VIE ET MILIEU - LIFE AND ENVIRONMENT, 2007, 57 (3) : 7-13

SOME BIOLOGICAL PARAMETERS OF THE THIN-LIPPED MULLET *LIZA RAMADA* (PISCES, MUGILIDAE) IN THE NERETVA RIVER DELTA (EASTERN ADRIATIC, CROATIAN COAST)

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MUGILIDAE
LIZA RAMADA
AGE
GROWTH
MORTALITY
REPRODUCTION

ABSTRACT. – Aspects concerning age, growth, reproduction and recruitment were analysed in the thin-lipped mullet, *Liza ramada*, collected in Neretva River delta estuary (East Adriatic, Croatian coastline). The study was based on the collection of a total of 362 individuals on a monthly basis. The von Bertalanffy growth curve parameters were estimated: TL_∞ = 59.96 cm, K = 0.269 year^{-1}, t_0 = -0.455. Natural mortality was estimated at 0.32 year^{-1}. Total mortality (Z) was estimated at 0.70 year^{-1} (range 0.55-0.85 year^{-1}). Fishing mortality was estimated at 0.38 year^{-1} and the exploitation ratio at E = 0.54. The gonado-somatic index profile shows a single peak during the year in October. The sex ratio profile shows skewed sex ratios throughout the year except the period prior to reproduction peak. This *L. ramada* population is suggested to be in good status.

INTRODUCTION

Mullets (Mugilidae) are among the most common species from tropical and temperate marine coastal waters in the world and constitute a fundamental protein resource for a number of human populations living in coastal areas (Nelson 1994). The thin-lipped mullet, *Liza ramada* (Risso, 1826) is a pelagic species inhabiting various habitats, from shallow brackish and marine waters close to lagoons, estuaries and river deltas, and surviving in extreme salinity conditions as well as abrupt changes of water quality (Thomson 1990). It is found along East Atlantic coasts, the Mediterranean and the Black Sea (Fischer *et al.* 1987).

Thin-lipped mullet is a valuable species in the area of Neretva River estuary (eastern Adriatic Sea, Croatia), and it is considered as a target fishery for the artisanal fishermen. The recent increase of population density and summer catches in all water bodies of Neretva River delta (Bartulović & Glamuzina, unpubl data) show that thin-lipped mullet population is in propagation, for unknown reasons. The same observation was made 20 years ago in the Krka River estuary (Modrušan *et al.* 1991), but after uncontrolled fishery with extreme catches, the population level remains low and not of interest for commercial fishery (Dulčić, pers comm). This example shows that a better management policy is needed in order to preserve good population structure and sustainable future fishery of the thin-lipped mullet in the Neretva River estuary.

This paper presents results on the growth, mortality, reproduction and morphometry of the thin-lipped mullet, *Liza ramada*, in Neretva River delta as a basic step to launch a modern fishery management strategy for this species.

MATERIAL AND METHODS

The present study was carried out from January to December 2003 in the estuary of the Neretva River, situated on the south-eastern Adriatic coast of Croatia at 40° 52' N; 17° 40' E (Fig. 1). The water mixing leads to daily and seasonal changes in temperature and salinity. Average monthly temperatures varied between 25°C in August and 9°C in February. Water temperature during winter is affected by an inflow of freshwater, which is colder (7.4°C) than sea water (11.4°C). Salinity varied between 10 and 38 psu in Winter, and between 30 and 38 psu in Summer.

Monthly collections of near-shore and estuary samples of thin-lipped mullet were performed. A total of 362 individuals were collected within a period of 1 year. Adult individuals were caught using static nets. The sampled individuals were kept on ice until they were transported to the laboratory for further analysis. Fish were identified by using the identification key of Šoljan (1975). Length measurements were taken using a simple calliper and a ruler for larger individuals. Weight was measured with 2 decimals precision. Fish were gutted in order to remove and measure gonad weight. Sex was recorded as well as the maturity stage (immature, early developing, late developing, ripe, spent). Gonado-Somatic index was estimated as [gonad weight/total weight * 100].

Age was determined by scale reading from the 362 individuals. Scale samples (8-15 scales) were removed from the base of the pectoral fin and below the first dorsal fin and were cleaned in 5% sodium peroxide.

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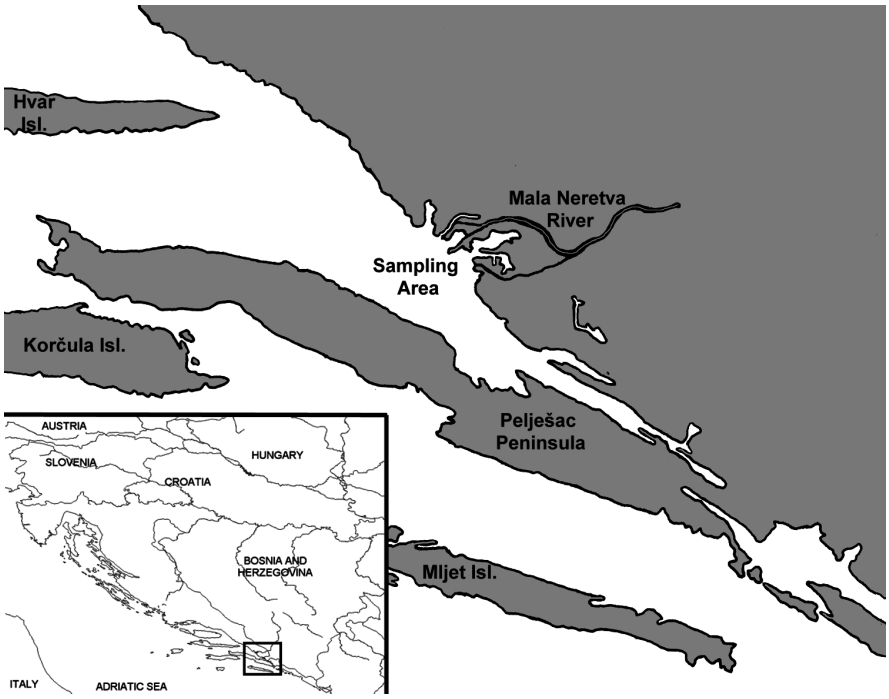

Fig. 1. – Map of the study area: the Neretva River estuary (East Adriatic, Croatian coastline).

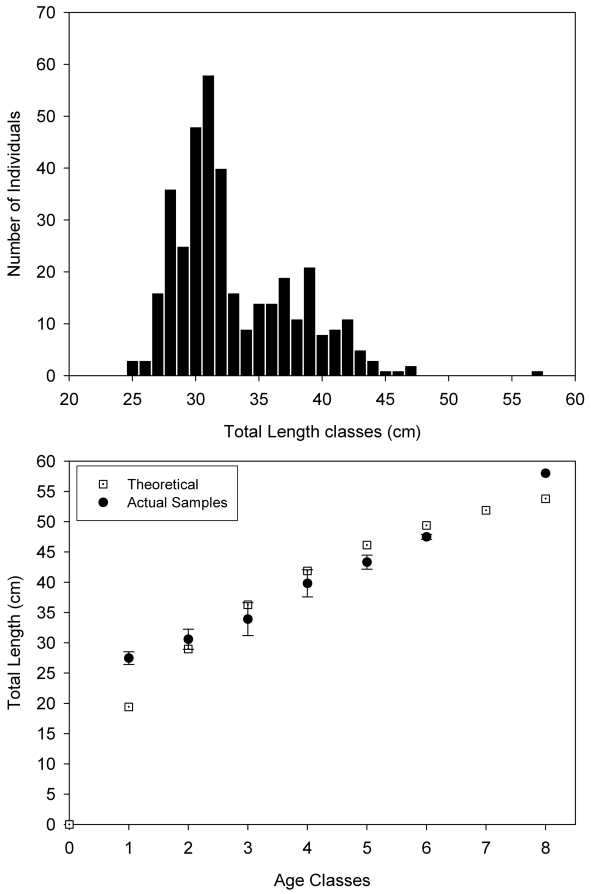

Fig. 2. – Population structure of the thin-lipped mullet, *Liza ramada*, from the Neretva River estuary (a-top), and growth curve (b-bottom).

Growth curve parameters were based on the von Bertalanffy equation (Biradar & Gjosaeter 1989) based on the reading of the annual scale rings.

Natural mortality was estimated using Pauly (1983) empirical formula using the growth curve parameters and the annual average temperature in the area (T = 16.13°C). Total mortality was estimated based on the length-converted catch curve method and the appropriate value was selected based on the smallest statistical range of the final value (Garcia & LeReste 1981, Sparre & Venema 1998). The percentage of non-survivors per year due to natural causes (M) and fishing (F) were estimated according to McCoy (1972).

Size and age at maturity 50% were estimated according to the logistic relationship (Groeneveld, 2000) linking the percentage of mature females to the overall female population using the sample data when the population showed the highest GSI value.

The commonly used length-weight relationship $W = aL^b$ was applied (Ricker 1975), where W is weight, L is total length, and *a* and *b* are constants.

RESULTS

Individual lengths ranged from 245 to 580 mm. The length frequency distribution for all fish is shown on Fig. 2a. The profile is multi-modal showing more than 5 modes. Age analysis based on scale rings examination indicated that samples are composed of individuals with an age varying between 1 and 8 years (Table I). Most fish belong to the 2-4 age classes (92%). Fitting of age data on the von Bertalanffy growth curve provided the following equation:

Table I. – Age analysis of the samples of *Liza ramada* from the Neretva River delta estuary.

	AGE GROUP							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mean TL (cm)	27.5	30.6	33.9	39.8	43.3	47.5		
SD (±)	1.1	1.7	2.7	2.2	1.2	0.4		1.5
Number	14	186	80	67	10	4		1
Percentage (%)	3.87	51.38	22.10	18.51	2.76	1.10		0.28

SD: standard deviation of mean TL

Number: number of sampled individuals belonging to the age group

Percentage: percentage of age group individuals to the total sample

$L = 59.96\ \{1 - e^{-0.269(t + 0.455)}\}$

and the maximum weight was estimated at 2080.44 g, based on the weight-length relationship (Fig. 2b).

Growth curve parameters of the thin-lipped mullet in the study area were $TL_\infty = 59.95$ cm, $K = 0.269$ year^{-1} and $T_0 = -0.455$ years. The maximum age of individuals were 8 years. However, only 5 individuals in the samples were older than 6 years old, therefore, it was difficult to provide estimates on the age composition of the population in Neretva delta area for these age classes.

Natural mortality was estimated at 0.32 year^{-1}. Total mortality (Z) was estimated at 0.70 year^{-1} (range 0.55-0.85 year^{-1}). Fishing mortality was estimated at 0.38 year-1 and the exploitation ratio at 54.3%. Based on the mortality data, the percentages of non-survivors were:

From natural causes = $1 - e^{-M} = 27.39\%$

From fishing = $1 - e^{-F} = 22.95\%$

The annual profile of the gonado-somatic index is illustrated in Figure 3a. The profile shows a single yearly peak in October, when GSI was 8.33% for females, 2.55% for males and 5.44% for both sexes. Estimation of the gonado-somatic index of mature females per age showed that the highest GSI values were obtained when fish were 6 years of age and above (Fig. 3b).

The whole sample was made of 51% female and 49% males. The annual profile of the sex ratio in Neretva river delta is illustrated in Fig. 4. The profile shows skewed sex ratios throughout the year. However, sex ratio becomes close to 1:1 in the period prior of reproduction indicating the timing of gathering of the fish in the reproductive grounds.

Length-weight relationships estimations are the following:

Overall Population

$W = 0.004\ (TL)^{3.180}$, $r^2 = 0.947$, ± 59.06 g

$W = 0.030\ (SL)^{2.821}$, $r^2 = 0.951$, ± 57.12 g

Males

$W = 0.014\ (TL)^{2.852}$, $r^2 = 0.957$, ± 43.99 g

$W = 0.049\ (SL)^{2.667}$, $r^2 = 0.942$, ± 48.61 g

Females

$W = 0.003\ (TL)^{3.278}$, $r^2 = 0.951$, ± 66.6 g

$W = 0.055\ (SL)^{2.590}$, $r^2 = 0.948$, ± 67.82 g

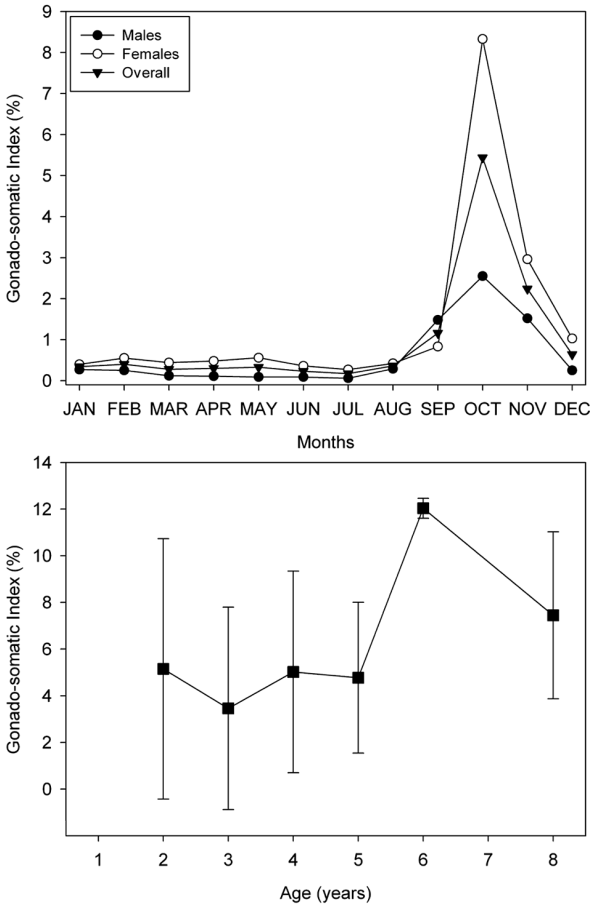

Fig. 3. – Annual gonado-somatic index (GSI) profile of *Liza ramada* from the Neretva River estuary (a-top) and correlation between GSI values of mature females per age (b-bottom).

DISCUSSION

The age of 8 years we found is close to the known longevity of the species, estimated to 10 years (Thomson 1990). The maximum known TL is 70.0 cm and the maximum weight is 2900.0 g (Thomson 1990). In this study, the maximum length was estimated at 59.95 cm and the corresponding weight is 2 kg. In Table II, the known

Table II. – Growth parameter comparison in *Liza ramada.*

Locality	L_∞ (cm)	Length used	K	Temperature (°C)	Reference
France	31.60	SL	0.330	17.20	Autem 1979
Tunisia	31.60	TL	0.450	19.00	Farrugio 1975
Greece	33.50	SL	0.352	19.00	Koutrakis & Sinis 1994, Stergiou *et al*. 1997
Tunisia	40.50	TL	0.310	19.00	Farrugio 1975
Greece	45.90	SL	0.175	19.00	Koutrakis & Sinis 1994, Stergiou *et al.* 1997
France	47.00	SL	0.150	17.20	Campillo 1992, Autem 1979, Djabali *et al.* 1993
Tunisia	47.80	TL	0.320	17.00	Chauvet 1986, Djabali *et al.* 1993
Portugal	51.393	TL	0.107	-	Moura & Gordo 2000
Morocco	50.70	TL	0.205	21.00	Kraïem *et al*. 2001
Tunisia	53.00		0.218	19.40	
Egypt	54.60		0.229	20.00	
Croatia	**59.30**	**TL**	**0.140**	**16.13**	**Present study**

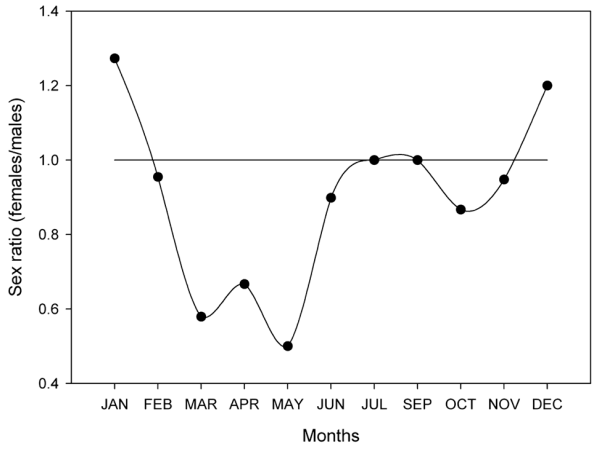

Fig. 4. – Annual sex ratio profile of *Liza ramada* from the Neretva River estuary.

information on the growth parameters for the species is summarised. Our results suggest that the population of the Neretva river delta includes more age classes in comparison to other coastal areas. The average K value for the species is 0.15 year^{-1} (Thomson 1990) and varies between 0.11 and 0.45 year^{-1} which is in accordance to the findings of this study. The K values reported in the literature (Table II) are higher but this may be due to the fact that growth analysis of these populations included young individuals (mainly between 0 and 4 years old), probably leading to an overestimation of the K value. For the same reason, low TL_∞ values are expected (Table II).

Natural mortality level estimated in this study was 0.32 year^{-1}. This is close to the known levels of M for the species (0.39 year^{-1}; Farrugio 1975). Total mortality was estimated to 0.70 year^{-1} and can be considered as a high value. This high mortality level can probably be explained by the high value of fishing mortality (0.38 year^{-1}) due to the intensive fishing in this area by coastal and artisanal fishermen. The exploitation ratio is equally high and reaches 54.3%.

The spawning season of the thin-lipped mullet in the Neretva River delta area is short and exhibits peaks in the October-November period according to the gonado-somatic index profile. The literature is divided on this issue but suggests a geographical effect on the spawning season peak and duration. The populations from the Atlantic coast of Europe spawn from June to August while the Mediterranean populations spawn later, between September and February (Maitland & Campbell 1992, Keith & Allardi 2001, Billard 1997). However, more variations have been found for example in Bristol Channel where species spawn between April and June (Claridge & Potter 1985). The spawning period observed in this study is in accordance to the known information for the Mediterranean region, but is very short with a single peak in October. According to Maitland & Campbell (1992), regardless of the spawning season, *L. ramada* exhibits one single and very distinct peak per year. Our results are similar to those described by Modrušan *et al.* (1991) for the same species in Krka River estuary (Croatia). The spawning season in Akgöl-Paradeniz lagoon (Turkey) is in November-December (Ergene 2000), while in Crocodile Lake (Egypt) it is extended from October to December (Salem & Mohammad 1983).

Table III. – Summary of known Length-Weight parameters for *Liza ramada.*

Locality	a	b	Sex	Length range	Reference
France	0.0257	2.840	Females		Campillo 1992
Croatia	0.0214	2.934		23.5-59.8 cm TL	Dulcic & Kraljevi_ 1996
France	0.0176	2.940	Males		Campillo 1992
Greece	0.0107	2.948		1.7-7.4 cm TL	Koutrakis & Tsikliras 2003
Greece	0.0110	2.955		1.6-8.3 cm TL	
France	0.0120	3.000			Djabali *et al*. 1993; Autem 1979
Greece	0.0177	3.013		1.5-39.5 cm SL	Koutrakis & Sinis 1994; Stergiou & Moutopoulos 2001
Morocco	0.0184	2.821		12.1-36.7 cm TL	Kraïem *et al*. 2001
Tunisia	0.0057	3.141	All unsexed	12.3-39.0 cm TL	
Egypt	0.0060	3.130		12.2-40.8 cm TL	
Croatia	0.004	3.182	All	25.6-58.0 cm TL	Present study
	0.030	2.821		20.9-52.1 cm SL	
	0.014	2.852	Males	25.6-48.0 cm TL	
	0.049	2.667		20.9-38.7 cm SL	
	0.003	3.278	Females	27.5-58.0 cm TL	
	0.055	2.590		22.2-52.1 cm SL	

The highest GSI value, 8,33%, was found in October. This is much lower than values measured in Turkey (16.67% in November (Ergene 2000)) and 18.96% in November (Yerli 1991), but higher than in Egypt (2.2-4.3% (Salem & Mohammad, 1983)). GSI values per age remained statistically similar during the first 5 years of age. The GSI value for age 6 seems to be higher. However, the small number of individuals in the samples above 6 years of age and the standard deviations suggest this value is an outlier which should be considered with caution, and it can be concluded that the GSI values per age in *L. ramada* remain relatively constant in this study.

The sex ratio of the thin-lipped mullet population in the Neretva River estuary was close to 1:1 for the whole yearly sample, but was significantly skewed throughout the year, except for the period between July and September. A similar situation was already observed in different areas. In Turkey, Ergene (2000) reported 56.72% of females and 43.28% males, and Yerli (1991) 58.57% females and 41.43% males. More then 90% of fish in River Tagus (Portugal) were females (Oliveira & Ferreira, 1997). However, most of these results were not based on monthly sampling throughout the year and are close to our results in most months. Period and habitat where fish were sampled clearly affected sex ratio. Moreover, males and females seems to occupy different areas and to arrive asynchronously in spawning areas. The ratio increases after the spawning season peak as more females leave the coastal areas and appear in the open sea reproduction grounds. Males then seem to move close to the coast faster than females, leading sex ratio to decrease and remain biased toward males until the next spawning season. The faster migration of males to coastal areas may be due to the high energetic cost of reproduction for females, which in turn affects their migration speed towards their usual feeding grounds close to the coast.

The length-weight relationships show allometry as b values are different from 3. Known data reported in the literature are summarised in Table III. In comparison to previous studies (Table III), the values obtained in this study are similar or higher. The difference in morphometric coefficient between males and females can be related to the completely different length and weight distributions. In particular, males range from 25.6 to 48.0 cm in TL and 162 to 936 g in weight, while the females range from 27.5 to 58.0 cm in TL and 190 to 2350 g in weight. Although TLs clearly overlap, weight ranges are different. According to the ANCOVA based on the log-transformed TL and weight values, 90% of the variance is explained by a single model, suggesting that males and females come from the same population. Statistical analysis of slopes and intercepts of both models indicates they are similar ($F = 3118.56$, $df = 1$, $p = 0$).

We conclude that the thin-lipped mullet population from the Neretva delta estuary is in good status, even when exploited by artisanal fishery for which we estimated a very high exploitation ratio. This suggests to not involve commercial companies in this fishery activity in

order to preserve the thin-lipped mullet traditional and local artisanal fishery in the Neretva River estuary. Our results also point to need to protect this species during spawning migrations in the September-October period, at least during the main Neretva River flow, in order to secure future spawning.

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Received January 27, 2006
Accepted October 17, 2006