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Recruitment and feeding of juvenile leaping grey mullet, *Liza saliens* (Risso, 1810) in the Neretva River estuary (south-eastern Adriatic, Croatia)

Vlasta BARTULOVIĆ[1], Sanja MATIĆ-SKOKO[5] , Davor LUČIĆ[2], Alexis CONIDES[3], Nenad JASPRICA[2], Aleksandar JOKSIMOVIĆ[4], Jakov DULČIĆ[5] and Branko GLAMUZINA[1*]

[1] Department of Aquaculture, University of Dubrovnik, Ćira Carića 4, 20000 Dubrovnik, Croatia

[2] Institute for Marine and Coastal Research, University of Dubrovnik, Kneza Damjana Jude 12, 20000 Dubrovnik, Croatia

[3] Hellenic Centre for Marine Research, Agios Kosmas, Hellinikon, 16604 Athens, Greece

[4] Institute for sea biology, P.O.Box 69, 85330 Kotor, Montenegro

[5] Institute of oceanography and fisheries, P.O.Box 500, 21000 Split, Croatia

**** Corresponding author, e-mail: glamuzin@unidu.hr***

The recruitment of leaping grey mullet, Liza saliens *juveniles in the Neretva River estuary (middle eastern Adriatic Sea, Croatia) started in July, was highest in August, decreased in September, and was unobserved later. The juveniles firstly occupied mouths of rivers and channels and then started migrating to more freshwater habitats. By feeding investigation, the harpacticoid copepods were the dominant prey in the stomachs of* L. saliens *juveniles during the period from August to December and nematodes replaced those as the dominant prey from January to April. Plant material in the stomachs started to appear at 24 mm of standard length, and was common prey in fish larger than 26 mm. In comparison with other Adriatic mullet's species, the leaping grey mullet juveniles first started to recruit during July and August, while other grey mullet species appeared later (in September) in the Neretva River estuary. Such intraspecies spawning and recruitment segregation together with the optimal quantity and quality of available and preferable prey could provide an explanation for the recent success and propagation of this species in this area.*

Key words: leaping grey mullet, *Liza saliens,* juveniles, recruitment, feeding, Neretva estuary, Croatia

INTRODUCTION

The Neretva River estuary is the only typical estuary on the eastern Adriatic coast. During the estuary's history, fishery was of the highest economic importance to the local population. However, changes in the estuary's natural properties due to conversion of wetlands into agricultural land and building of large port facilities in the past 50 years significantly modified the composition of fish communities and subsequently influenced the economic importance of the fishery in the delta (GLAMUZINA & GLAMUZINA, 2001). These changes limited available habitats for the recruitment and feeding of many typical estuarine species, with mullet (Mugilidae) being the best example. According to a recent survey on grey mullet recruitment and fisheries in the Neretva River estuary (BARTULOVIĆ, 2006), the leaping grey mullet, *L. saliens* became a dominant species in this area.

The leaping grey mullet is a pelagic species found in various habitats, from shallow brackish and marine waters, to lagoons, estuaries, rivers and freshwater lakes (JARDAS, 1996). However, the economic importance of *L. saliens* is the lowest among the grey mullet species in Adriatic, and its dominance has lead to a lower economic value of mullet fishery in the area. Like most Mugilidae, this species reproduces at sea, after which fry undertake a trophic migration shoreward to continue their development in food-rich lagoons, rivers and even lakes (KOUTRAKIS *et al*., 1994). According to older findings, leaping grey mullet spawns in the south-eastern Adriatic during summer and autumn (JARDAS, 1996), and juveniles appear along the middle Adriatic coast in August (KATAVIĆ, 1980; JUGDUJAKOVIĆ, 1988). In other areas of the Mediterranean Sea the periods of recruitment differ from that mentioned earlier. So, it starts in June in Israel (ZISMANN & BEN-TUVIA, 1975), Greece (KOUTRAKIS *et al*., 1994), and Canal Vell lagoon in Spain (GISBERT *et al*., 1995). Recruitment in the Po River delta (FERRARI & CHIEREGATO, 1981) was recorded in July while in Languedoc-Roussillon lagoons in France (CAMBRONY, 1984) recruitment starts even later, in September - one month later than in the Adriatic Sea. These reveal an obvious latitudinal gradient, with delayed recruitment at higher latitudes for this species distribution in the Mediterranean.

Food type and its availability is of the highest importance for the success of recruitment of fish species. In general, *L. saliens* juveniles with a total length shorter then 35 mm feed mainly on animal prey (ZISMANN *et al*., 1975; FERRARRI & CHIEREGATO, 1981; TOSI & TORRICELLI, 1988; TORRICELLI *et al*., 1988; GISBERT *et al.*, 1995), while longer and older juveniles and adults feed mainly on detritus (DRAKE *et al*., 1984).

This paper evaluates recruitment of the leaping grey mullet at five stations in the Neretva River estuary, including natural and artificial habitats, and feeding habits in terms of the composition of prey species in stomach content. Those factors can be useful as possible explanations for the successful progress of *L. saliens* population in the past 10 years and for future monitoring of this and other Mugilidae species status, as well as for their specific interrelationship in this area.

MATERIAL AND METHODS

Juvenile fish were sampled between July 2003 and April 2004 at five stations in the Neretva River estuary, Croatia where the geographic position of the site is: 40°52'N; 17°40'E (Fig. 1). Station 1 was in the Port of Ploče, along a 30-year-old seaside promenade exposed to the flow of municipal sewage and rainwater drainage. Depth at this site is 1 - 2 m and the bottom is composed mainly of small rocks. Station 2 was located by the mouth of Kanal channel, an artificial channel which connects freshwater ecosystems (Vlaška Lake and the Crna Rijeka River) with the sea. It is 50 m wide and 10 m deep, banks are vertical and covered with marsh vegetation, and at the mouth there are muddy-sand beaches. Station 3 was a muddy beach on the left side of the Neretva River, one hundred meters from the mouth of the Neretva River. The depth of water there is up to ten centimeters, with a bottom covered with mud and sometimes clay. There is no vegetation. A shallow beach

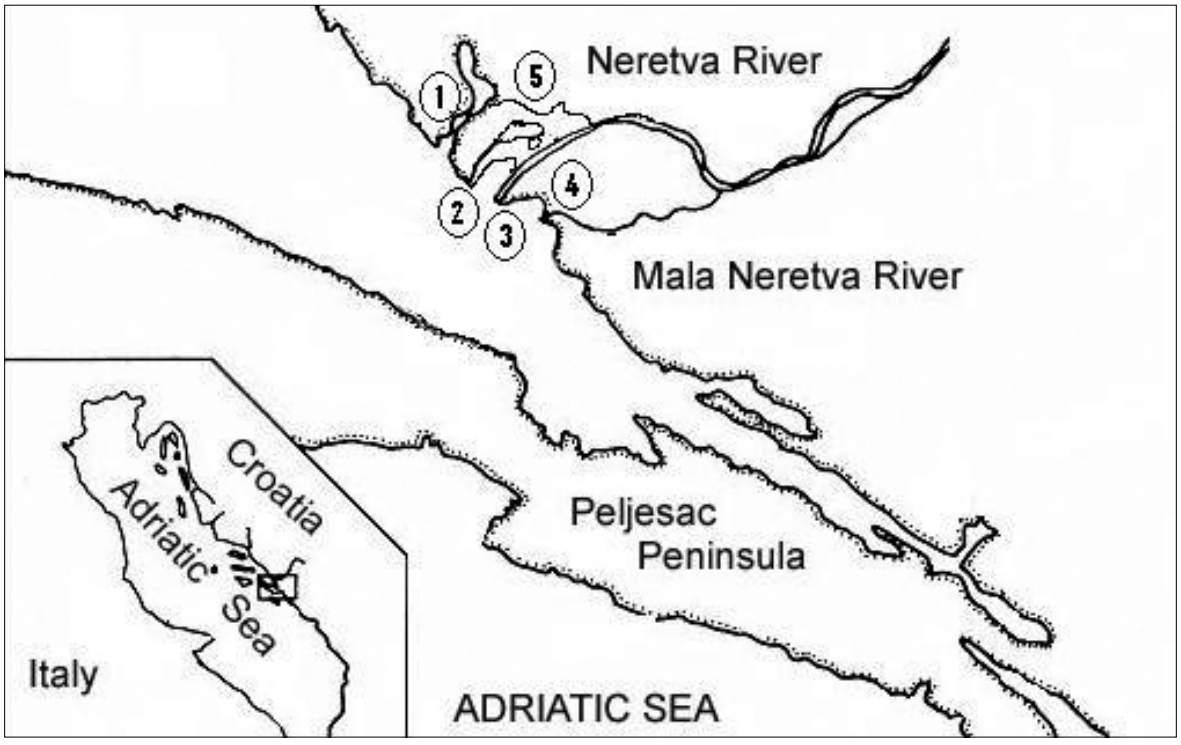

Fig. 1. Map of the researched area (geographic position of the site is: 40°52'N; 17°40'E)

composed of fine sand in the Mala Neretva River estuary was chosen as Station 4. There, depth was up to twenty centimeters. Station 5 was along the Crna Rijeka River, near the village of Rogotin, where the river bank and bottom are composed mainly of artificially placed rocks covered with mud. The depth ranged from 0.5 to 1 m.

Temperature and salinity were measured with portable digital instruments (WTW) and the values are presented in Fig. 2 a, b.

The different characteristics of the stations demanded different types of gear for effective sampling. Owing to the depth and nature of the bottom, a small net mounted on a 2-m-long pole was used at Station 1 and Station 5. A 22 m long beach seine with wings of 7.5 m and central collecting area of 7 m was used to sample at Stations 2, 3 and 4. The outer wings were of 4 mm mesh size and the central sac of 2 mm. The net was always hauled from deep (max. 2 m depth) to shallow water.

Fish were preserved in 4% formalin immediately after sampling, then transported to the

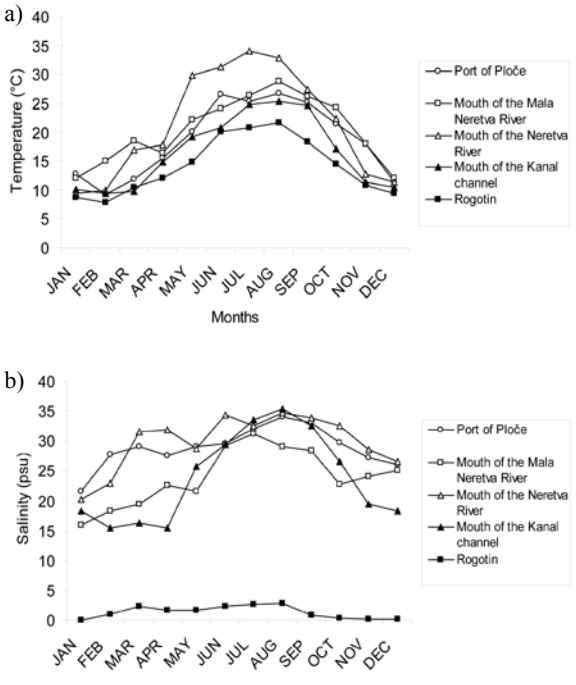

Fig. 2. Temperature (a) and salinity (b) values at sampling stations in the Neretva River estuary (Station 1: Port of Ploče; Station 2: Kanal channel; Station 3: Neretva River; Station 4: Mala Neretva River; Station 5: Crna Rijeka River)

laboratory where total (TL) and standard (SL) length were measured to the nearest 0.01 mm with a digital caliper and body wet weight (W) was measured to the nearest 0.0001 g with an analytical balance. Prey composition in the stomachs of 50 randomly selected fish from each sample was determined to the lowest possible taxon with a binocular microscope at 400 x. Sub-samples of stomach contents were examined using an inverted microscope (Olympus IX 71) at 400 x to determine microalgal taxa. Diatoms were identified following standard techniques (BATTARBEE, 1986). The relative numerical contribution of each microalgal taxon was determined from 50 randomly selected fields of vision.

Following HUREAU (1970), the methods used to quantitatively and qualitatively describe the diet were: a) numeric (%N = (n/N)x100), where n was the number of prey items of a particular taxon and N was the total number of prey items found in all stomachs; b) frequency of occurrence %F, which was the proportion of all stomachs examined which contained a particular taxon or prey group; c) the coefficient of emptiness: CV=(total number of empty stomachs/ total number of stomachs analyzed)x100) was calculated (HUREAU, 1970).

RESULTS

Monthly values of temperature and salinity for all five stations are presented in Fig. 2a and Fig. 2b. Temperature ranged from 8.7°C in winter (January, Station 5) to 34.0°C in summer (July, Station 3). Salinity ranged from 15.4 in spring (April, Station 4) to 34.7 in summer (August, Station 3).

A total of 1566 juveniles were collected: 158 at Station 1 (Port of Ploče), 348 at Station 2 (mouth of Kanal channel), 199 at Station 3 (mouth of Neretva River), 721 at Station 4 (mouth of Mala Neretva River) and 140 at Station 5 (Rogotin). The juveniles were found at all stations from August to September, and later were concentrated only at Station 3 and Station 4.

The recruitment started in July, was highest in August, and decreased in September. No recruits were observed in October. The period of recruitment lasted for 60-80 days. From October to April the juveniles were caught only at Station

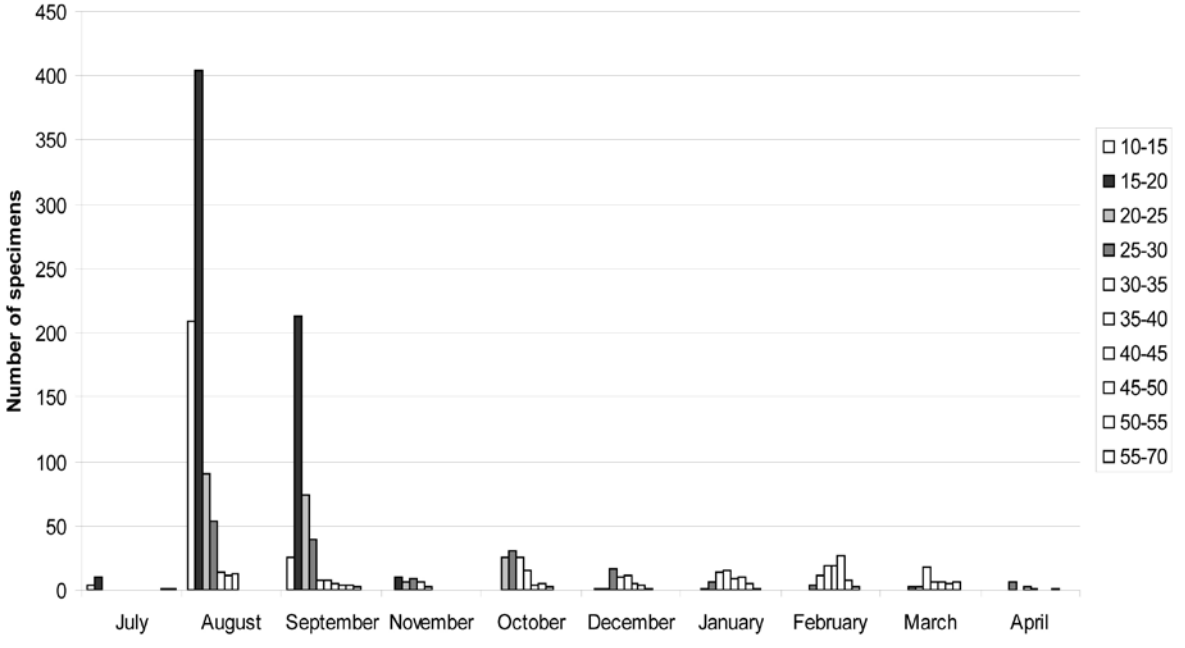

Fig. 3. Length frequencies of leaping grey mullet, Liza saliens *length classes during the recruitment period in the Neretva River estuary*

4 (mouth of Mala Neretva River) and ranged in length from 25 to 70 mm (Fig. 3).

The strongest recruitment was recorded during August. The highest number of juveniles was caught at Station 2 (Kanal channel), followed by Station 4 (Mala Neretva River mouth) and Station 1 (Port of Ploče). During August juveniles were also caught at the freshwater Station 5 (Rogotin) due to saltwater inflow into the Crna Rijeka River. During September the highest number of juveniles was caught at Station 4 (Mala Neretva River mouth) followed by Stations 3 (Neretva River mouth) and Station 2 (Kanal channel mouth). Length frequencies from 10 mm to 70 mm of *L. saliens* recruits and newly settled juveniles are presented in Fig. 3. indicating that July was the first time that *L. saliens* entered in the estuary habitats in summer.

Juveniles of leaping grey mullet dominated in the area of the sand-muddy beaches of Station 4 (mouth of Mala Neretva), Station 3 (mouth of Neretva River) and Station 2 (mouth of Kanal channel) in September. The juveniles ranging in total length from 15 mm to 20 mm dominated, while the percentage of those ranging from 10 mm to 15 mm was considerably less than in August. In general, recruits of leaping grey mullet occupied a wide area of the Neretva River estuary and were found at all sampling stations during the summer months. From October, juveniles started to concentrate at the shallow muddy and sandy beaches of Station 2, Station 3 and Station 4, and were not found at Station 1 and Station 5.

The index of emptiness of juveniles of *L. saliens* at Station 4 (Mala Neretva) varied from 0% during February, August and October to 30% in March. This value fluctuated and was 9% in January, 18% in April, 7% in September, 3% in November and 4% in December. At Station 2 (mouth of the Kanal channel), vacuity index was 14.29% in July, 8.7% in August and 0% in September. There were no empty stomachs in leaping grey mullet at Station 1 (Port of Ploče) during August. Vacuity index was 5% at the Station 5 (Rogotin) in August. Vacuity index was 0% for samples from Station 3 (mouth of the Neretva River) in September.

The dominant prey in stomachs of the leaping grey mullet juveniles at Station 4 (Mala Neretva River mouth) during the period from August to December was harpacticoid adults and copepodites. This percentage fluctuated from 100% in August to 20% in February, but dominated from August to December (> 80%). Nematodes were the dominant group found in stomachs from January to April, with a presence of 75% in January-February, and around 50% in March-April. All other groups of prey represented less then 7% during the entire period of investigation, except in November when Cyclopoida-oncaeid copepodites represented 20% of prey in the analyzed stomachs. In the period from January to April when nematodes dominated in the stomachs of fish larger than 30 mm, harpacticoid copepods were also present (from 22% in February to 48% in April). During the entire period of recruitment these two prey groups represented more than 95% of prey. The exception was the sample from November when oncaeid copepodites represented 18% of prey and those from March with 6% comprising of polychaete larvae. Other groups did not represent significant prey (Fig. 4). Results of feeding analysis are shown only for Station 4 (Mala Neretva mouth) because *L. saliens* juveniles were the most abundant here and were present for the longest period.

At Station 4 (Mala Neretva mouth), from August to December, the most frequent prey

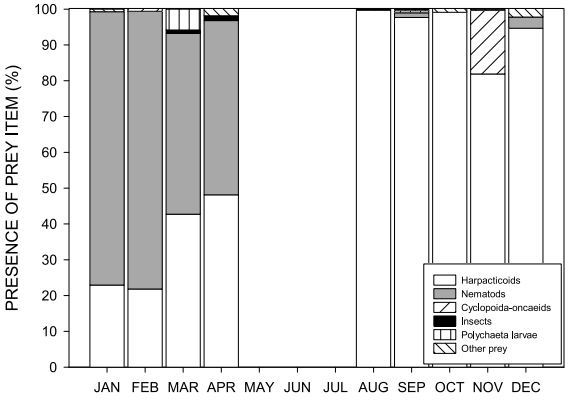

Fig. 4. Percentage of prey in stomachs of leaping grey mullet juveniles Liza saliens*, from the station at the mouth of the Mala Neretva River from August, 2003 to April, 2004*

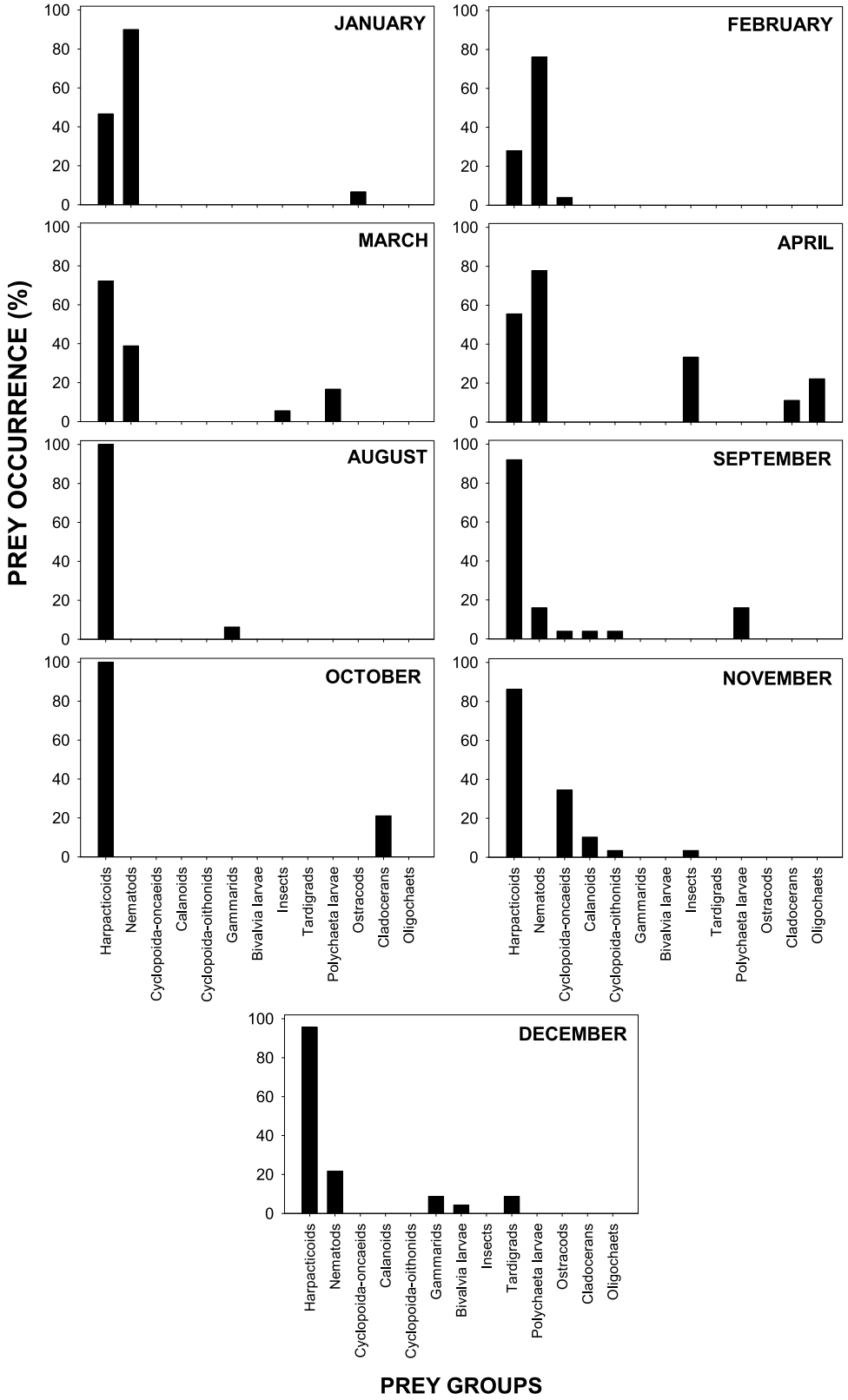

Fig. 5. Frequency of prey in stomachs of leaping grey mullet Liza saliens*, from the station at the mouth of the Mala Neretva River from August, 2003 to April, 2004*

was harpacticoid copepods, ranging from 100% in August and October to 86.2% in November. Nematodes were the most frequent prey in January (90%), February (76%) and April (77.77%). The frequency of oncaeides was 34.48% in November, oligochaets 22.22% in April, cladocerans 21.05% in October and insects 33.33% in April. All other groups represented less than 20% during the entire period. Diversity of prey varied from two groups in August and October to six during the period from September to November (Fig. 5).

At Station 2 (Kanal channel mouth) harpacticoid copepods dominated with more than 95%. Nematodes were present as 4.02% of prey in August. Other groups (Insecta, Turbellaria, Rotatoria, Bivalvia, Cladocera and Calanoida,) were present at less than 0.2%. In August harpacticoid copepods dominated as a prey at all stations with higher salinity; from more than 95% at Station 2 (mouth of Kanal channel) and Station 1 (Port of Ploče) to 100% at Station 3 (mouth of the Neretva River). At freshwater Station 5 (Rogotin), insects dominated as 68.66% percent of prey although marine organisms such as harpacticoid copepods (29.11%) were also present.

Harpacticoid copepods were the most frequent prey at sites with higher salinities in August, and insects were the most frequent prey (89.47%) at the freshwater Station 5 (Rogotin). The most diverse composition of prey (eight different groups) was found at Station 5. The lowest diversity of prey (only two groups) was found at Station 4 (Mala Neretva River mouth). The most frequent prey found at Station 2 (mouth of the Kanal channel) from July to September were also harpacticoid copepods. Other groups, with the exception of nematodes in August (27.27%), represented less than 12% of the prey found. The highest prey diversity was observed during September when eight different groups were recorded (Fig. 6).

The difference in food composition at different stations was evident during August, when harpacticoid copepods had the highest frequency of occurrence at all brackish stations. This prey was found in 100% of juveniles on Station

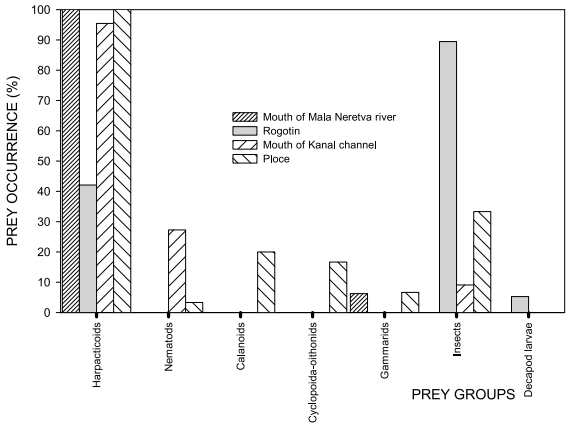

Fig. 6. Frequency of prey in stomachs of leaping grey mullet Liza saliens*, from Station 1 (Port of Ploče), Station 2 (mouth of Kanal channel), Station 4 (Mala Neretva) and Station 5 (Rogotin) in August*

4 (Mala Neretva River mouth) and Station 1 (Port of Ploče) and in 95% of juveniles at Station 2 (Kanal channel mouth). However, at the freshwater Station 5 the most frequent prey were insects (90%). They also appeared at Station 1 with a frequency of 33% and at Station 2 mouth with a frequency of 10%. Insects were not found in the stomachs of juveniles caught at Station 4.

Evidently, the diet composition profile of the juveniles showed two distinct periods of the year: January to May and August to December. This indicated that the prey preference of the juveniles changed significantly over the year regardless the fact that harpacticoid copepods were the most frequent prey items in the diet.

In stomachs of *L. saliens* juveniles from Station 4 (mouth of the Mala Neretva River) during winter plant material was present in a great number of specimens; 85% in January, 100% in February, 53% in March and 45% in April. Sand was found in the stomachs of all sampled fish. There was no plant material in the samples in September and October. The presence of plant material was 48% in November and 42% in December. Moreover, all of those individuals caught in late autumn were longer than 30 mm. The most represented species, temporally and quantitatively, was *Navicula distans*, from November to March, with the highest presence during the period from December to February. *Achnanthes longipes* was present in

Table 1. List of phytoplankton species found in the stomachs of leaping grey mullet, Liza saliens *at the Mala Neretva River mouth. Frequency of occurrence is expressed as: r = ≤20%; rr = 21-60%; rrr = 61-100%.*

Taxa/Month-Year	11-2003	12-2003	01-2004	02-2004	03-2004
Bacillariophyta					
Achnanthes longipes C. Agardh	r	rr	r	r	.
Bacillaria paxillifera (O.F. Müller) N.I. Hendey	.	r	.	.	.
Diploneis bombus Ehrenberg	.	r	.	r	.
Fragilaria ulna (Nitzsch) Lange-Bertalot	.	.	r	.	.
Grammatophora oceanica Ehrenberg	.	r	.	.	.
Licmophora flabellata (Carmichael) C. Agardh	rrr	r	r	.	.
Navicula distans (W. Smith) Ralfs (incl. other naviculoid cells)	r	rrr	rrr	rrr	r
Nitzschia longissima (Brébisson) Ralfs	.	r	.	.	.
Pleurosigma angulatum (Quekett) Wm. Smith	.	rr	.	.	.
Striatella unipunctata (Lyngbye) C. Agardh	.	r	.	.	.
Synedra fulgens (Greville) W. Smith	.	rr	.	r	.
Synedra sp.	.	r	.		.
Thalassionema nitzschioides (Grunow) Grunow ex Hustedt	.	.	rr		.
Cyanobacteria					
Oscillatoria limosa C. Agardh ex Gomont	r	r	.	.	.
Oscillatoria sp.	.	.	.	.	r
Undetermined algal cells (2-20 μm)	.	.	.	r	.

stomachs of sampled fish from November to February. *Licmophora flabellata* was present from November, when it was abundant, to December and January, when its numbers decreased. *Pleurosigma angulatum* was present in December, while *Thalassionema nitzschioides* was present in significant quantities in the stomachs of fish in January. Other plant material was present though varying with time and in lower quantities (Table 1).

There was plant material in the stomachs of 30% of fish samples from Station 2 (mouth of the Kanal channel) and in 10% of those from Station 5 (Rogotin), but only small quantities were observed in both.

The profile of ontogenetic changes in the feeding of leaping grey mullet juveniles in the estuary of the Mala Neretva River is shown in Fig. 7. Only animal food was found in juveniles smaller then 24 mm. The plant food appeared in the stomachs of fish from the 24-25 cm group, and was composed of different diatom species. The diatoms represented the only plant food in juveniles from 24 to 31 mm. In fish from 31 mm length plant material of higher marine algae and plants (mainly decomposed *Cymodocea nodosa* leafs) appeared frequently in stomachs, together with sand. However, animal food was always found in the stomachs of fish of length up to 45 mm (Fig. 7).

DISCUSSION

The shallow bottoms of inland waters, estuaries and lagoons play an important role in the life stages of many fish. Many species have a complex life cycle that begins with a pelagic larval stage in open waters, followed by a demersal stage in coastal habitats (GARCIA-RUBIES & MACPHERSON, 1995). Temperature and salinity, as well as food availability are important regulating factors for the spatial and temporal distribution of fish species in estuary systems (KOUTRAKIS *et al*., 1994). All demographic parameters, particularly population size, growth and mortality of all fish species strongly depend on

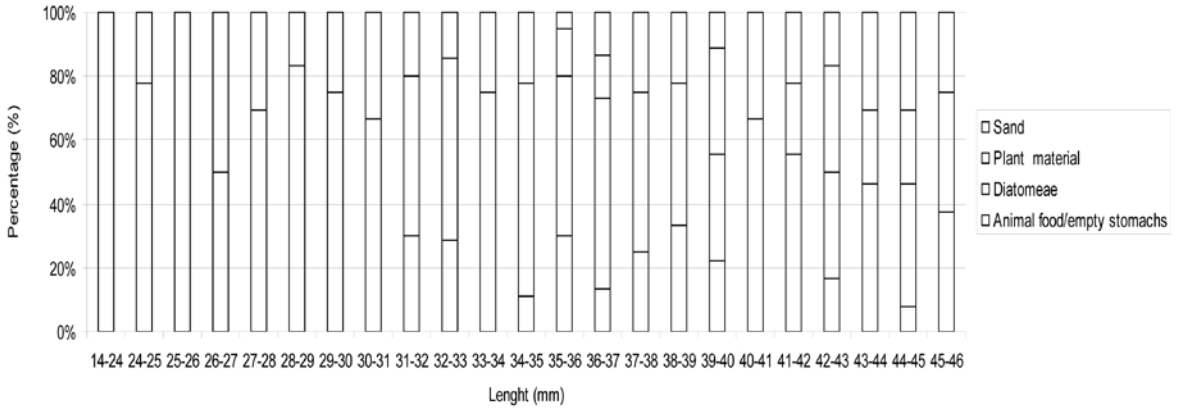

Fig. 7. Different type of prey frequency in stomachs of leaping grey mullet, Liza saliens *from Station 4 from June to April*

success of recruitment and quantity of available food (GISBERT *et al*., 1996). Therefore, knowledge of these parameters is necessary for understanding dynamic population processes of any fish species.

The first appearance of *L. saliens* juveniles in the Neretva estuary were observed in July, and highest rate of recruitment was observed in August and September. The smallest specimen of 8.9 mm total length was caught in August. KATAVIĆ (1980) reported that the first appearance of *L. saliens* juveniles in the coastal waters of the central eastern Adriatic was in August and that the smallest specimen was 16 mm. JUG-DUJAKOVIĆ (1988) found the first appearance of those young specimens in the Kornati Archipelago, eastern middle Adriatic, in August. The earliest recruitment was noted in June along the coast of Israel, with the fry varying from about 17-20 mm in total length, and continues to appear at sizes of about 20 mm or more until October or November (ZISMANN & BEN-TUVIA, 1975). In western Greece the first occurrence was also in June and in the estuarine systems of the Strymonikos Gulf (Greece) the smallest observed specimen was 12 mm of standard length (KOUTRAKIS, 2004). In the Porto-Lagos lagoon and Lake Vistonis (Greece) recruitment of leaping grey mullet started in July, reached the highest rates in August and September, and was prolonged during the entire of October (KOUTRAKIS *et al*., 1994). Similar to other coastal and estuarine species, such as sand smelt *Atherina boyeri* (BARTULOVIĆ *et al*., 2006), the spawning starts earlier and lasts longer in southern parts of the Mediterranean while it is shorter and starts later in its northern part, such as in the Adriatic Sea.

The grouping profile between the Mala Neretva River and the Kanal channel sampling stations is consistent with the temperature profile and the sea bottom morphology. The juveniles seem to prefer sand-muddy bottoms during their first appearance along the Croatian coast. This is also consistent with the fact that during this period of first appearance (July-September) the juveniles show greatest preference for harpacticoid copepods which usually are more abundant in fine-grained bottoms like sand-mud (CHERTOPRUD *et al*., 2007; FECHTER *et al*., 2004). Food type and its availability is of the highest importance for the success of recruitment of fish species.

Harpacticoid copepods was the most frequent prey at sites with higher salinities in August, while insects were the most frequent at the freshwater sites. At the sites where insects were found as prey, the banks were covered with vegetation, forests and meadows. This is the explanation for the presence of insects which, taken by wind and water, arrived to the sea and became the prey of mullet juveniles. On the other side, the mouth of the Mala Neretva River is sandy and lacks vegetation which results in a smaller number of insects.

Our results show that the leaping grey mullet juveniles between 15-24 mm of total length feed exclusively on animal prey; between 24-55

mm SL the food is mixed, and after 45 mm is almost completely of plant origin. Similar was observed in France (ALBERTINI-BERHAUT, 1973; ZISMANN *et al*., 1975; FERRARRI & CHIEREGATO, 1981; TOSI & TORRICELLI, 1988; TORRICELLI *et al*., 1988; GISBERT *et al.*, 1995), while DRAKE *et al*. (1984) reported that longer and older juveniles and adults feed mainly on detritus. The smaller juveniles of leaping grey mullet (SL<30 mm) in the Po River delta in spring feed on animal prey while those with SL>30 mm feed preferentially on benthic elements (nematodes, polychaetes and algae). In the July-August samples, the favored food of the smaller-sized juveniles was nauplii of copepods and of barnacles, harpacticoid copepodites, decapod larvae and adult insects. In Marseille Bay (France) harpacticoid copepods represented 85% of grey mullet stomach contents (ALBERTINE-BERHAUT, 1973; FECHTER *et al.,* 2004; CHERTOPRUD *et al*., 2007).

TOSI & TORRICELLI (1988) grouped specimens from the Arno River (Tyrrenian coast) in two size classes (first: SL=10-29 mm; second: SL=30-75 mm), but the obtained results did not reveal a qualitative differences in diet between those groups. However, the quantitative data revealed that larger specimens preferred larger prey, i.e. insects. The total quantity of ingested animal prey was lower than in the smaller fish size class. Copepods were the most important food item in the gut, in every period of the year and for all sizes of mullet (ZISMANN *et al*., 1975).

Diatoms started to appear sporadically in juveniles of 24 mm TL, while at TL greater than 30 mm plants and sand started to dominate. Similar findings were reported by CARDONA (2001). The benthic and planktonic diatoms are abundant on the shallow beaches of the Neretva River estuary (JASPRICA & HAFNER, 2005). In the stomachs of leaping grey mullet juveniles from the mouth of the Mala Neretva River during winter, plant material was present in a large number of specimens. However, during summer and early autumn the presence of plant material in stomachs was not found frequently. Sand was recorded in the stomachs of all sampled fish during the winter period. Also, in the period from January to April nematodes dominated in the stomachs of fish larger than 30 mm. Although frequent, it is also possible that they might be parasites instead of ingested food.

As a conclusion, *L. saliens* fry prefer harpacticoid copepods and probably swallow diatoms when preying on the former. Only when and where harpacticoid copepods are rare they shift to insects. Our results support previous research regarding the transition from carnivorous fry to herbivorous-detritivorous juveniles reported for other grey mullets (GISBERT *et al*, 1966; CARDONA, 2001).

The recruitment of *L. saliens* that started in July was strongest in August and had a duration of 60-80 days. Not a single recruit was observed in October. The period of recruitment lasted for 60-80 days. From October, juveniles started to concentrate on shallow muddy and sandy beaches, and were not found in deeper brackish and freshwater habitats. During the recruitment period of the leaping grey mullet, especially in July and August, there were no juveniles of the other mullet species found at the research stations, and only in later September flathead grey mullet *Mugil cephalus* juveniles started to appear (BARTULOVIĆ, 2006). Hence, during two months of recruitment the leaping grey mullet solely occupied beaches and freshwater bodies in the Neretva River estuary, exploiting alone all the available food resources without intraspecific competition within mullet species. The lowest level of intraspecific competition at the fry stage of leaping grey mullet among all grey mullet species was also described by GISBERT *et al*. (1996), while CARDONA (2006) demonstrated that such low levels of competition at the fry stage causes leaping grey mullet to be one of the most abundant species in the Balearic Islands. Later on, from October to February, they shared the same habitats with two other mullet species, flathead grey mullet (*M. cephalus*) and golden-grey mullet (*Liza aurata*) juveniles, which prey mostly on similar food (harpacticoid copepods). The competition between these three species is significant (BARTULOVIĆ, 2006). However, as the other two are smaller and younger than the leaping grey mullet, it has a great advantage due to higher mobility and consumption of a greater amount of food per single fish.

The evident raising dominance of the leaping grey mullet in the River Neretva Estuary should be caused by recruitment during the favored summer season, when food is abundant and competition with other mullet species is lower. The other potential reasons including better recruitment due to the recent warming of shallow estuary ecosystems preferred by *L. saliens* and lower fishery efforts if compared to other grey mullet species. On the other side, climate change causes the strongest inflow of eastern Mediterranean water in the southern part of the Adriatic Sea, and as a consequence a number of aggressive piscivorius fish such as, for example, bluefish *Pomatomus saltatrix* enter the Neretva River estuary where they establish a large population with a strong predation preference for all grey mullet species including *L. saliens* (TUTMAN, pers. comm.) as the most dominant one. All of these aspects should be investigated in detail, in order to predict future changes to the leaping grey mullet population status.

REFERENCES

ALBERTINE-BERHAUT, J. 1973. Biologie des stades juveniles de teleosteens Mugilidae, *Mugil auratus* Risso 1810, *Mugil capito* Cuvier 1829 et *Mugil saliens* Risso 1810 (Biology of the juvenile stages of the Mugilidae teleosts *Mugil auratus* Risso 1810, *Mugil capito* Cuvier 1829 and *Mugil saliens* Risso 1810). Aquaculture, 2: 251-266.

BARTULOVIĆ, V. 2006. Reproduktivni ciklusi i novačenje mlađi cipala (Mugilidae) na području ušća Neretve (Reproduction cycles and recruitment of mullet's juveniles (Mugilidae) in the mouth of Neretva River). Ph.D. Thesis, University of Zagreb, 158 pp.

BARTULOVIĆ, V., B. GLAMUZINA, A. CONIDES, A. GAVRILOVIĆ & J. DULČIĆ. 2006. Maturation, reproduction and recruitment of the sand smelt, *Atherina boyeri* Risso, 1810 (Pisces: Atherinidae) in the estuary of Mala Neretva River (southeastern Adriatic, Croatia). Acta Adriat., 47(1): 5-11.

BATTARBEE, R.W. 1986. Diatom analysis. In: B.E. Berglund (Editor). Handbook of Holocene palaeoecology. John Wiley, Chichester, pp. 527-570.

CAMBRONY, M. 1984. Identification et periodicite du recrutement des juveniles de mugilidae dans les etangs littoraux du Languedoc – Roussillon (Identification and periodicity of the recruitment of juvenile mugilidae in littoral ponds in Languedoc-Roussillon). Vie Milieu, 34(4): 221-227.

CARDONA, L. 2001. Non-competitive coexistence between Mediterranean grey mullet (Osteichthyes, Mugilidae): evidences from seasonal changes in food availability, niche breadth and trophic overlap. J. Fish Biol., 59: 729-744.

CARDONA, L. 2006. Habitat selection by grey mullets (Osteichtyes: Mugilidae) in Mediterranean estuaries: the role of salinity. Sci. Mar., 70: 431-442.

CHERTOPRUD, E., M. CHERTOPRUD, L. GARLITSKAYA, A. AZOVSKY & D. KONDAR. 2007. Spatial variability of harpacticoida (copepoda) taxocen structure in the intertidal and sublitoral zones of the European seas. Oceanology, 47(1): 1-10.

DRAKE, P., A.M. ARIAS & L. GALLEGO. 1984. Biologia de los mugilidos (Osteichthyes, Mugilidae) en los esteros de las Salinas de San Fernando (Cadiz). III. Habitos alimentarios y su relacion con la morfometria del aparato digestivo (Biology of mullets (Osteichtyes, Mugilidae) in the marshes of Salinas de San Fernando (Cadiz). III. Alimentary habits and their relationship to the morphometry of the digestive apparatus). Inv. Pesq., 48: 337-367.

FECHTER, A., D. THISTLE, G. ARLT, K. SUDERMAN & K. VOPEL. 2004. Do harpacticoid copepods (Copepoda) use water-borne cues to aid in locating food parcels? P.S.Z.N.I. Marine Ecology, 25(3): 217–223.

FERRARI, I. & A.R. CHIEREGATO. 1981. Feeding habits of juvenile stages of *Sparus aurata* L., *Dicentrarchus labrax* L. and Mugilidae in brackish embayment of the Po River delta.

Aquaculture, 25: 243-257.

GARCIA-RUBIES, A. & E. MACPHERSON. 1995. Substrate use and temporal pattern of recruitment in juvenile fishes of the Mediterranean littoral. Mar. Biol., 124: 35-42.

GISBERT, E., L. CARDONA & F. CASTELLO. 1995. Competition between mullet fry. J. Fish. Biol., 47: 414-420.

GISBERT, E., L. CARDONA & F. CASTELLO. 1996. Resource partitioning among planktivorous fish larvae and fry in a Mediterranean coastal lagoon. Est. Coast. Shelf Sci., 43: 723-735.

GLAMUZINA, B. & M. GLAMUZINA. 2001. Management of the Neretva River Estuary: Past and Future of a Rich and Fragile Nature Heritage. Naše More, 5-6: 226-230.

HUREAU, J.C. 1970. Biologie comparée de quelques poissons antarctiques (Nototheniidae). Thèse d'État, Bull. Inst. Océanogr. Monaco. Univ. de Paris.

JARDAS, I. 1996. Jadranska ihtiofauna (Adriatic ichthyofauna). Školska knjiga, Zagreb, pp. 533.

JASPRICA, N. & D. HAFNER. 2005. Taxonomic composition and seasonality of diatoms in three Dinaric karstic lakes in Croatia. Limnologica, 35: 304-319.

JUG-DUJAKOVIĆ, J. 1988. Prilog poznavanju ekologije mlađi gospodarski interesantnih vrsta riba u šibenskom području (Contribution to the knowledge of the ecology of juvenile economically interesting fish species in the area of Šibenik). M.sc. Thesis, University of Zagreb.

KATAVIĆ, I. 1980. Temporal distribution of young mugilids (Mugilidae) in the coastal waters of the central eastern Adriatic. Acta Adriat., 21(2): 137-150.

KOUTRAKIS, E.T., A.I. SINIS & P.S. ECONOMIDIS. 1994. Seasonal occurrence, abundance and size distribution of grey mullet fry (Pisces, Mugilidae) in the Porto-Lagos lagoon and Lake Vistonis (Aegean sea, Greece). Isr. J. Aquac. Bamidgeh, 46(4): 182-196.

KOUTRAKIS, E.T. 2004. Temporal occurrence and size distribution of grey mullet juveniles (Pisces, Mugilidae) in the estuarine systems of the Strymonikos Gulf (Greece). J. Appl. Ichthyol., 20(1): 76-78.

TORRICELLI, P., P. TONGIORGI & G. GANDOLFI. 1988. Feeding habits of mullet fry in the Arno River (Tyrrhenian coast). I. Daily feeding cycle. Boll. Zool., 3: 161-169.

TOSI, L. & P. TORRICELLI. 1988. Feeding habits of mullet fry in the Arno River (Tyrrhenian coast). II. The diet. Boll. Zool., 3: 171-177.

ZISMANN, L., V. VERDUGO & B. KIMOR. 1975. The food and feeding habits of early stages of grey mullet in the Haifa Bay region. Aquaculture, 6(1): 59-76.

ZISMANN, L. & A. BEN-TUVIA. 1975. Distribution of juvenile mugilids in the hypersaline Bardawil lagoon January 1973 - January 1974. Aquaculture, 6: 143-146.

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Novačenje i prehrana mlađi cipla dugaša, *Liza saliens* (Risso, 1810) u području estuarija rijeke Neretve, jugoistočni Jadran, Hrvatska

Vlasta BARTULOVIĆ[1], Sanja MATIĆ-SKOKO[5], Davor LUČIĆ[2], Alexis CONIDES[3], Nenad JASPRICA[2], Aleksandar JOKSIMOVIĆ[4], Jakov DULČIĆ[5] i Branko GLAMUZINA[1*]

[1] *Odjel za akvakulturu, Sveučilište u Dubrovniku, Ćira Carića 4, 20000 Dubrovnik, Hrvatska*

[2] *Institut za more i priobalje, Sveučilište u Dubrovniiku, Kneza Damjana Jude 12, 20000 Dubrovnik, Hrvatska*

[3] *Helenski centar za morska istraživanja, Agios Kosmas, Hellinikon, 16604 Atena, Grčka*

[4] *Institut za biologiju mora, P.P. 69, 85330 Kotor, Crna Gora*

[5] *Institut za oceanografiju i ribarstvo, Šetalište Ivana Meštrovića, 63, 21000 Split, Hrvatska*

***** *Kontakt adresa, e-mail: glamuzin@unidu.hr*

SAŽETAK

Novačenje mlađi cipla dugaša, *Liza saliens* na području estuarija rijeke Neretve počinje u srpnju, najveće je u kolovozu, smanjuje se u rujnu, nakon čega nije zabilježeno. Mlađ se najprije pojavljuje na ušćima rijeka i kanala, a zatim počinje migrirati prema vodama niže slanosti. U prehrani mlađi cipla dugaša od kolovoza do prosinca su dominirali harpatikoidni kopepodi, a od siječnja do travnja oblići. Biljni materijal se počinje pojavljivati u probavilima jedinki najmanje ukupne dužine 24 mm, a uobičajen je u probavilima riba većih od 26 mm. Uspoređujući s ostalim vrstama cipala u području estuarija rijeke Neretve koje se mrijeste u ljetno-jesenskom razdoblju, dugaš se počinje novačiti prvi, tijekom srpnja i kolovoza, dok se ostale vrste pojavljuju u rujnu. Ovo ranije mriještenje i novačenje mlađi bez nazočnosti drugih vrsta cipala, tijekom razdoblja optimalnog sastava i brojnosti hrane, može biti jedan od razloga recentne propagacije cipla dugaša na području estuarija Neretve.

Ključne riječi: cipal dugaš, *Liza saliens*, mlađ, novačenje, prehrana, Neretva, Hrvatska