

EFFECTS OF DIFFERENT FEEDING SCHEDULES ON SURVIVAL AND GROWTH RATE OF THICKLIP GREY MULLET (CHELON LABROSUS) FRY REARED IN A CLOSED RECYCLING SYSTEM

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A b s t r a c t

*Chelon labrosus* fry was exposed to different feeding schedules during two experimental phases. In experimental phase I the influence of different feeding frequencies (1×, 3×, 6× times per day) was examined, and in experimental phase II the influence of different feeding rates (4<sup>0</sup>/<sub>0</sub>, 6<sup>0</sup>/<sub>0</sub>, 8<sup>0</sup>/<sub>0</sub>, 10<sup>0</sup>/<sub>0</sub>). Fish were fed with commercial trout food with a protein content of 45<sup>0</sup>/<sub>0</sub>.

At the end of experimental phase I fry fed with six portions per day showed the best growth performance. This feeding schedule was characterized by the highest values for average weight, average length, absolute and relative weight and length increment, food conversion efficiency and specific growth rate.

Decreasing the feeding rate did not result in decreasing values of growth parameters. The daily ratio of 4<sup>0</sup>/<sub>0</sub> resulted in the best growth performance of 50 mm *Ch. labrosus* fry. This feeding rate should be used during the growing period until the fry reaches about 60 mm standard length, the most suitable size for stocking purposes.

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## I z v o d

### UTICAJ RAZLIČITIH REŽIMA ISHRANE NA PREŽIVLJAVANJE I TEMPO RASTA MLAĐI CIPOLA PUTNIKA (*CHELON LABROSUS*) U ZATVORENOM RECIKLAŽNOM SISTEMU

Mlađ cipola putnika (*Chelon labrosus*) bila je izložena različitim režimima ishrane tokom dvije eksperimentalne faze. U prvoj eksperimentalnoj fazi praćen je uticaj frekventnosti dnevnih porcija (1×, 3×, 6×), dok je tokom druge faze praćen uticaj različitih količina hrane (4<sup>o</sup>%, 6<sup>o</sup>%, 8<sup>o</sup>%, 10<sup>o</sup>%) na tempo rasta mlađi cipola putnika. Mlađ je tokom eksperimenta hranjena vještačkom hranom proteinskog sastava od 45<sup>o</sup>%. Na kraju ove eksperimentalne faze, najfrekventnije hranjena grupa (6×) pokazivala je najbolje performance rasta (srednja težinska i dužinska vrijednost, apsolutni i relativni dužinski i težinski prirasti, konverzioni faktor, specifična stopa rasta).

Mlađ eksperimentalne grupe, hranjene sa količinom hrane u iznosu od 4<sup>o</sup>% od težine stoka, pokazivala je najbolje performance arsta na kraju druge eksperimentalne faze. Predlažemo da se mlađ cipola uzrasne klase od 50 mm hrani iznosom hrane u visini od 4<sup>o</sup>% od ežine do vremena dok ne gosignu 60 mm, dužine ijela koja je najpovoljnija za nasadivanje u uzgojne bazene.

## INTRODUCTION

The influence of different feeding schedules on the survival and growth rate of thicklip grey mullet (*Chelon labrosus*) fry reared in a closed recycling system was studied. Recycling systems offer the possibility of following and controlling factors which are in direct connection to survival and growth rate of fish fry (temperature, salinity, light regime, water quality, gradual adaptation on freshwater environment, feeding, stocking density, etc.). Because of these possibilities recycling systems might be used as a nursery to accelerate the growth of mullet fry in order to provide fish of appropriate size and number for pond-stocking purposes (Honer et al., 1988). In that aim the identification of feeding frequency and the evaluation of the optimum feeding rate are of great importance.

## MATERIAL AND METHODS

Fry of thicklip grey mullet (*Chelon labrosus*, Risso, 1826) was caught in June 1987 in the Budva region, South-Adriatic coast. After one month acclimatization to the recycling system conditions and artificial food, the fry was used for experimental purposes.

The experiment was carried out in two phases. In the first phase (I) the influence of feeding frequency on mortality and growth rate of *Ch. labrosus* fry was examined. Three experimental groups A, B and C were fed with the same amount of food (expressed in % of initial body weight), but with a different number of portions per day. Food was offered in one (1×), three (3×) and six (6×) portions to the experimental group A, B and C, respectively. Experimental groups consisted of two replicates of 150 individuals (average weight = 0.6 g; average fork length = 35 mm) each.

In the second phase (II) the influence of feeding rate on growth and survival of *Ch. labrosus* fry was examined. This experimental phase was carried out with four experimental groups A<sub>1</sub>, B<sub>1</sub>, C<sub>1</sub> and D<sub>1</sub>. Each experimental group consisted of two replicates of 40 individuals (average weight = 2.2 g; average fork length = 53 mm) each. Fish were fed six times per day with a daily food amount of 4%, 6%, 8% and 10% of the initial body weight for group A<sub>1</sub>, B<sub>1</sub>, C<sub>1</sub> and D<sub>1</sub>, respectively. Phase I lasted 30 days and phase II 21 days.

At the beginning and at the end of each experimental phase individual measurements were accomplished. Weight ( $\pm 0.01$  g) and fork length ( $\pm 1$  mm) were determined. During experimental phase I every ten days a control weighing of the total stock was carried out to follow mortality and growth rate and to adjust the daily food amount. These control weighings in phase II were carried out every 7 days.

During both phases fish were fed with commercial trout food with a protein content of 45%. Fish were fed by hand.

Fish were kept in plastic aquaria of 20.3 l volume. The flow rate was 2 l/min and all aquaria were well aerated. This experimental system was connected to a recycling system (15 m<sup>3</sup> total volume, T = 25.5-29.0 C; S = 29.0-33.7‰).

The specific growth rate was calculated according to the equation

$$G = \frac{\log_e Y_T - \log_e Y_t}{T - t} \times 100$$

where:  $\log_e$  = base of natural logarithm

Y<sub>T</sub> = final value (at time T)

Y<sub>t</sub> = initial value (at time t)

Food conversion efficiency was calculated as units of food offered per unit of fish weight gain and is presented as a food conversion factor.

Here we want to point out that in this paper according to Zismann (1981) and his terminology young *Ch. labrosus* less than 60 mm total length were considered as fry.

## RESULTS

**Experimental phases I** — The mortality rate of *Ch. labrosus* fry during the first experimental phase is presented in figure 1. Mortality rate (A = 28.70%; B = 22.30%; C = 12.33%) was high with the lowest value for the experimental group C (6×). A prominent number of dead fish showed signs of infection.

Weight growth rate is presented in figure 2 and in table 1. Experimental group C (6×) had the highest mean weight value (A = 1.643 g; B = 1.588 g; C = 1.751 g) at the end of this experimental phase. Mean weight values were tested with t-test ( $P < 0.005$ ). The differences between experimental groups C/A and C/B were statistically significant ( $P < 0.005$ ) while it was not the case for experimental groups A/B ( $P < 0.005$ ). Also the absolute (A = 1.072 g; B = 1.030 g; C = 1.194 g) and relative weight increment (A = 187.74%; B = 184.59%; C = 214.36%) and the specific growth rate (A = 3.52; B = 3.31; C = 3.82) were the highest for the experimental group C (6×) which was fed with the highest frequency. Food conversion factors were 2.55, 2.50 and 1.97 for experimental group A (1×), B (3×) and C (6×), respectively.

Statistically significant differences were not found when average length values were tested ( $P > 0.005$ ). However, absolute (A = 12.87 mm; B = 12.59 mm; C = 13.86 mm) and relative length increment (A = 36.42, B = 26.0, C = 39.67) and the specific growth rate (A = 1.037; B = 1.027; C = 1.113) showed the highest values for experimental group C (6×), but these differences between experimental groups were slightly expressed (figure 3, table 2).

**Experimental phase II** — Figure 4 represents the mortality rate of the four experimental groups A<sub>1</sub> (16.25%), B<sub>1</sub> (23.75%), C<sub>1</sub> (15%) and D<sub>1</sub> (7.5%) fed with different daily amounts of food. The mortality rate was lowest in the experimental group D<sub>1</sub> fed with the smallest feeding rate (4%), while it was highest in the experimental group B<sub>1</sub> (8% daily food amount). The ratio between these two mortality rates was 1:3.

Eksp. grupa Exp. group	$\bar{W}_0$ (g)	$\bar{W}_t$ (g)	$\bar{W}_t - \bar{W}_0$ (g)	$\bar{W}_t - \bar{W}_0$ (%)	G
A	0.571	1.643	1.072	187.74	3.52
B	0.558	1.588	1.030	184.59	3.31
C	0.557	1.751	1.194	214.36	3.82

Tab.1 PARAMETRI TEŽINSKOG RASTA MLADI CIPOLA (Chelon labrosus) U I FAZI EKSPERIMENTA:

$\bar{W}_0$  - inicijalna srednja težinska vrednost;  $\bar{W}_t$  - finalna srednja težinska vrednost; G - trenutna stopa rasta.

WEIGHT GROWTH PARAMETERS OF THICKLIP GREY MULLET FRY (Chelon labrosus) DURING EXPERIMENTAL PHASE I;  $\bar{W}_0$  - initial mean wet weight;  $\bar{W}_t$  - final mean wet weight; G - growth rate.

Eksp. grupa Exp. group	$\bar{L}_0$ (mm)	$\bar{L}_t$ (mm)	$\bar{L}_t - L_0$ (mm)	$\bar{L}_t - \bar{L}_0$ (%)	G
A	35.34	48.21	12.87	36.42	1.037
B	34.97	47.56	12.59	26.00	1.027
C	34.94	48.80	13.86	39.67	1.113

Tab. 2 PARAMETRI DUŽINSKOG RASTA MLADI CIPOLA (Chelon labrosus) TOKOM I EKSPERIMENTALNE FAZE;  $\bar{L}_0$  - inicijalna srednja srednja dužina;  $\bar{L}_t$  - finalna srednja dužinska vrednost; G - trenutna stopa rasta.

LENGHT GROWTH PARAMETERS OF THICKLIP GREY MULLET (Chelon labrosus) DURING EXPERIMENTAL PHASE I;  $\bar{L}_0$  - initial mean length;  $\bar{L}_t$  - final mean length; G - growth rate.

Eksp. grupa Exp. group	$\bar{W}_0$ (g)	$\bar{W}_t$ (g)	$\bar{W}_t - \bar{W}_0$ (g)	$\bar{W}_t - \bar{W}_0$ (%)	G
A <sub>1</sub>	2.306	3.313	1.007	43.67	1.72
B <sub>1</sub>	2.166	3.303	1.137	52.49	2.01
C <sub>1</sub>	2.157	3.211	1.054	48.86	1.90
D <sub>1</sub>	2.176	3.394	1.218	55.97	2.12

Tab. 3 PARAMETRI TEŽINSKOG RASTA CIPOLSKE MLADI (Chelon labrosus) u II eksperimentalnoj fazi;

$\bar{W}_0$  - inicijalna srednja težinska vrednost;  $\bar{W}_t$  - finalna srednja težinska vrednost; G - trenutna stopa rasta.

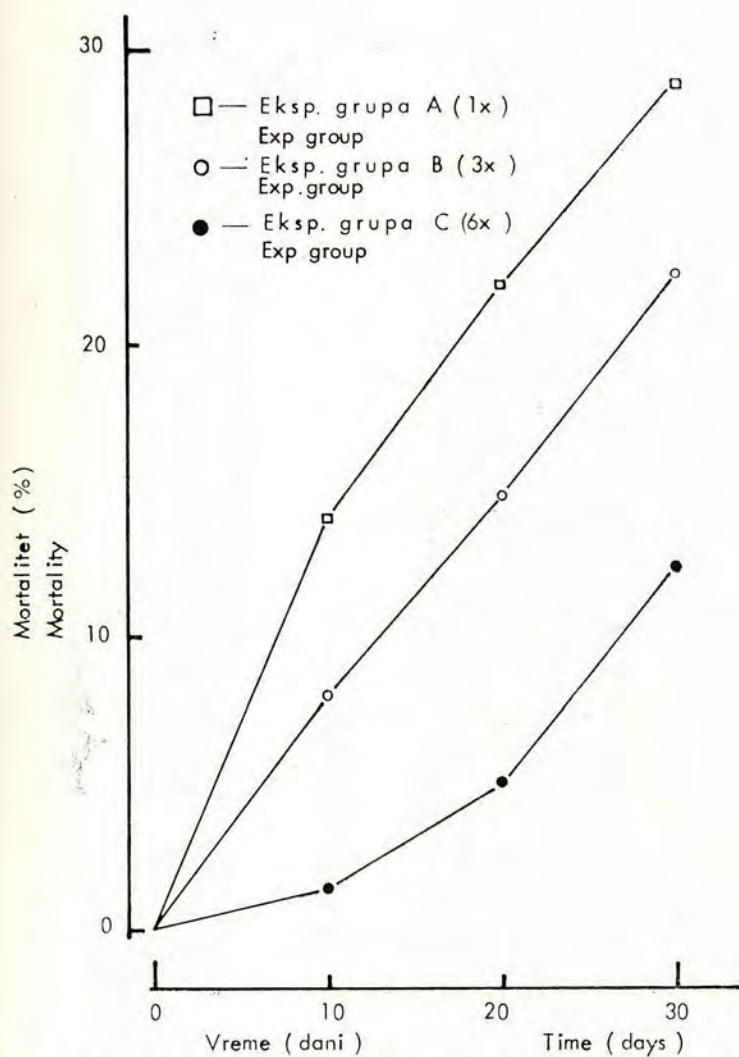
WEIGHT GROWTH PARAMETERS OF THICKLIP MULLET FRY (Chelon labrosus) DURING EXPERIMENTAL PHASE II;  $\bar{W}_0$  - initial mean wet weight;  $\bar{W}_t$  - final mean wet weight; G - growth rate.

Eksp grupa Exp group	$\bar{L}_0$ (mm)	$\bar{L}_t$ (mm)	$\bar{L}_t - \bar{L}_0$ (mm)	$\bar{L}_t - \bar{L}_0$ %	G
A <sub>1</sub>	54.33	62.28	7.95	14.63	0.65
B <sub>1</sub>	53.19	62.18	8.99	16.90	0.75
C <sub>1</sub>	52.91	61.94	9.03	17.07	0.75
D <sub>1</sub>	53.63	63.49	9.86	18.39	0.80

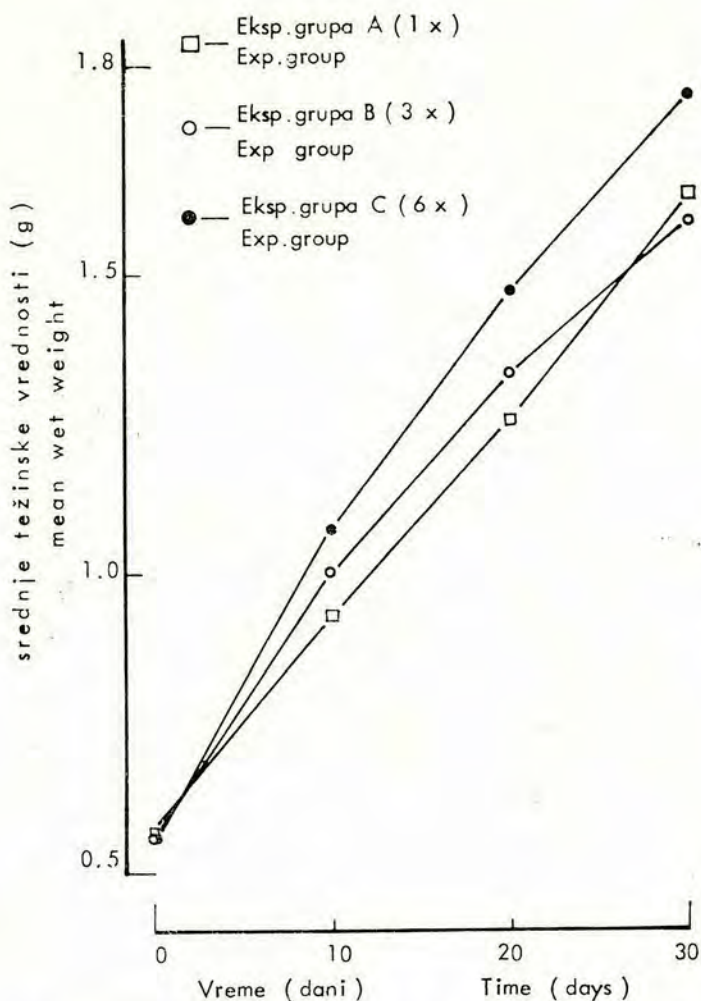
Tab.4 DUŽINSKI RAST MLADI CIPOLA PUTNIKA (Chelon labrosus) TOKOM II EKSPERIMENTALNE FAZE:  $\bar{L}_0$  - inicijalna srednja dužina ;  $\bar{L}_t$  - finalna srednja dužinska vrednost ; G - trenutna stopa rasta.

LENGHT GROWTH PARAMETERS OF THICKLIP GREY MULLET FRY (Chelon labrosus-) DURING EXPERIMENTAL PHASE II:  $\bar{L}_0$  - initial mean length;  $\bar{L}_t$  - final mean length; G - growt rate

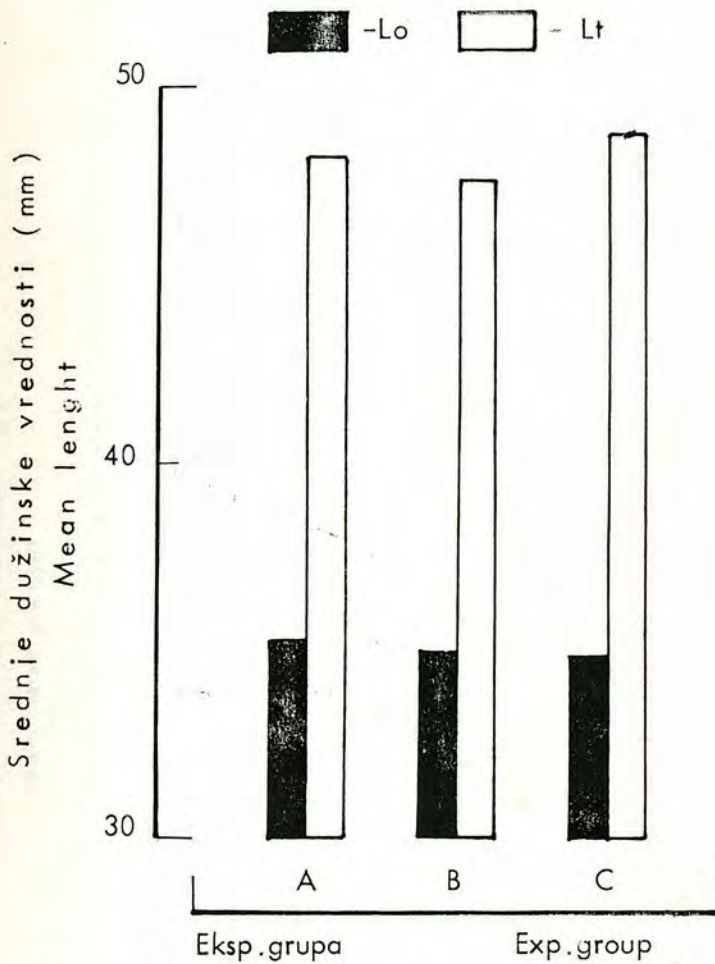




SI.1 STOPA MORTALITETA MLADI CIPOLA PUTNIKA (*Chelon labrosus*)  
 TOKOM PRVE FAZE EKSPERIMENATA  
 MORTALITY RATE OF THICKLIP GREY MULLET FRY (*Chelon labrosus*)  
 DURING EXPERIMENTAL PHASE I



SI. 2 TEMPO TEŽINSKOG RASTA MLADI CIPOLA (*Chelon labrosus*);  
 I eksperimentalna faza (uticaj različitog broja dnevnih porcija  
 na tempo rasta )  
 GROWTH RATE OF THICKLIP GREY MULLET (*Chelon labrosus*)  
 FRY DURING EXPERIMENTAL PHASE I (diferent feeding frequency)



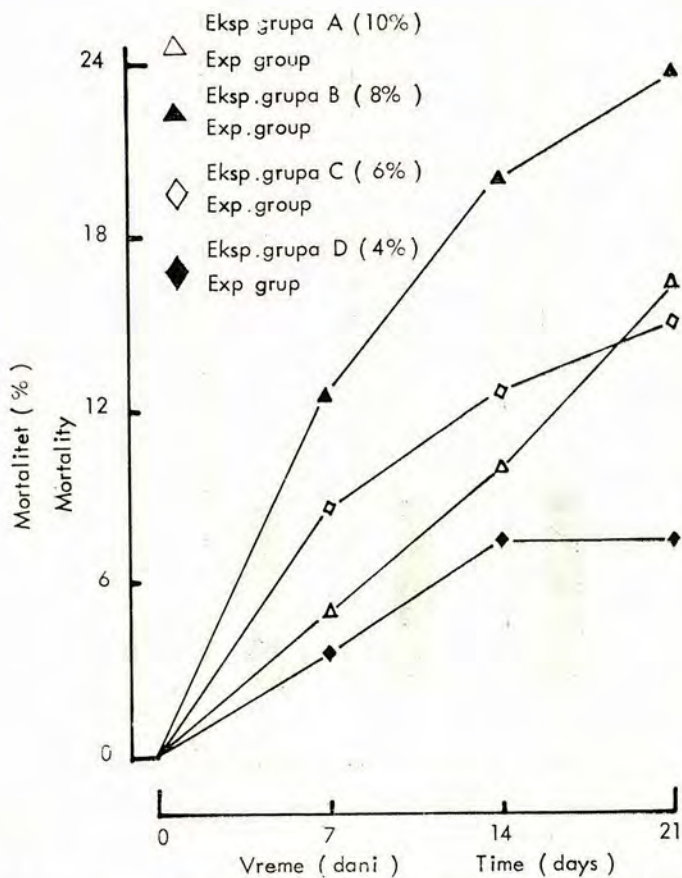
SI.3 DUŽINSKI RAST MLAĐI CIPOLA PUTNIKA

(Chelon labrosus): I faza eksperimenta

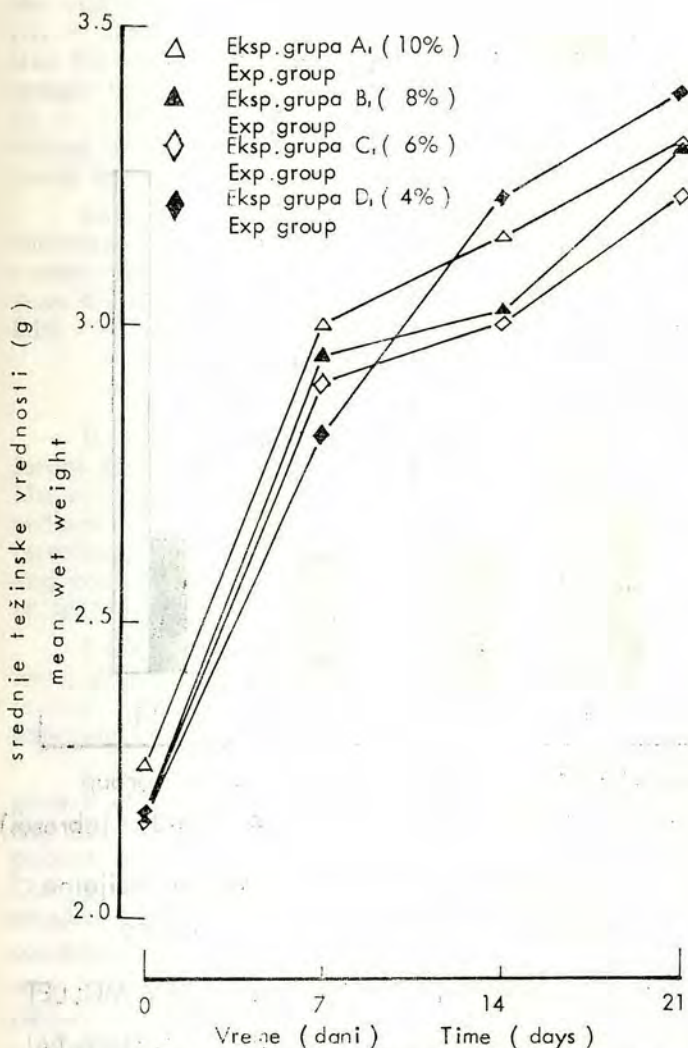
LENGTH GROWTH OF THICKLIP GREY MULLET

FRY (Chelon labrosus) DURING EXPERIMENTAL

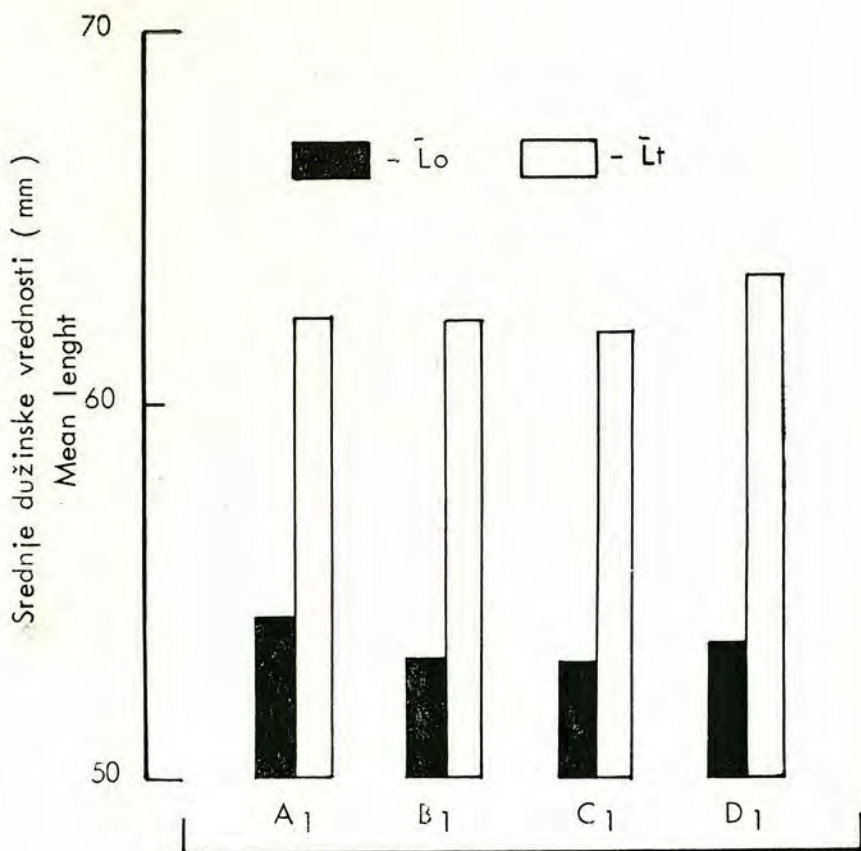
PHASE I; Lo - initial mean length; Lt - final mean length.



SI. 4 STOPA MORTALITETA MLAĐI CIPOLA PUTNIKA (*Chelon labrosus*)  
 TOKOM DRUGE FAZE EKSPERIMENTATA  
 MORTALITY RATE OF THICKLIP GREY MULLET FRY (*Chelon labrosus*)  
 DURING EXPERIMENTAL PHASE II.



SI. 5 TEMPO TEŽINSKOG RASTA MLAĐI CIPOLA ( *Chelon labrosus* )  
 TOKOM II FAZE EKSPERIMENTA ( različite količine hrane )  
 GROWTH RATE OF THICKLIP GREY MULLET FRY ( *Chelon labrosus* )  
 DURING EXPERIMENTAL PHASE II ( different amount of food )



SI. 6 Eksperimentalna grupa Experimental group  
DUŽINSKI RAST MLAĐI CIPOLA (*Chelon labrosus*)

TOKOM II FAZE EKSPERIMENTA:  $\bar{L}_0$  - inicijalna srednja dužina,  $\bar{L}_t$  - finalna srednja dužina

LENGTH GROWTH OF THICKLIP GREY MULLET FRY (*Chelon labrosus*) DURING EXPERIMENTAL PHASE II

$L_0$  - initial mean length  
 $L_t$  - final mean length

The parameters of weight growth rates are represented in figure 5 and in table 3. There were no statistically significant differences between mean weight ( $A_1 = 3.313$  g;  $B_1 = 3.303$  g;  $C_1 = 3.211$  g;  $D_1 = 3.394$  g) of these experimental groups ( $P > 0.005$ ) at the end of the experimental phase. However, analysis of absolute ( $A_1 = 1.007$  g;  $B_1 = 1.137$  g;  $C_1 = 1.054$  g;  $D_1 = 1.218$  g) and relative ( $A_1 = 43.67\%$ ;  $B_1 = 52.49\%$ ;  $C_1 = 48.86\%$ ;  $D_1 = 55.97\%$ ) weight increment and specific growth rate ( $A_1 = 1.72$ ;  $B_1 = 2.01$ ;  $C_1 = 1.90$ ;  $D_1 = 2.12$ ) shows that an increasing trend of these values in function of a decreasing feeding rate exists. The same trend is obtained for the length growth (figure 6 and table 4).

Low productivity of experimental groups  $A_1$ ,  $B_1$  and  $C_1$  is reflected by extremely low food conversion efficiencies with conversion factors of 11.93, 11.38 and 5.46, respectively. At the same time the food conversion factor for the experimental group  $D_1$  was 2.28.

#### DISCUSSION

It was not possible to conclude conclusively what effect different feeding schedules had on the survival of *Ch. labrosus* fry. Mulletts, especially the fry, are very sensitive to the handling procedures. Also, a prominent number of dead fish showed signs of infection, so frequent experimental manipulation (control weighing and counting) and the infection were probably the major reasons of such a high mortality rate.

Differences in length growth between experimental groups were slightly expressed during both experimental phases. Length is more conservative character than weight and it seems that the experimental time was too short for this growth parameter.

Food supply is probably the most potent factor affecting the growth of fishes, for only if the food supply is sufficient in quantity and adequate in quality can fishes attain maximum growth possible for the existing physico-chemical conditions (Brown, 1957). During early stages of life mulletts are carnivorous feeders which require food with a high protein level. This type of feeding in combination with intensive farming in a recycling system, as nursery, permits the use of artificial food which is rich in proteins (Höner et al., 1988; Vallet et al., 1970). One of the major problems with the feeding of fry is the identification of the optimum feeding frequency. Because of the relatively small stomach and the high metabolic rate of fish fry it is desirable to feed them frequently, but the optimum feeding frequency may vary with species and cultivation method. The optimum feeding frequency for *Channa striatus* fry is once-a day (Sampath, 1981), three per day for *Cy-*

*prinus carpio* fry (Charles et al., 1984), eight times daily for channel catfish maintained in a intensive culture system (Stickney, 1979).

A feeding frequency of six times per day resulted in higher weight growth rate and better food conversion efficiency, than once-a-day and three times per day feeding frequency schedule, for *Ch. labrosus* fry reared in the intensive recycling system. Food intake is governed by hunger level which in turn depends on food retention time (Brett, 1971), and also by feeding behavior. Yashouv and Ben-Sachar (1967) reported that the time span of food retention, for *Liza ramada* fry, depends primarily on the amount of food available. Mulletts are daylight feeders with the peak of activity around midday (De Silva and Wijeyarante, 1977; Brusle, 1981), so food should be offered all over the daylight period to accelerate fry growth. Yashouv and Ben-Shachar (1967) noted for *Liza ramada* fry that after three minutes of intense feeding the ratio lessens. They explained this phenomena by the filling of the stomach and not to the reduction in the number of food animals. Offering food in six daily portions to *Ch. labrosus* fry gave them opportunity to feed all over the daylight period.

One of the adverse effects of frequent feeding might be increasing in specific dynamic action and swimming activity. These activities could reduce food conversion efficiency what was not achieved in the present study. On the contrary frequent feeding resulted in better food conversion efficiency. Also, it should be pointed out that frequent feeding may reduce the wastage of food.

Evaluation of the optimum feeding rate is one of the major tasks in aquaculture practice. The optimum feeding rate supplies maximum growth and reduces the costs of farming.

Decreasing of feeding rate in our experiment did not result in decreased growth of *Ch. labrosus* fry. On the contrary the 4% daily food ratio resulted in the best growth performance and food conversion efficiency. This result is in discrepancy to the result which was reported by Vallet et al. (1970). They reported that in grey mullet culture, a ration of 8% of the body weight is sufficient to obtain almost maximum growth. Mulletts are changing their natural feeding regime from carnivorous to herbivorous at the standard length of about 50 mm (Ben-Yami, 1981; Albertini-Berhaut, 1973; Vallet et al., 1970). Papaparaskeva-Papoutsoglou and Alexis (1986) reported that the optimum protein level in the diet of *Liza ramada* fry (50 mm standard length, 2.5 g weight) for maximum protein retention and optimum growth is around 24%. This protein optimum is similar to that reported by Vallet et al. (1970). In our experiment we used food with a protein content of 45%



for the *Ch. labrosus* fry of similar size. However, it should be noted that there are no big differences for average weight and food conversion rate between our results and the results reported by Papaparaskeva-Popoutsoglou and Alexis. Both pairs of results have similar values.

From these results it seems that it is possible to culture *Ch. labrosus* fry until they reach a size of about 60 mm standard length (the most suitable size for stocking purposes) with artificial food of high protein content. This food should be offered, after fry reaches size of about 50 mm standard length, in a daily amount which is not higher than 4% of total body weight.

We have to point out that one of the primary rules in feeding any species in aquaculture is that the organisms should not be overfed (Stickney, 1979). Overfeeding could have adverse influence on the fish physiological condition and on water quality, what can lead to reduced survival and growth rates as a final result.

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## I z v o d

Upotreba zatvorenih reciklažnih sistema, kao rastilišta, u cilju produkcije mladi riba za nasadivanje uzgojnih basena, omogućava praćenje i kontrolisanje fizičkih, hemijskih i biotičkih faktora koji stoje u direktnoj vezi sa rastom i preživljavanjem mladi. Jedan od osnovnih problema intenzivnog uzgoja je pravilan izbor hraniva i adekvatnih režima ishrane. Ispitivali smo uticaj različitih režima ishrane (različit broj dnevnih porcija, različite količine hrane) na rast i preživljavanje mladi cipola putnika, *Ch. labrosus*.

Tokom ranih stadijuma razvića cipoli su karnivori, prelazeći na omnivorni i herbivorni tip ishrane pri standardnoj dužini tijela od oko 50 mm. Karnivorni tip ishrane i intenzivni način uzgoja opravdavaju upotrebu visokoproteinskih vještačkih hraniva pri uzgoju mladi cipola u rastilištu (u ovom slučaju reciklažni sistem) do dostizanja nasadne veličine od oko 60 mm standardne dužine (uzrast najpovoljniji za nasadivanje uzgojnih basena).

U I fazi eksperimenta ispitivan je uticaj različitog broja dnevnih porcija (1×, 3×, 6×) na rast mladi cipola putnika. Eksperimentalna grupa hranjena sa 6 dnevnih porcija pokazivala je na kraju eksperimenta najbolje performance rasta (srednja težinska vrijednost, apsolutni i relativni težinski prirast). Testiranjem srednjih težinskih vrijednosti t-testom dobili smo da postoji statistički značajna razlika ( $P < 0.05$ ) između eksperimentalnih grupa hranjenih 6×/1× i 6×/3×, dok ova razlika nije nađena za eksperimentalne grupe 3×/1×. Cipoli se hrane tokom cijelog dnevnog perioda sa pikom aktivnosti oko sredine dana. Zbog relativno malog stomaka i intenzivnog metabolizma poželjno je mlađ cipola hraniti u većem broju dnevnih porcija.

U drugoj fazi eksperimenta ispitivan je uticaj različitih dnevnih količina hrane (10%, 8%, 6%, 4%) na rast mladi cipola putnika, koja je dostigla uzrast od 50 mm standardne dužine. Sve četiri eksperimentalne grupe hranjene su u 6 dnevnih porcija. Testiranjem srednjih težinskih i dužinskih vrijednosti nijesmo dobili da postoji statistički značajna razlika ( $P > 0.05$ ) između eksperimentalnih grupa. Međutim, niska produktivnost eksperimentalnih grupa hranjenih sa dnevnom količinom hrane od 10%, 8% i 6%, totalne težine stoka, ogledala se u visokim vrijednostima konverzio-

nog faktora hrane (11.93, 11.38, 5.46). Vrijednost konverzionog faktora za eksperimentalnu grupu hranjenu sa dnevnom količinom hrane od 4% od težine stoka bila je 2.28. Smatramo da mlađi cipola, uzrasne klase od 50 mm standardne dužine, ne treba u uslovima intenzivnog uzgoja i ishrane visokoproteinskim vještačkim hranivima davati hrane u iznosu većem od 4% od težine stoka. Ova mlad bi se uzgajala u intenzivnom sistemu do dostizanja uzrasta od oko 60 mm, nakon čega bi se vršilo njeno nasađivanje u uzgojne ribnjake.