Research Article

Open Access

Variability of Biological Features of a *Mugilidae Chelon Ramada* in Two Tunisian Reservoirs

Abstract

Mullet is the most massively harvested species, representing the third of the total freshwater fish landing in Tunisia. To ensure freshwater fish farming durability and development in the country, reservoirs have been stocked with Mugilidae fry which was collected from coastal and estuaries areas after a short adaptation period. The objective of this paper is to compare and contrast *Chelon ramada's* age, growth, and mortality in two Tunisian freshwater reservoirs (Seliana and Kasseb). The sample species were caught with a multi-mesh gillnets and were classified into five age groups. The study of the age and growth demonstrated variability between *Chelon ramada* species' features. The optimal size of the captured mullet (Lopt) was equal to 37.62 cm for M=0.48, L∞=57.05 and K=0.31 in Siliana Reservoir. Whereas, it measured 31.42cm in Kasseb Reservoir, for M=0.795, L∞=48.15 and K=0.31. It has also been found that the fishing mortality rate is very high at Siliana Reservoir when compared to Kasseb Reservoir. This work is a contribution to the identification of the biological features of *Chelon ramada* that lives in Siliana and Kasseb Reservoirs. It seeks to ensure a rational and sustainable exploitation of fishery resources in these Tunisian freshwater reservoirs and it recommends the development and preservation of mullet fisheries.

Keywords: *Chelon ramada*, age, growth, mortality, fishery management, Seliana reservoir, Kasseb reservoir, Tunisia

Volume 11 Issue 2 - 2022

Sami Mili,[1] Rym Ennouri,[1] Manel Fatnassi,[1] Tahani Chargui,[1] Hajer Zarrouk,[1] Rabeb Thabet,[1] Houcine Laouar,[2] Nawfel Romdhane[3]

[1]University of Carthage, Higher Institute of Fisheries and Aquaculture of Bizerte, Tunisia
[2]Technical Center of Aquaculture, Tunisia
[3]Directorate General of Fisheries and Aquaculture, Tunisia

Correspondence: Sami Mili University of Carthage, Higher Institute of Fisheries and Aquaculture of Bizerte, Tunisia, Email mili.sami.ispa@gmail.com

Received: November 30, 2021 | **Published:** August 05, 2022

Abbreviations: ISPAB, higher Institute of fisheries and aquaculture of Bizerte; TCA, technical centre of aquaculture; IRESA, institution of agricultural Research and higher education; Lopt, optimal capture size; F, fishing mortality; M, natural mortality; Z, total mortality; R, the scale radius (mm); a, the intercept; b, the slope; L∞: asymptotic length that the fish can reach; K, growth rate constant; t, age of the fish; t0, theoretical age of the fish when its length is zero; Φ', growth performance index; N(t), number of survivors at time t; N0, number of individuals at time 0; Z: constant; L∞: asymptotic length; L': length «cut-off length»; L mean: mean length; T, mean annual temperature; Lt, total length; Lst, standard length; Lf, fork length; Wt, total weight; Lr, the recruitment size; VPA, The Virtual Population Analysis

Introduction

Man has been exploiting both inland and marine fish resources for years on end. These fisheries provide a major source of food for a lot of people and allow many others to earn a living. However, the strong pressure exerted on the marine environment, leading to the overexploitation of fish stocks and sometimes their depletion, is the main cause of the recent downward trend in world production.[1,2]

Over the years, and following the socio-economic scientific and technological development, Man has found other breeding and fishing forms of aquatic species. This activity can now be conducted in marine, fresh or geothermal waters alike, and even in environments that are not in contact with the sea, which created the concept of inland fish farming. In fact, the reservoirs which were initially built to respond to a need for water supply and irrigation, and then to the production of electricity, are now deployed for fish farming.

The first Tunisian experience of freshwater fish farming in reservoirs was initiated in the 1960s by the National Fisheries Office. This began with the experimental stocking of reservoirs with mullet captured from natural sites and acclimatized in Reservoirs.[3-5] Actually, the Technical Center of Aquaculture (TCA) ensures the seeding of 9 million mullet fries per year in 25 large Tunisian reservoirs in order to contribute to the sustainability of Mugilidae stocks.[6]

The family Mugilidae is very common in Tunisia and it encompasses six species: the bighead mullet (*Mugil cephalus*), the pig mullet (*Chelon ramada*), the golden mullet (*Chelon aurata*), the jumping mullet (*Chelon saliens*), the lippu mullet (*Chelon labrosus*) and the labéon mullet (*Oedalichulis labeo*).[7] The most commonly exploited ones are *M. cephalus* and *C. ramada*. Pig mullet has been identified as a potential species for aquaculture diversification in the Mediterranean region, as well as in other parts of the world.[8-11] This type of Mugilidae has great tolerance to variations in salinity and temperature (euryhaline and eurythermal), strong forbearance to captivity, fast growth, omnivorous feeding habits, and high market price.[12]

The aim of this study is to compare the variability in age, growth and mortality parameters estimated for *Chelon ramada* sampled from Siliana and Kasseb Reservoirs between April 2015 and May 2016. This comparison allowed to identify the site with optimal conditions for mugilids growth, which would eventually enhance the management of these resources. Due to lack of information related to this filed, this comparison was conducted using literature resources in combination with the studied parameters. The results of this study can serve in the development of a management plan and stock assessment.

Material and methods

Study areas: This study was conducted in two Tunisian reservoirs: Kasseb and Seliana (Figure 1). The selected reservoirs are both located in the northern part of the country, with different surface areas and bathymetries.

Kasseb Reservoir (36°45'32" N, 9°0'20" E) was built in 1968. It is situated at 20Km kilometers from the town of Beja, and it belongs to the north hydrological watershed of Madjerda. It covers an area of

430ha and contains $70Mm^3$of water. It is mainly used as a drinking water supply by the city of Tunis at a rate of $40Mm^3$/year.[13]

Seliana Reservoir (36°09'26''N, 9°20'55''E) was built in 1978 and it has a surface area of 600ha. It is located near the City of Seliana and it belongs to the south hydrological watershed of Medjerda. Seliana Reservoir is used for irrigation at the perimeter of Gaafour/Laaroussia City with $23Mm^3$/year.[13]

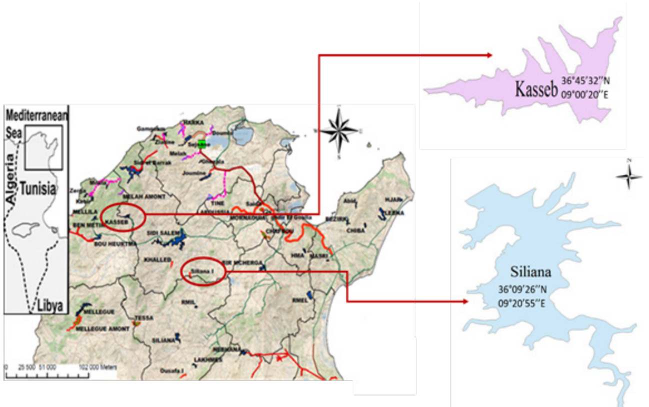

Figure 1 The map of Tunisia indicating the location of the two studied reservoirs: Kasseb and Seliana.

For fish sampling in these reservoirs, a multi-mesh gillnet was deployed as per the methods recommended in the European Program prEN 14575 (CEN 2005). Sampling operations were carried out with a seasonal frequency between 2015 and 2016 (Table 1). A total of 530 fishes were captured: 320 individuals from Siliana Reservoir and 210 from Kasseb Reservoir.

Table 1 Sampling periods in Siliana and Kasseb Reservoirs

Siliana Reservoir	17-18/05/2015	7-8/09/2015	1-2/12/2015	01-04/03/2016
Kasseb Reservoir	18-19/05/2015	7-8/09/2015	1-2/12/2015	02-09/03/2016

A study of the growth of *C. ramada* in Kasseb and Seliana Reservoirs was conducted to find out which reservoir presents the best growth rates. The growth model of Von Bertalanffy was adopted using the age-length key. The ages of *C. ramada* were determined from scales measurements. The analyses of these parameters were carried out by means of the software "FISAT II".[14] Estimation of fishing (M), natural (M) and total (Z) mortality related to body size and to the number of cohorts of the mullet populations in Seliana and Kasseb Reservoirs were made using FISAT II routines.

Age estimation

In this study, we used scale aging. The scales in the area between the dorsal fin and the head were carefully collected and kept in well-labeled pockets to be used later for age reading. The superimposition of several rings induces the formation of a dark zone which informs either about stunting or a slow-down of the growth. This state can be caused by a physiological condition such as reproduction, the variation of the physicochemical parameters of the environment (winter period), or food availability.

Approximate Age

The age valuation is done by reference to the number of the formed circuli. Several cases can be presented:

Group 0: Scale with 0 circulus

Group I: Scale with a circulus very close to the edge

Group I+: Scale with one circulus very far from the edge

Group II: Scale with two circuli where the second one is very close to the edge

Group II+ and III, III+...

The measurements of the radii of the different circuli in the scale were made with an ocular micrometer (Figure 2).

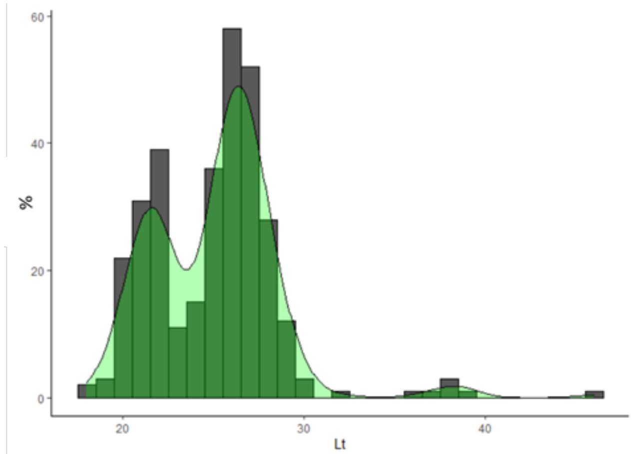

Figure 2 Size frequency distribution of *C. ramada* in Siliana Reservoir.

Growth study

The study of growth is a very delicate approach in fisheries. Therefore, to ensure the success of this process, it was crucial to find the most appropriate method that best fits the basic data (size-age pairs) and to choose the most relevant model describing the relationship between these two variables.[15]

Fish length - scale radius relationship

The fish length-scale radius relationship is established according to the following linear regression model:

$$TL = a * R + b$$

With: **R:** scale radius (mm); **TL:** total fish length (cm); **a:** intercept; **b:** slope.

Absolute growth

Among the most commonly used growth models is that of Von Bertalanffy (1938) with the following mathematical expression:

$$LT_t = LT_\infty[1 - e^{-k(t-t_o)}]$$

With: **Lt:** length of the fish at time t; L∞: asymptotic length that the fish can reach; K: growth rate constant; t: age of the fish; t0: theoretical age of the fish when its length is zero.

The estimation of the parameters of the Von Bertalanffy equation (L∞ and k) remains easy based on the size frequency distribution, and through the use of different methods integrated in FISAT II software. Only those values that have an adequate growth performance index (Φ') are retained[16] with:

$$\Phi' = log10(K) + 2log10(L\infty)$$

Elefan I Method: this routine allows the estimation of L∞ and K by a direct projection of frequency-size data without translating the length scale into the age scale.[14] In addition, this method allows the identification of the growth curve.

Shepherd's Method: this method is very similar to the Elefan method except that the values of WP and C are considered zero.

Powell-Wetherall Method: this method estimates L∞ and Z/K from a sample representing the population.[17-19]

Size-age data analysis: this method estimates growth parameters from the length-age relationship, and plots the growth curve.[20-23]

Relative linear growth

The different relationships between lengths are established by linear regression based on the least squares method. The relationships were expressed as a function of the form $Y=aX^b$, which is transformed into a logarithmic function of the form Y=Log (a) + bLog (X). This transformation is the simplest method to linearize the relationship, stabilize the variances and normalize the variables.[24]

After growth curve plotting, the value of a (intercept) and b (slope or allometry coefficient) are determined. Moreover: if b = 1, isometry or isometric allometry; if b < 1, negative allometry; if b > 1, positive allometry.

It should be noted that the values of *a* and *b* vary according to the species and the sex. They are also dissimilar in different regions.

Relative weight growth

The relationship between the size and weight of fish is defined according to Le Cren[25] by the following equation:

$W = a L^b$

With: **W:** the weight of the fish (Wt or We) in grams; **L:** the length of the fish (Lt, Lf or Lst) in centimeters; **a:** constant corresponding to the weight of an individual of length equal to unity; **b:** allometry coefficient.

Three cases can occur[24]: if b=b theoretical, an isometry between the two characters; if b<b theoretical, there is a negative allometry; if b > b theoretical, the allometry is positive.

Absolute weight growth

The equation that describes absolute weight growth is obtained by combining parameters from the length growth equation and the length-weight relationship.

$$Wt = W\infty \left(1 - e^{-k(t - t\,0)}\right)^b$$

With: Wt**:** weight of the fish at age t; W∞ = a (L∞) b: theoretical asymptotic weight corresponding to L∞; **k:** growth coefficient; **t:** age of the fish; **t0:** the theoretical age of the fish when the length of the fish is zero; **b:** the allometry coefficient of the length- weight relationship.

Mortality

The study of mortality focuses essentially on the estimation of fishing mortality (F), natural mortality (M) and total mortality (Z = M + F). This parameter is considered very important for stock assessment. In general, the evolution of survival fish can be described by a negative exponential function with the following mathematical formula:

$$N\,(t) = N0\, e^{-Zt}$$

With: **N(t):** number of survivors at time t; **N0:** number of individuals at time 0; and **Z:** constant.

In this work, we estimated the parameters M, F and Z using different routines of the Software FISAT II. This application requires, as input, the growth parameters (L∞ and K).

Total mortality (Z)

The total mortality rate can be considered as the sum of the fishing and natural mortality rates. It varies according to size class and to the number of cohorts in a population. This rate is influenced by growth the parameters and water temperature in the study area. Z can be determined by different methods such as:

Jones/van Zalinge curve.[26,27]

It is possible to estimate the total mortality Z by referring to this curve which is incorporated in FISAT II. It allows the comparisons between the results obtained. Z can be determined from the average lengths using FISAT routines.

Beverton and Holt Model.[28]

This model is applied primarily to long-lived, slow-growing fish. For these species, the value of total mortality is estimated by deploying the following mathematical formula:

$$Z = K * (L\infty - L\ mean) / (L\ mean - L')$$

With: **K:** growth rate; **L∞:** asymptotic length; **L':** length "cut-off length"; **L mean**: mean length.

Method of Ault and Ehrhardt.[29,30]

Unlike the previous method, this model is applied to short-living species. The parameters needed for the calculation of Z are L∞, K, "cut-off length" (L'), mean length (L mean) and maximum length (L max).

With:

$$(L\infty - L\ max / L\infty - L')Z/K = [Z(L' - L\ mean) + K(L\infty - L\ mean)]/[Z(L\ max - L\ mean) + K(L\infty - L\ mean)]$$

Hoenig's model.[31]

This method is used when the maximum age of the fish is identified during the sampling operations. The following formula is used to estimate Z.

$$Ln\,(Z) = 1.44 - 0.984\, Ln\,(tmax)$$

Natural mortality (M)

Natural mortality is an important index in stock assessment models. This index describes the number of individuals that die due to disease, predation, aging or fluctuations in ecological parameters. The estimation of M can be made using two methods:

Rikhter and Efanovs Method

This method is based on the knowledge of t mass which is defined as the age in years of mass maturity of fish. The mathematical formula used to estimate M is:

$$M = (1.52\ /\ t\,(mass)\ 0.72) - 0.16$$

Pauly's Method

The formula that describes this method is the following:

$$log\ M = -0.0066 - 0.279 log\,(L\infty) + 0.6543\, log\,(k) + 0.4634\, log\,(T)$$

With: L∞: asymptotic length that the fish can reach it; K: growth rate; T: mean annual temperature.

Fishing mortality (F)

This parameter remains interesting for the evaluation of stocks, since it gives accurate information on the level of exploitation of the fishing populations. F is estimated by a routine in FISAT II. This is based on the catch-at-length curve. This method allows the estimation of F, E (= F/Z) and M, following the introduction of the mean annual temperature of the habitat (in °C) and the probability of capture for each length group of fish in the input data needed to run the model.

Results and discussion

Population dynamics of the mullet *Chelon ramada*

Size structure: The size range of the captured mullet is varied between the two studied reservoirs ($p<0.05$). Sizes ranged from 18.5 to 46 cm in Siliana Reservoir and from 19.6 to 43 cm in Kasseb Reservoir (Figure 2 & 3). The population sampled during the spring season is made up exclusively of immature specimens. The average length of the captured specimen's ranges is around 29.42 cm in Siliana. In Kasseb, mullets show a more important annual development with an average length about 31.25 cm. This variability may be due to environmental conditions favorable to mullet growth or to less fishing pressure at Kasseb Reservoir.

Estimation of growth parameters

Fish growth is influenced by biotic and abiotic factors. Abiotic parameters refer to extrinsic factors such as dissolved oxygen and water temperature that act directly on the physiology and growth of the fish fauna and on its reproduction.[32] In order to evaluate the differences in growth rates between mullet from the two reservoirs, we determined the growth parameters of this species using several methods (Table 2).

In this study, the age classes of the individuals caught vary from 0+ to 3+. The number of specimens of C. ramada caught during the sampling operations shows great age variability ($p<0.05$).

Comparison of growth parameters between mullets from the two Reservoirs affirms that *C. ramada* from Siliana has a higher asymptotic length compared to Kasseb. This length is very close to the maximum size caught. However, the asymptotic weight, the fish attains, is more important at Kasseb. The comparison of the Von Bertallanfy growth parameters estimated for *C. ramada* in Siliana and Kasseb with other studies conducted in other areas are presented in table 3. These results show that L∞, K and T0 obtained are comparable to those found by other authors.

The growth rate of mullet in the studied reservoirs is slightly higher compared to other regions. This difference may be explained by variability in biotic and abiotic factors between these environments. Mili *et al.*[3] have found that the maximum age for *L. ramada* is 10 years corresponding to a total length ranging from 52.9 cm to 58.0 cm. These authors reported that *C. ramada* reached an asymptotic size of 58.5 cm, 57 cm and 48.6 cm respectively in Sidi El Barrak, Seliana and Kasseb Reservoirs.[1] Losse *et al.*[37] revealed that only *M. cephalus* and *L. ramada* are present in the reservoirs of Sidi Salem and Bir Mcherga. Furthermore, these authors demonstrated that the maximum age recorded for *L. ramada* is 8 years.

The differences observed in growth rate of mullet in the Tunisian reservoirs are probably due to the effect of temperature, salinity, quantity of food available, population density, fishing season and ripening stage in freshwaters.[3] Numerous studies carried out in different regions reported that the growth variability observed in Mugilidae may be due to different environmental conditions and to migration, which favors mixing between migrant and local populations.[38,7,12] However, differences in growth rate according to the genetic origin of stocks are not excluded.[12]

Biometric relationships

The biometric study was conducted to determine the following morphometric relationships: total length-standard length (TL-ST), total length-fork length (TL-FL) and total length-total weight (TL-TW). All the equations of the biometric relations are summarized in the following table (Table 4).

Table 2 Estimation of growth parameters for *C. ramada* in Siliana and Kasseb Reservoir

Estimation Method	Siliana Reservoir			Kasseb Reservoir		
	L∞	K	Φ'	L∞	K	Φ'
ELEFAN	57.05	0.31	3.061	48.65	0.46	3.037
SHEPHERD	50	0.46	3.061	48.60	0.46	3.036
POWELL	46.75	0.46	3.002	48	0.46	3.025
Von Bertallanfy Equation	$Lt = 57.05(1-e^{-0.31(t+0.048)})$ $Wt = 708.24(1-e^{-0.31(t+0.048)})^{2.880}$			$Lt = 48.65(1-e^{-0.46(t-0.02)})$ $Wt = 874.49(1-e^{-0.46(t-0.02)})^{2.675}$		

L∞, asymptotic length; **K,** growth coefficient; **Φ',** growth performance index; **Lt,** length of the fish at age t, **Wt:** weight of the fish at age t.

Table 3 Comparison of estimated growth parameters for *Chelon ramada*

L∞	K	T_0	Total	Equation	Study area	Reference
57.05	0.31	0.048	143	$Lt=57.05(1-e^{-0.31(t-0.048)})$	Siliana Reservoir	The current study
48.65	0.46	0.02	14	$Lt=48.65(1-e^{-0.46(t-0.02)})$	Kasseb Reservoir	The current study
58.05	0.25	0.005	65	$Lt=58.05(1-e^{-0.25(t-0.005)})$	Sidi el Barrak Reservoir	Mili et *al.*,[3]
53	0.21	-0.18	166	$Lt=53(1-e^{-0.21(t+0.18)})$	Ichkeul Lake	Kraim et *al.*,[33]
54.6	0.22	-0.07	74	$Lt= 54.6(1-e^{-0.22(t+0.07)})$	Edku Lake (Egypte)	Kraim et *al.*,[33]
50.7	0.20	-0.31	53	$Lt=50.7(1-e^{0.20(t+0.31)})$	Merja Zargua (Maroc)	Kraim et *al.*,[33]
48.9	0.21	-1.01	120	$Lt=48.9(1-e^{-0.21(t+1.01)})$	Gökova Bay (Turquie)	Kasimoglu et *al.*,[34]
59.96	0.26	-0.45	362	$Lt=59.96(1-e^{-0.26(t+0.45)})$	Neretva delta River (Croatia)	Glamuzina et *al.*,[35]
53.44	0.12	-1.5	419	$Lt=53.44(1-e^{-0.12(t+1.5)})$	Tagus River (Portugal)	Almeida *et al.*,[36]

L∞, asymptotic length; **K,** growth rate; **T0,** theoretical age of the fish when its length is zero; **Lt,** length of the fish at time t.

Table 4 Comparison of the biometric relations in *C. ramada* in Siliana and Kasseb Reservoir

Reservoir	Equation	a	b	R^2	T	P	Allometry
Siliana	TL = 0.6688SL+4.883	0.668	4.883	0.713	6.84	S	+
	TL=0.8855 FL+0.9674	0.885	0.967	0.813	12.47	S	-
	TW =0.3524 $TL^{2.8808}$	0.352	2.880	0.719	5.39	S	-
Kasseb	TL= 0.7909SL+1.6999	0.790	1.699	0.997	6.24	S	+
	TL= 0.8606 FL+1.7587	0.860	1.758	0.996	8.62	S	+
	TW=0.0267$TL^{2.6769}$	0.026	2.676	0.994	11.24	S	-

A, intercept ; b, allometry coefficient; **R^2,** coefficient of determination; **TL,** total length; **FL,** fork length; **TW,** total weight; **SL,** standard length ; **T,** student t-test; **P,** p-value of t-test ; **S,** significance.

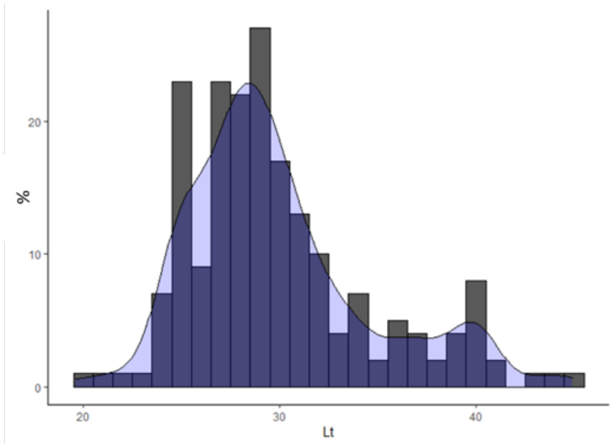

Figure 3 Size frequency distribution of *C. ramada* in Kasseb Reservoir.

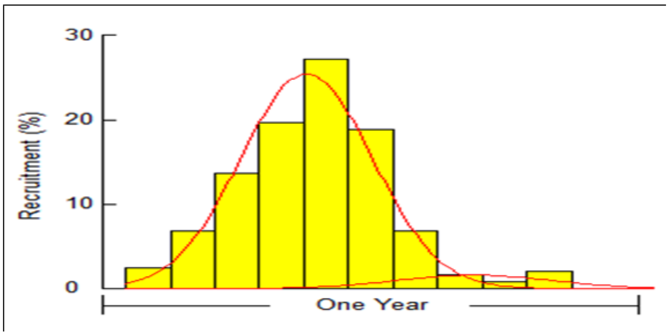

Figure 4 Histogram of *C. ramada* recruitment for a period of one year at Siliana Reservoir.

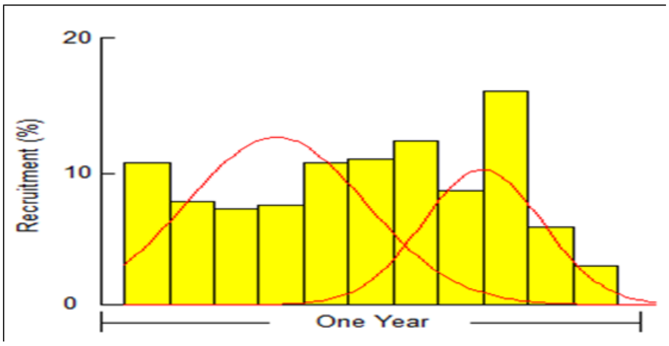

Figure 5 Histogram of *C. ramada* recruitment for a period of one year at Kasseb Reservoir.

The relationship between total length and standard length shows allometry coefficients greater than 1 for mullets from Siliana and Kasseb ($t = 3.61$, $P < 0.05$), which allows to affirm the presence of a positive allometry between these parameters. The relationship linking the total length to the fork length displays a negative allometry for the mullets from Siliana, while it is positive in Kasseb. The coefficients of determination reveal the existence of a strong link between the different lengths for mullets in these reservoirs. The relationship between total length and total weight shows a negative allometry for Mullet in both reservoirs, reflecting a faster growth in the cube of length compared to weight. The *b* value was significantly lower than the theoretical value of 3 in Siliana (t = 5.28, $P < 0.05$) and Kasseb reservoir (t = 3.33, $P < 0.05$).

Estimation of recruitment

In order to estimate the maximum recruitment rate for *C. ramada* in the studied reservoirs, we analyzed the histograms of recruitment versus time (Figure 4 and 5). The obtained figures demonstrated that the maximum level of mullet recruitment is reached within the 5th sub-group in May. During this period, 27.15% and 10.79% of the population were new recruits respectively in Siliana and Kasseb. The second group presented a maximum rate of recruits within the 4th sub-group in September, for the mullets in Siliana and for the 5th sub-group in October, for the mullets in Kasseb. Moreover, we noted a very low recruitment rate at Siliana when compared to Kasseb with respective percentages of about 1.80% and 15.89%.

The optimal size of mullet capture (Lopt) is equal to 37.62 cm for M = 0.48, $L\infty$ = 57.05 and K = 0.31 at Siliana. Lopt is about 31.42 cm in Kasseb for M = 0.795, $L\infty$ = 48.15 and K = 0.31.

The minimum size observed is approximately 18 cm and 19.6 cm respectively in Siliana and Kasseb. These sizes appear to be consistent with the recruitment size 'Lr'. This observation can be explained by the optimal state of exploitation of these resources or by the absence of mullet reproduction in freshwater reservoirs.

Mortality

The Virtual Population Analysis (VPA), integrating all the parameters of the dynamics; such as asymptotic length, growth rate, fishing and natural mortality rates, as well as the values of 'a' and 'b' of the lenght-weight relationship, allowed us to elucidate the level of exploitation and the state of the mullet populations in the two reservoirs.

The following graphical illustrations are used to determine F and M for each size and age class. The fish captured during the sampling operations represent only 2 to 10% of the total existing population. Mullet stocks are dominated by specimens with sizes between 18cm and 28 cm in Siliana and between 19cm and 30 cm in Kasseb Reservoir (Figure 6, and 7). The results obtained show that the number of survivors is high compared to the number of fish affected by fishing mortality in both reservoirs.

At Siliana Reservoir, fishing mortality (F) is higher in the larger size classes. Fish between 28-32 cm and 38 cm have respective fishing mortality rates of 4.5 and 3. Individuals aged 4.6 and 5 years are the most affected by F, which indicates that adult specimens are the most vulnerable to fishing gear and the most targeted.

Natural mortality (M) affects individuals with a size between 18 and 24 cm (1 or 2 years old). In fact, these species are very sensitive to the physicochemical parameters of the water, which explains the high natural mortality rate.

At Kasseb Reservoir, fishing mortality affects mainly fish with length varying between 22 and 39 cm (age between1.7 and 3 years). Natural mortality affects the young individuals of the mullet population (1year old).

Gophen and Snovsky's[39] study showed that the calculated factor of natural mortality, with respect to growth rate and landing statistics, gives a similar survival rate: 27 % of stocked fingerlings recruited into the "catchments categories" for *C. ramada*.

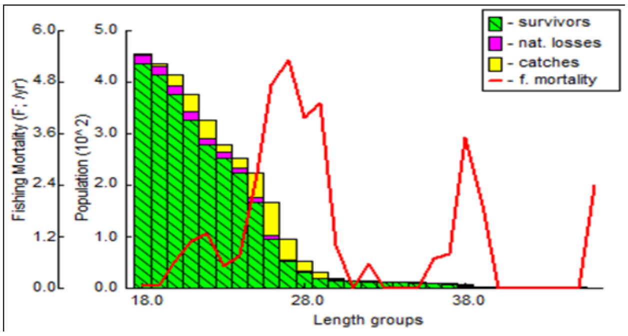

Figure 6 Mortality evolution based on *Chelon ramada* size structure in Siliana Reservoir.

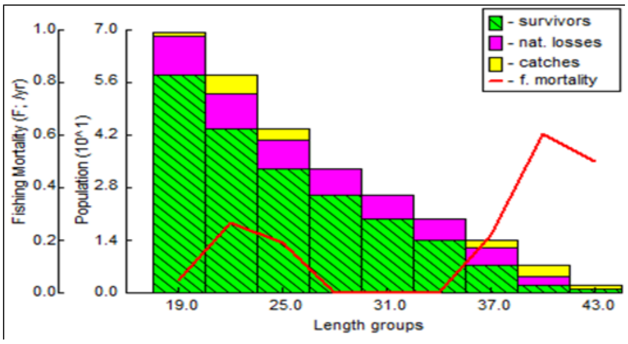

Figure 7 Mortality evolution based on *Chelon ramada* size structure in Kasseb Reservoir.

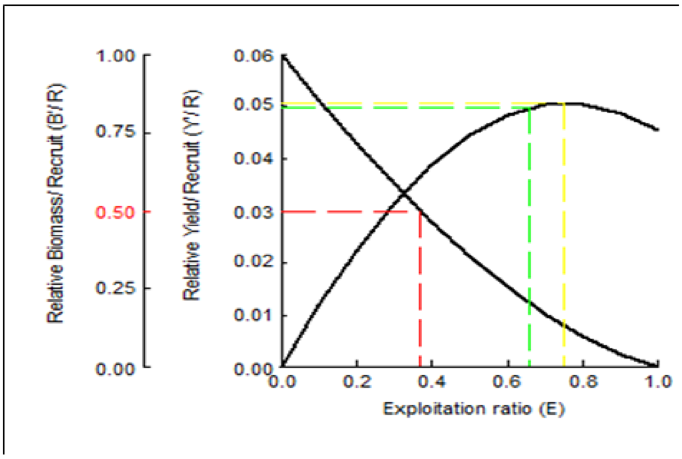

Figure 8 Graphical representation of the biomass and yield evolution per recruit of *Chelon ramada* in Siliana Reservoir.

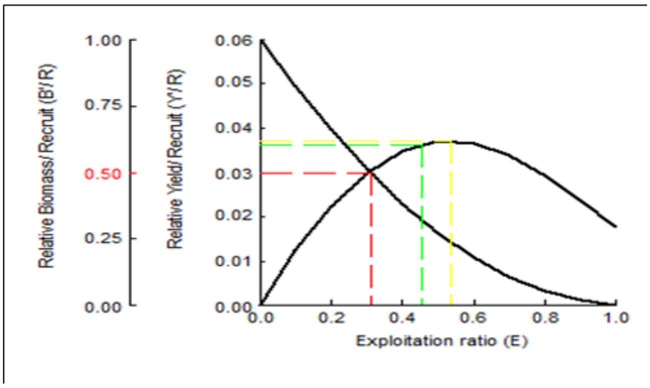

Figure 9 2D Graphical representation of the biomass and yield evolution per recruit of *Chelon ramada* in Kasseb Reservoir.

Exploitation level estimation

Analyses of the stocks of mullet in the two reservoirs led to the identification of the exploitation level of these resources (Figure 8 and 9). The figures above show that the relative biomass curve B'/R gradually decreases with the increase of the mullet exploitation level. The current yield per recruit Y'/R is about 0.0375 in Kasseb and 0.0498 at Siliana. The relative biomass per recruit B'/R in Siliana is around 0.249 per unit of effort, while it is around 0.376 in Kasseb. The predictive value Emax, which corresponds to an operation with maximum efficiency, is estimated at 0.73 in Siliana and 0.54 in Kasseb.

Conclusion

Freshwater fish is the most exploited halieutic resource with an impact on the economy as well as the environment and species' biodiversity. However, the identification of biological parameters, such as growth, reproduction and mortality of these fish species are limited due to the scarcity of scientific research conducted in Tunisian reservoirs.

The comparison of growth parameters estimated by the Von Bertallanfy Model for *Chelon ramada* in two reservoirs shows a linear growth and weight gain in favor of the specimens collected from Siliana compared to those taken from Kasseb. However, the cessation of the fry stocking operations in Kasseb will ultimately have bad economic consequences on the fishermen's incomes and on the ecosystem.

The present work has shown that the eco-biological conditions are favorable for the growth of *Chelon ramada* in Siliana Reservoir compared to other freshwater reservoirs in Tunisia.[3,40] Besides, the fishing mortality rate is higher in Siliana compared to Kasseb Reservoir.

The lack of reliable fisheries statistics can be considered as a major handicap which hinders the development of freshwater fish farming in Tunisia. The reported statistics for freshwater fish, particularly for mullet, and the confusion and uncertainty over species are criticized by both professionals and scientists. In fact, the reliability of the studies based on these data.[41] is limited. Additionally, in Tunisian reservoirs, the data which have been acquired with regard to fish distribution patterns.[41] remain insufficient. This information is necessary, to improve our understanding of the stocks and reform fisheries management.[42]

The good growth rate of mullet species entails that these resources have a significant production potential. Development of mullet fishery should therefore be supported, especially because the juveniles have a good growth rate.[3] Moreover, after reservoirs are stocked with mullet fry, whether from hatcheries or natural sites, their exploitation should be encouraged.

Acknowledgements

This work is part of a collaborative project involving the Technical Centre of Aquaculture, the Higher Institute of Fisheries and Aquaculture, Bizerte, and the General Directorate of Fisheries and Aquaculture, Tunisia. We are most thankful for the Institution of Agricultural Research and Higher Education (IRESA) that has provided financial support for the research project (AMBISEPT) which in turn led to the realization of this research. We also would like to thank TCA technical staff and students from ISPA Bizerte for their efforts in the practical part of this work.

Conflicts of interest

Authors declares there are no conflicts of interests.

References

1. FAO. La Situation Mondiale des Pêches et de l'Aquaculture 2020. 2020.
2. DGPA (Direction Generale de la Pêche et de l'Aquaculture). Annulaire des Statistiques des peches et aquaculture en Tunisie, Ministere de l'agriculture. 2020.
3. Mili S, Ennouri R, Laouar H, et al. Study of age and growth of two species of Mugilidae (Mugil cephalus and Liza ramada) in the reservoirs of three Tunisian dams. *Bulletin de la Société zoologique de France*. 2015;140(3):181–197.
4. Mili S, Ennouri R, Dhib A, et al. Characterization of fish assemblages and population structure of freshwater fish in two Tunisian reservoirs: implications for fishery management. *Environmental Monitoring and Assessment*. 2016;188(6):364.
5. Chargui T, Fatnassi M, Ennouri R, et al. Exploring freshwater fish assemblages and population structure in three Tunisian reservoirs for better fishery management. *Biodiversity Int J.* 2021;5(2):37–45.
6. CTA. Rapport technique des activités du Centre Technique d'Aquaculture en Tunisie. *CTA Tunisie*. 2013;49.
7. Fehri Bedoui R, Gharbi H. Age and growth of *Chelon aurata* (Mugilidae) along Tunisiancoasts. *Cybium*. 2005;29(2):119–126.
8. Gautier D, Hussenot J. European sea mullets: synthesis of knowledge on the biological basis and aquaculture techniques [2005]. Éditions *Quae*. 2005;119.
9. Whitfield A, Panfili J, Durand JD. A global review of the cosmopolitan flathead mullet *Mugil cephalus* Linnaeus 1758 (Teleostei: Mugilidae), with emphasis on the biology, genetics, ecology and fisheries aspects of this apparent species complex. *Rev. Fish Biol. Fish*. 2012;22:641–681.
10. Crosetti D. Current State of Grey Mullet Fisheries and Culture. In Biology, Ecology and Culture of Grey Mullets (Mugilidae). *CRC Press: Boca Raton, FL, USA*. 2016;23:398–450.
11. Abou Gabal AA, Abbas EM, Ali HMM, et al. Molecular Identification of Grey Mullet species in the Mediterranean Sea of Egypt. Egypt. *J. Aquat. Biol. Fish*. 2018;22:125–139.
12. Abo Taleb HA, El feky MMM, Azab AM, et al. Growth Performance, Feed UtiChelontion, Gut Integrity, and Economic Revenue of Grey Mullet, *Mugil cephalus*, Fed an Increasing Level of Dried Zooplankton Biomass Meal as Fishmeal Substitutions. *Fishes*. 2021;6(3):38.
13. Soudoud. Specific database of large dams in Tunisia. General Directorate of Dams and Major Hydraulic Works. *Ministry of Agriculture and Water Resources*. Tunisia. 2006.
14. Gayanilo FC, Sparre P, Pauly D. Microhabitat Use and Population Structure of a Chinese Kissing Loach, Leptobotia tchangi, in the North Tiaoxi River, China. 2014;4(7):190.
15. Sidibé A. Guinea's coastal demersal fishery resources: exploitation, biology and dynamics of the main species of the Sciaenidae community. 2003;320.
16. Pauly D, Munro JL. Once more on the comparison of growth in fish and invertebrates. *Fishbyte*. 1984;2(1):1–21.
17. Pauly D. A simple method for estimating the food consumption of fish populations from growth data and food conversion experiments. *United States Fishery Bulletin*. 1986;4(4):827–842.
18. Powell DG. Estimation of mortality and growth parameters from the length frequency in catch. *Rapp P V Reun. Cons Int Expl Mer*. 1979;175:167–169.
19. Wetherall JA. A new method for estimating growth and mortality parameters from length-frequency data. *Fishbyte*. 1986;4:12–14.
20. Kvalseth TO. Cautionary note about r2. *American Statistician*. 1985;39:279–285.
21. Vakily JM. Determination and comparison of bivalve growth, with emphasis on Thailand and other tropical areas. ICLARM Technical Reports. 1992;36 :125.
22. Saila SB, Recksiek CW, Prager MH. Basic fishery science programs. Elsevier science. 1988;230.
23. Soriano ML, Jarre A. On fitting Somers' equation for seasonally oscillating growth, with emphasis on t-subzero. *Fishbyte*. 1988;6(2):13–14.
24. Mili S, Jaroui O, Missaoui H. Caractères biométriques de la squille Squilla mantis dans les eaux tunisienne. *Bull. Inst. Natn. Tech. Mer de Salammbô*. 2008;35:1-14.
25. Le Cren ED. The length weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*. 1951;20(2):201–219.
26. Jones R. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). *FAO Fish.Tech.Pap*. 1984;256:118.
27. Jones R, Van Zalinge NP. Estimations of mortality rate and population size for shrimp in Kuwait waters. *Kuwait Bull Mar Sci*. 1981;2:273–288.
28. Beverton RJH, Holt SJ. A review of methods for estimating mortality rates in exploited fish populations with special reference to sources of bias in catch sampling. *Rapp. P. V. Reun Cons Int Expl Mer*. 1956;140:67–83.
29. Ault JS, Ehrhardt NM. Correction to the Beverton and Holt Z-estimator for truncated catch length-frequency distributions. *ICLARM Fishbyte*. 1991;9(1):37–39.
30. Ehrhardt NM, Ault JS. Analysis of two length based mortality models applied to bounded catch length frequencies. *Transactions of the American Fisheries Society*. 1992;121:115–122.
31. Hoenig JM. Estimating mortality rate from the maximum observed age. ICES. 1982;10.
32. Djemali I. Evaluation de la biomasse piscicole dans les plans d'eau douce tunisiens: approche analytique et acoustique. Institut National Agronomique de Tunisie: Tunisie. Thèse de Doctorat en Sciences Agronomiques. 2005;250.
33. Kraïem MM, Ben Hamza C, Ramdani M. Some observations on the age and growth of thin-lipped grey mullet, *Chelon ramada* Risso, 1826 (Pisces, Mugilidae) in three North African wetland lakes: Merja Zerga (Morocco), Garâat Ichkeul (Tunisia) and Edku lake (Egypt). *Aquatic Ecology*. 2001;35:335–345.
34. Kasimoğlu C, Yilmaz F, Torcu Koç H. Growth and Reproductive Characteristics of the Thin lipped Grey Mullet, *Liza ramada* (Risso, 1826) Inhabiting in Gökova Bay (Gökova Bay (Muğla), the Southern Aegean Sea, Turkey. *Balikesir* Üniversitesi *Fen Bilimleri Enstitüsü Dergisi Cilt*. 2011;13(2):35–49.

35. Glamuzina B, Dulčić J, Conides A, et al. Some biological parameters of the thin-lipped mullet, *Liza ramada* (Pisces, Mugilidae) in the Neretva River delta (Eastern Adriatic, Croatian coast). *Vie et Milieu*. 2007;57(3):131–136.

36. Almeida PR, Moreira FM, Domingos IM, et al. Age and growth of *Liza ramada* (Risso, 1826) in the River Tagus, Portugal. *Scientia Marina*. 1995;59(2):143–147.

37. Loss GF, Nau W, Winter M. The development of freshwater fisheries in northern Tunisia. Study carried out within the framework of Tunisian-German technical cooperation. *GTZ GmbH: Tunisia*. 1991.

38. Quignard JP, Farrugio H. Age and growth of grey mullet. In: *Aquaculture of grey Mullets*, (Oren O.H., ed.), International Biological Program 26 Cambridge, Cambridge Univ Press; 1981. 155–184 p.

39. Gophen M, Snovsky G. Silver Carp (*Hypophthalmichthys molitrix*, Val. 1844) Stocking in Lake Kinneret (Israel). *Open Journal of Ecology*. 2015;5(8):343–351.

40. Mili S, Ennouri R, Laouar H, et al. Freshwater Fish Farming and Fishery Management in Tunisian Reservoirs: Limitations and Opportunities. In: Khebour Allouche F, Abu-hashim M, Negm AM. (eds) *Agriculture Productivity in Tunisia under Stressed Environment*. Springer Water. Springer, Cham; 2021.

41. Mili S, Ennouri R, Laouar H, et al. Fisheries in the Tunisians dams: diagnosis of the current situation and development opportunities. *FAO Fish and Aqua Proceedings*. 2015;39:95–106.

42. Djemali I, Laouar H, Toujani R. Distribution patterns of fish biomass by acoustic survey in three Tunisian man-made lakes. *Journal of Applied Ichthyology*. 2010;26(3):390–396.

Citation: Mili S, Ennouri R, Fatnassi M, et al. Variability of Biological Features of a *Mugilidae Chelon Ramada* in Two Tunisian Reservoirs. *J Aqauc Mar Biol.* 2022;11(2):41–48. DOI: 10.15406/jamb.2022.11.00335