. In general, the comparison of results showed only small differences in calculated Ø′. Ø′ values collected from bibliographic sources vary between 2.4 and 3. Thus, the growth parameters calculated in this study are above the range of the estimates made elsewhere since they vary from 4.02 to 4.14.

Differences between the Ø′ growth parameter estimated here may be explained by variations in the size range sampling data (Piñeiro & Sainza, 2003). Fish sample sizes are affected by seasonality (seasonal and interannual variation), and the otolith method of age reading can also affect estimated growth parameters (difficulties of differentiation between single and double rings can influence growth estimates). Differences in the characteristics of biogeographical zones such as dynamic hydro-climatic and environmental conditions are among other factors affecting the growth parameters (Pauly & Munro, 1984**;** Layachi *et al.,* 2007; Mellon-Duval *et al.,* 2010; Belhoucine, 2012; El Habouz *et al.,* 2014). Phi--prim values of Ø′ calculated using the same approach (otoliths, size distribution) are typically similar within the same study area, however, in

Tab. 8: Age-weight key obtained for** Trisopterus luscus **females, males and sex combined from the area of the Central Atlantic Moroccan coast.
Tab. 8: Starostno-masni podatki za samce in samice ter za oba spola francoskega moliča** Trisopterus luscus **na vzorčenem predelu osrednje atlantske maroške obale.

Sex T(year)	Female (g)	Male (g)	Combined (g)
0	17.40	25.59	23.26
1	26.18	42.34	38.81
2	36.48	62.15	57.73
3	48.07	84.09	79.34
4	60.69	107.28	102.94
5	74.09	130.97	127.85
6	88.05	154.55	153.48

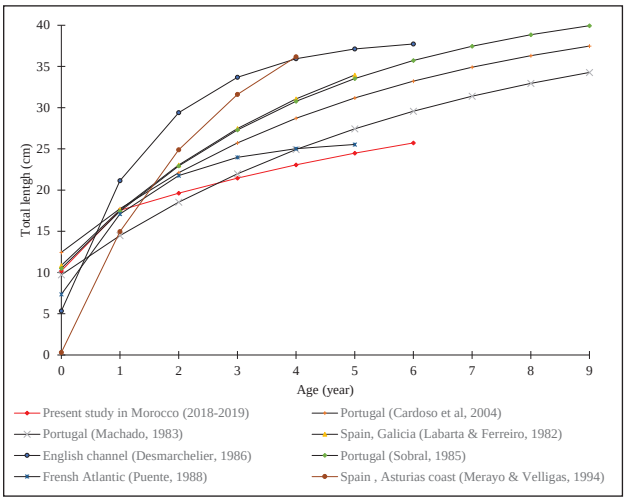

Fig. 7: Linear growth curves in the different** Trisopterus luscus **stocks according to different distributional areas.
Sl. 7: Linearne rastne krivulje za različne populacije francoskih moličev** Trisopterus luscus **v različnih območjih razširjenosti.

the Moroccan otolith study the Ø′ values remain higher than those in other Mediterranean and North Atlantic regions.

The Ø estimated for the higher latitudes (Atlantic France) is higher than that obtained in the Portuguese or Galician studies, indicating faster growth in the northern European region (Tab. 7). On the other hand, the phi-primes obtained in our study are higher than those reported in previous work (see Cardoso *et al*. (2004); Machado (1983); Labarta & Ferreiro (1982); Desmarchelier (1986); Puente (1988); Merayo (1994); Alonso-Fernández *et al.*, (2008)). The higher phi growth performance index (despite the maximum sizes of 31 cm in females) in the Moroccan study area may be due to the upwelling providing favorable conditions for the growth of this species. It should be noted that in the French and Spanish coastal zones, the growth curves established from the otoliths are superimposed, indicating a high degree of similarity between the two. The same result is also observed for curves drawn from the size distribution method and otolith measurements from the Portuguese coasts. The growth curve obtained here coincides with those obtained by Puente (1988) in the French Atlantic coast. The linear growth characteristics of pouting in the Moroccan Atlantic tests the hypothesis of the rapid growth that has been demonstrated elsewhere: in Portugal (Cardoso *et al.,* 2004; Sobral, 1985), in the Galician coasts (Labarta & Ferreiro, 1982), Asturian coasts (Merayo, 1994), in the English Channel (Demarchelier, 1988), and in the French Atlantic (Puente, 1988). Linear growth of the common pouting therefore appears to be faster in the North Atlantic (English Channel and the Asturian coastal areas) than in the Moroccan Atlantic, where the growth increase of the common pouting after year 2 is inferior to those established in previous studies (Fig. 7).

It should be noted that these earlier studies in the Spanish region report values by Labarta & Ferreiro (1982) and are not consistent with those of Merayo (1994). It is also noteworthy that the former used on average overall lengths lower than the average values obtained for young individuals (Merayo, 1994).

The value of the growth rate (k) obtained in this study is relatively low compared to previous studies of *T. luscus*. On the French coast (the Channel and the North Sea), the rates were k = 0.85 (male) and 0.66 (female) according to Desmarchelier (1986), and k = 0.52 (male) and 0.74 (female) according to Puente (1988) on the Aquitaine coast, and on the coast of Asturias, also by Puente (1988), k = 0.64 (male) and k = 0.53 (female). On the Galician coast, k was 0.21 (Labarta & Ferreiro, 1982), the value being almost the same as our results, k = 0.08 (male) and k=0.13 (female); our fish also reached a smaller maximum size than those in the previous studies. These differences may partly be due to the different methods used to estimate the growth parameters of fish from the Moroccan Central Atlantic, which grew more slowly than in other areas, reaching a smaller size at the same age.

It has been suggested that the pouting on the Galician coast exhibits slower growth but reaches a greater length age (9-year-old fish) (Labarta & Ferreiro, 1982) than the Cantabrian pouting, possibly because the colder conditions on the Galician coast provide a more favorable environment for this species. Other possible causes of the differences observed by Labarta & Ferreiro (1982) could be the interpretation of otolith data or the method of cutting otoliths and/or differences in the reading of otoliths (single or double rings).

Gherbi-Barre (1983) and Puente (1988) showed that on the French coast, the average lengths were only slightly lower compared to values obtained for the Spanish Asturian coasts. This suggests that growth increases meridionally along the Atlantic coastal zones from the north to the south.

This is supported by the representation of von Bertalanffy's equations for the linear growth of different regions on the same graph (Fig. 7), which show that the length growth of this species is faster in French and Spanish coasts compared to the south Atlantic.

With regard to the size-weight relationship curves, the observed peaks are very near the theoretical curve, which is explained by the fact that the values of the correlation coefficient are high. This demon-

Tab. 9: Methods used in male-female growth studies of** T. luscus **in different areas.
Tab. 9: Uporabljene metode za raziskave rasti samcev in samic vrste** T. luscus **v različnih predelih.

Area	Method	Authors	Sex	L cm	k	t_0	Ø′
Morocco	Otoliths	Present study	Males	35.6	0.08	-5.21	4.02
			Females	32.9	0.12	-4.02	4.14
			Combined	35.9	0.10	-3,76	4.14
Portugal	Otoliths	Cardoso et al. (2004)	Males	32.3	0.24	-2.03	2.4
			Females	43	0.19	-1.8	2.5
			Combined	43	0.16	-2.30	2.5
Portugal	Lenght freq	Machado (1983)	Combined	41.9	0.16	-1.65	2.4
Galicia (Spain)	Otoliths	Labarta & Ferreiro (1982)	Males	38.1	0.21	-1.16	2.5
			Females	46.4	0.21	-1.27	2.7
English Channel and North sea	Otoliths	Labarta & Ferreiro (1982)	Males	31.3	0.86	-1.21	2.9
			Females	38.4	0.65	-0.23	3
			Combined	35.1	0.65	-0.23	2.9
Portugal	Otoliths	Sobral (1985)	Males	38.4	0.19	-1.42	2.5
			Females	44.2	0.23	-1.18	2.6
French Atlantic	Otoliths	Puente (1988)	Males	33	0.52	-0.44	2.8
			Females	26	0.74	-0.45	2.7
Coast of Asturias	Otoliths	Merayo (1994)	Males	36.2	0.59	-0.014	-
			Females	45.7	0.39	-0.017	-
			Combined	40.2	0.48	-0.016	-

strates that the different equations used adequately reflect the relationships between the total fish weights and their total lengths. Comparison of the regression line slopes of the total length-weight relationship between male and female individuals shows that the relative growth in females is greater than in males.

This study shows that the larger female weight is related to the gonad weight. Our results coincide with those of Demarcheliers (1984) from the English Channel and Labarta & Ferreiro (1882) from the Galician coast; Merayo *et al*. (1986) made similar observations in relation to fish from the Asturian coast (Tab. 9).

A comparison between the slopes of the length--weight relationships, relative to value 3, allows us to point out that relative weight growth is isometric in both sexes. This tells us that weight growth is proportional to linear growth. The results of other authors related to growth parameters reported for different regions of the Mediterranean and the Atlantic are compared in Table 10. In general, the size-weight relationship in pouting (regardless of sex) obtained by this study is similar to those previously estimated in these other areas, and value (b) is statically approximately equal to 3 in both males and females of the central Moroccan Atlantic. This implies an "isometric" growth for both sexes of the species, as somatic growth is in proportion to increasing total length (see Tab. 8).

Divergence between some results could be closely related to the number of samples and the pairs of values considered for the calculation of the size--weight relationship, where coefficient b increases with the length of the fish (Tab. 10).

Overall, this study shows that weight measurement results clearly demonstrate differential growth rates between the two sexes of the pouting and that the females have a higher asymptotic weight than the males of the same size. The weight growth in the *T. luscus* of

Tab. 10: Size-weight relationship of** Trisopterus luscus **in different periods and areas.
Tab. 10: Odnos med velikostjo in maso pri vrsti** Trisopterus luscus **v različnih periodah in predelih.

Period and area	Authors	Sex	a	b	r^2	t	Growth α = 0.01
Present study		Males	0.00001	2.958	0.997	0.0497	NS
		Females	0.000008	3.037	0.997	0.0198	NS
		Combined	0.000008	3.0097	0.986	0.0497	NS
1982 Galician Coast	Labarta & Ferreiro	Males	2.3*10-5	2.87			
		Females	2*10-5	2.95			
1986-87 Asturian	Merayo & Villegas	Males	0.000007	3.148	0.9836	0.145	NS
		Females	0.000008	3.112	0.992	0.076	NS
		Combined	0.000008	3.113	0.989	0.147	NS
1987-88 Asturian		Males	0.000012	3.048	0.990	0.0301	NS
		Females	0.000016	2.9889	0.990	-0.006	NS
		Combined	0.000014	3.017	0.990	0.0015	NS
1984 France	Desmarchelier	Males	1.25*10-3	3.002	0.976	-	-
		Females	9.61*10-3	3.090	0.956	-	-

the Moroccan Central Atlantic is in favor of females and these results are consistent with those obtained by Demarcheliers (1984) in the English Channel, and Labarta & Ferreiro (1882) and Merayo *et al*. (1986) in the Galician and Asturian coasts, respectively. Nevertheless, a comparison of the growth rates among pouting stocks in eastern Atlantic coastal seas shows differences in the methods used, indicating further work is required to harmonize the methodologies.

Our sample study on the growth characteristics of the Moroccan population of the pouting lays the foundations for further work on population dynamics and stock management of this species. It is suggested that the stock could become a sustainably managed fishery rather than exploited simply as bycatch. Whilst the pouting is not very appreciated by consumers, the larger fish do have the potential of becoming a more widely exploitable food resource if promoted and marketed attractively as an alternative to premium white fish.

CONCLUSIONS

Study of the growth biology of *Trisopterus luscus* in the Moroccan Atlantic coasts revealed that the length and weight growth rate of females is higher than that of males from the completed first year of life onwards. The linear growth analysis of this species tests the hypothesis of rapid growth age readings from otoliths which underestimates the growth of these fish. Weight-to-length changes in the pouting sample (regardless of sex) are constant and almost isometric, and in adults of equal size somatic weight gain by length is identical in both sexes, which supports the value of using otolith data. In the light of this preliminary research, which is the first of this kind in Morocco, it is recommended that more in-depth biological studies on this species should be carried out, including some on the growth-otolith measurement relationships and the population dynamics that would allow a better understanding of the stock dynamics and, potentially, facilitate fishery management as well.

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RAST IN STAROST FRANCOSKEGA MOLIČA *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) V ATLANTSKIH VODAH OSREDNJEGA MAROKA

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POVZETEK

Prispevek obravnava starost in rastne značilnosti francoskega moliča, Trisopterus luscus*, v osrednjem delu atlantske maroške obale na podlagi analize otolitov. Starost in rast populacije francoskih moličev sta bili raziskani na celotnem vzorcu 2210 primerkov, ujetih na mesečnih vzorčenjih od januarja 2018 do decembra 2019. Rastne krivulje (dolžina in teža), dobljene na podlagi ocene starosti iz preiskave otolitov kažejo, da se najvišja rast odvija v prvih dveh letih življenja. Z uporabo von Bertalanffyjevega modela so ocenili maksimalno starost na 6 let (za oba spola). Največji primerek je meril (samica) 316 mm v dolžino. Hitrost rasti se med spoloma razlikuje; povprečna dolžina je pri samicah enaka ali nekoliko večja kot pri samcih, teža samic pa je vedno večja od teže samcev v istih starostnih skupinah.*

Ključne besede: starost, rast, otoliti, *Trisopterus luscus,* atlantska maroška obala

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