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EVALUATION OF CYPRINIDS CONDITION REARED IN TWO INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) SYSTEMS BASED ON A FEW SOMATIC INDICES (VSI, HSI, GaSI AND RGL)

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Abstract

The present study was carried out to measures and analyses the condition of cyprinids, reared in a two IMTA systems by using a few organosomatic indices. The first pond (PCP) was used for rearing common carp in polyculture with other cyprinids. The second pond was divided in two parts: first part-common carp (CP) and the second part - polyculture (PP). During this experimental period (May to September), the biometric measurement was made monthly. Regarding to the feeding regime, fish were feed only in PCP and CP pond (part of CP-PP pond). At the end of the experiment the results showed an increase in viscerosomatic index (VSI), hepatosomatic index (HIS), gastrosomatic index (GaSI) at cyprinids in CP and PCP. This is mainly due to the fact that only in CP and PCP feed was administered. An increase in the relative gut length (RGL) index was observed especially in grass carp, followed by the other cyprinids in the PP pond, part of the CP-PP pond, in which feed was not administered. In conclusion, this shows us that cyprinids can adapt to the natural feeding conditions in case of feed absence (cereals mix).

***Key words**: cyprinids, IMTA, organosomatic indices, polyculture, relative gut length.*

INTRODUCTION

Over the past few decades, the increasing demand for world fishery production has led to a significant expansion of aquaculture, which accounts for about half of global seafood production (Zhu et al., 2019).

Impact of common carp (*Cyprinus carpio*, Linnaeus 1758) pond production on fish pond ecosystems has been extensively studied in Central and Eastern Europe (Pechar et al., 2002). Currently, the evaluation of possible positive, as well as negative effects of fishery management on surface water quality (Vsetickova et al., 2012) is another important issue, often linked to integrated aquaculture systems.

Strategies that aimed to reduce the impact of nutrients on aquaculture effluents have focused on optimizing feed composition, improving feed and feeding technology, as well as feeding strategy (Boyd, 1998).

Integrated multi-trophic aquaculture (IMTA) is the farming, in proximity, of species from different trophic levels and with complementary ecosystem functions in a way that allows one species uneaten feed and wastes, nutrients and by products to be recaptured and converted into fertilizer, feed and energy for the other crops, and to take advantage of synergistic interactions among species while biomitigation takes place (Chopin, 2013). The multi-trophic sub-systems are integrated in IMTA that refers to the more intensive cultivation of the different species in proximity of each other, linked by nutrient and energy transfer through water (Sasikumar & Viji, 2016).

Cyprinidae polyculture is also favored, based on the assumption that each fish species has its own feeding niche that does not overlap much with the feeding niche of the other species. As a result, a large fraction of natural food available in the pond is used in multi-species systems (Khan et al., 2016).

Feed and feeding are the key components of cost-effective aqua-culture, economic and nutritional achievements of the aquaculture mainly depend upon supplementary diets (Omosowone & Ogunrinde, 2018).

Fish diet has been found to be an important factor governing fish growth, welfare, condition factor, fecundity and migration patterns (Adeyemi et al., 2009; Rao, 1974). Feeding is the dominant activity of the entire life cycle of fish (Joadder & Hossain, 2008). The study of the food and feeding habit of fishes provide keys for the selection of culturable species and such information is necessary for successful fish farming (Manon & Hossain, 2011).

The study of fish condition is usually based on the analysis of length-weight data and of other indices like organosomatic indicators. Organosomatic indices can be described as the ratios of organs to body weight when the measured organ in relation to body mass can be directly linked to some environmental changes (Ronald & Bruce, 1990). It is manifested through changes in size that are reflected through a reduction or increase, influenced by environmental factors. Size and weight of the organs are related to the overall length and weight of fish and indicate the general status of health of the fish (Ronald & Bruce, 1990). However, organosomatic indices may provide more specific information related to the function of the selected organ (Martin-Diaz et al., 2005). It can also be used as indices of changes in nutritional and energy status (Maxwell & Dutta, 2005).

The aim of this research was to evaluate the condition of cyprinids, reared in a two IMTA systems, by using a few organosomatic indices like viscerosomatic index, hepatosomatic index, gastrosomatic index and relative gut length.

MATERIALS AND METHODS

Description of the study sites. The research were conducted at the "S.C. Piscicola Iasi" fish farm, which is situated at 24 km from Iasi, more exactly in the Larga Jijia village. The water source is represented by Jijia river. Both inlet and outlet are made gravitationally, by using monk hydraulic constructions. The location of the farm is described in the work published by Petrea et al. (2017).

Design experimental. The experiment was performed in two ponds with an area of 0.45 ha each, with an average water depth of 1.5 m.

The first pond (PCP) was used for rearing carps in polyculture like as: common carp (*Cyprinus carpio* - 2500 exemplars) with grass carp (*Ctenopharyngodon idella* - 100 exemplars), bighead carp (*Hypophthalmichthys nobilis* - 40 exemplars) and silver carp (*Hypophthalmichthys molitrix* - 40 exemplars).

The second pond was divided by using a net, and stocked as follows: first part with an area of 0.15 ha (CP - with 2000 common carp exemplars) and the second part with an area of 0.30 ha (PP - with 500 common carp exemplars, 40 silver carp exemplars, 40 bighead exemplars and 100 grass carp exemplars).

At the beginning of the research the individual average of common carp biomass weight was 61.9±10.0 g/ex, for silver carp was 2025.1±248.9 g/ex, for bighead carp was 1880.5±193.3 g/ex and for grass carp was 199.9±19.7 g/ex.

This experimental design was used for a growth research that had lasted from May to September characteristic for a carp growth cycle.

In the second pond, CP-PP pond, an intermittent hydraulic regime was applied during the day-time, in order to transport the fish metabolic wastes from CP pond area, to PP pond area, in order to assure the development of phytoplankton and therefore, to generate a better wastes management and valorisation.

Regarding to the feeding regime, fish were feed only in PCP and CP pond (part of CP-PP pond). The administered feed had a crude protein content of 28% and was represented by a mix of cereals (wheat lees, dry maize dregs, sunflower groats) in equal amounts and flour protein. Feed was manually administered twice/day, only in PCP and CP, for five days/week.

During the research, fisheries control were carried out every month. At each fishing control, biometric measurements were performed and also, fish were retained for the organosomatic analysis.

Organosomatic analysis. The analysis of organosomatic indices was determined at the Research Laboratory of Food Science, Food Engineering, Biotechnologies and Aquaculture Department from "Dunărea de Jos" University of Galaţi. Until the laboratory, during the transportation the fish were kept in refrigerated boxes. The fishes from sampling ponds were wiped dry with the help of a cotton towel. Each exemplar was weighed on a electronic balance. Then was followed immediately by fish evisceration to determine the organosomatic indices. Complete care was taken with the gut to prevent either the injury or pressure to avoid the loss of gut contents. Total length and total weight of gut was also recorded. Among the determined indices are listed: viscerosomatic index (VSI), hepatosomatic index (HSI), gastrosomatic index (GaSI) and relative gut length (RGL). These indices were calculated using the following formulas (sources 4, 7):

VSI (%) = 100 x viscer weight (g)/weight of fish (g) (1)

HSI (%) = 100 x liver weight (g)/weight of fish (g) (2)

GaSI (%) = 100 x weight of full gut (g)/ weight of fish (g) (3)

RGL = gut length (cm)/total length of fish (cm) (4)

Statistical analysis

The results obtained in this research were statistically analysed using IBM SPSS Statistics 20.0, Microsoft Excell 2010. To determine significant differences among groups was used the one-way analysis of variance (ANOVA); $p<0.05$ was considered as significant.

RESULTS AND DISCUSSIONS

Integrated multi-trophic aquaculture (IMTA) is considered a solution for converting the waste products from one food production process (in this case, fish production) into a source of food for other organisms, generating therefore valuable products, thus, improving the aquaculture industry sustainability and profitability (Petrea et al., 2019).

The individual length-individual weight linear regression.

A. PCP experimental variant

At the beginning of the experimental period, no significant differences ($p>0.05$) were observed between the experimental variants in terms of fish, individual length and individual weight. Therefore, the homogeneity of fish experimental biomass was statistically verified (Levene Test, $p>0.05$).

Common carp. The individual length-individual weight linear regression shows high homogeneity both at the beginning and at the end, but also during the experimental period. Therefore, the following linear regression factors were recorded: R^2 initial = 0.82; R^2 Int.1 = 0.953; R^2 Int.2 = 0.819; R^2 Int.3 = 0.909; R^2 final = 0.768 (Figure 1).

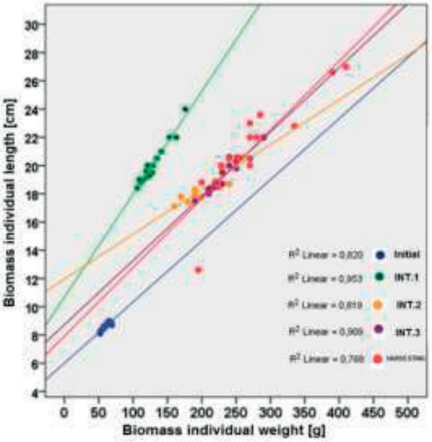

Figure 1. Linear regression of common carp biomass individual length-weight during the experimental period

Silver carp. The individual length-individual weight linear regression shows high homogeneity at the initial, Int.3 and at the final harvesting. Therefore, the following linear regression factors were recorded: R^2 initial = 0.879; R^2 Int.2 = 0.032; R^2 Int.3 = 0.997; R^2 final = 0.817 (Figure 2). The lowest value of linear regression factor, recorded at Int.2 is due to small number of silver carp caught at the control harvesting, this fact conducted to an inconclusive statistically result.

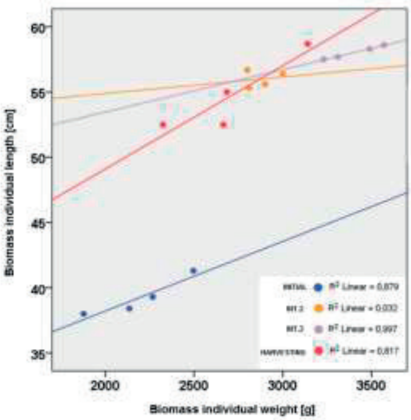

Figure 2. Linear regression of silver carp biomass individual length-weight during the experimental period

Bighead carp. The individual length-individual weight linear regression shows high homogeneity at the initial, Int.1 and at the Int.2 harvesting. Therefore, the following linear regression factors were recorded: R^2 initial = 0.905; R^2 Int.1 = 0.979; R^2 Int.2 = 0.856; R^2 Int.3 = 0.670; R^2 final = 0.523 (Figure 3). The lowest values of linear regression factor, recorded at Int.3 and final harvesting showed that there is an inconsistent linear relation between weight and length growth in the second half of the experimental period (Figure 3).

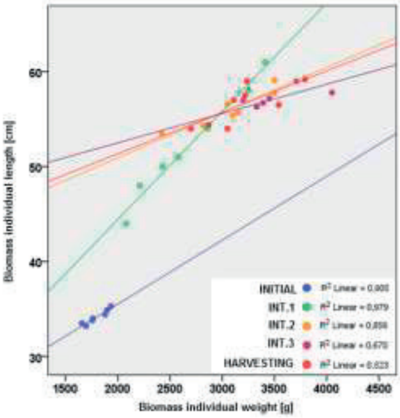

Figure 3. Linear regression of bighead carp biomass individual length-weight during the experimental period

Grass carp. The individual length-individual weight linear regression shows high homogeneity at the initial, Int.1, Int.2 and at the final harvesting. Therefore, the following linear regression factors were recorded: R^2 initial = 0.965; R^2 Int.1 = 0.978; R^2 Int.2 = 0.938; R^2 Int.3 = 0.746; R^2 final = 0.981 (Figure 4).

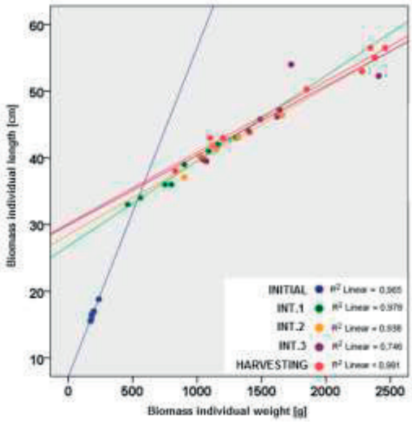

Figure 4. Linear regression of grass carp biomass individual length-weight during the experimental period

B. CP-PP experimental variant

Common Carp - CP. The individual length-individual weight linear regression shows high homogeneity throughout the experimental period. Therefore, the following linear regression factors were recorded: R^2 initial = 0.799; R^2 Int.1 = 0.998; R^2 Int.2 = 0.978; R^2 Int.3 = 0.962; R^2 final = 0.710 (Figure 5).

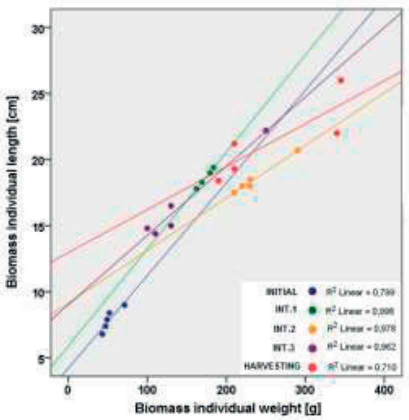

Figure 5. Linear regression of common carp biomass individual length-weight during the experimental period

Common Carp - PP. The individual length-individual weight linear regression shows high homogeneity from the beginning of the experimental period, until Int.3 (Figure 6). Therefore, the following linear regression factors were recorded: R^2 initial = 0.808; R^2 Int.1 = 0.938; R^2 Int.2 = 0.934; R^2 Int.3 = 0.695; R^2 final = 0.702 (Figure 6).

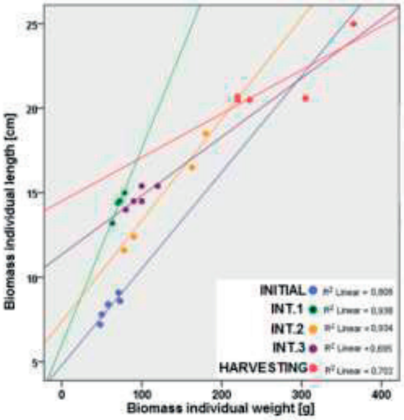

Figure 6. Linear regression of common carp biomass individual length-weight during the experimental period

Silver Carp - PP.
A high homogeneity of the initial and final fish biomass is also highlighted by the individual length-individual weight linear regression. Therefore, the following linear regression factors were recorded: R^2 initial = 0.992; R^2 final = 0.932 (Figure 7).

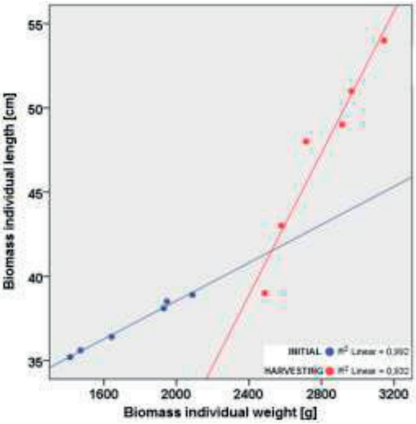

Figure 7. Linear regression of silver carp biomass individual length-weight during the experimental period

Bighead carp - PP. The individual length-individual weight linear regression shows high homogeneity at the initial and Int.2 harvesting. Therefore, the following linear regression factors were recorded: R^2 initial = 0.910; R^2 Int.2 = 896; R^2 Int.3 = 0.692; R^2 final = 0.694 (Figure 8). The lowest values of linear regression factor, recorded at Int.3 and final harvesting showed that there is an inconsistent linear relation between weight and length growth in the second half of the experimental period (Figure 8).

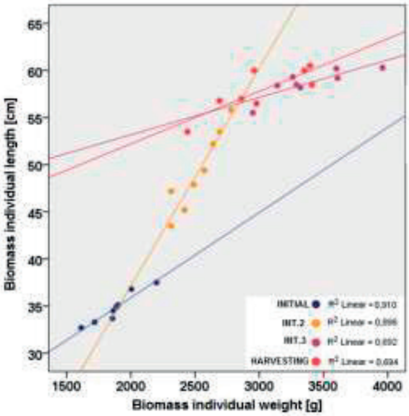

Figure 8. Linear regression of bighead carp biomass individual length-weight during the experimental period

Grass carp - PP. The individual length-individual weight linear regression shows high homogeneity of grass carp biomass during the entire experimental period (Figure 9).

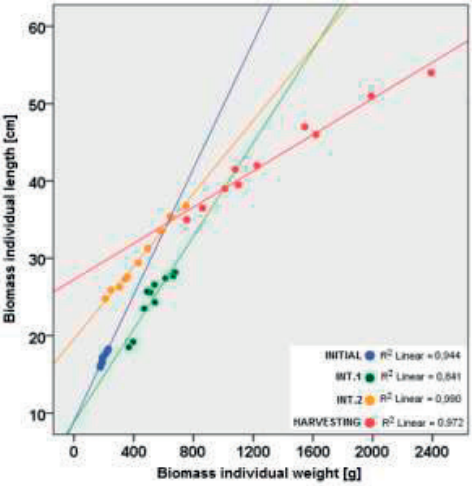

Figure 9. Linear regression of grass carp biomass individual length-weight during the experimental period

Therefore, the following linear regression factors were recorded: R^2 initial = 0.944; R^2 Int.1 = 0.841; R^2 Int.2 = 0.990; R^2 final = 0.972.

Organosomatic indices.

A. Viscerosomatic index (VSI %)

In addition knowledge of some quantitative aspects in fishes is an important tool for the study of biological fundamentals such as viscerosomatic and hepatosomatic indices, because measurement and analysis of these indices are very important in assessing food value (Ighwela et al., 2014).

When comparing the results obtained during the entire production cycle, it is found that VSI index recorded significant higher values ($p<0.05$) in CP pond (14.07±0.93%) in case of common carp, followed by the values obtained in PP pond (11.73±2.14%), respectively in PCP pond (11.40±1.25%) (Figure 10).

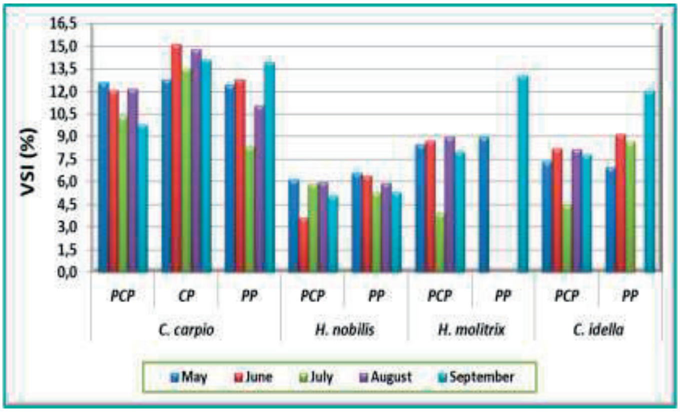

Figure 10. Changes of the viscerosomatic index (VSI) in response to different feeding regime

At the same time, in the case of the other species, it is observed that the VSI index showed higher values in PP pond (bighead carp - 5.90±0.69%, silver carp - 11.00±2.89%, grass carp - 9.21±2.10%), compared to the PCP pond (bighead carp - 5.34±1.05%, silver carp - 7.63±2.11%, grass carp - 7.19±1.55%), in which the feed was administered. No results are available during the experimental period, at intermediary stages (from June to August), because no exemplars of silver carp were harvested.

B. Hepatosomatic index (HSI %)

The study of viscerosomatic and hepatosomatic indices has an important role in the metabolism of the fishes, related to digestion and absorption, synthesis and secretion of digestive enzymes and carbohydrate metabolism (McLaughlin, 1983).

Singh and Canario (2004) observed that hepatosomatic index is one of the most investigated biomarker due to important role of liver in detoxification of pollutants.

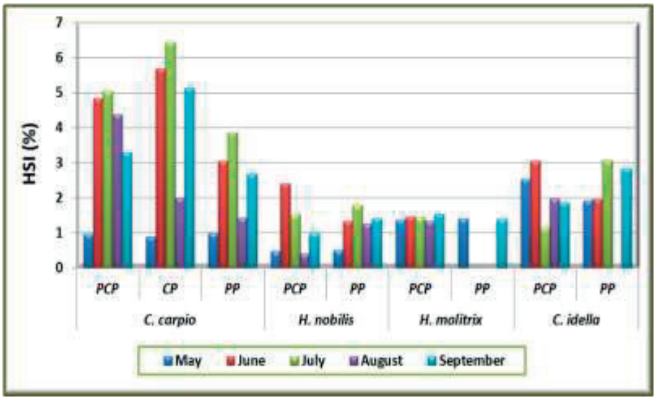

Figure 11. Changes of the hepatosomatic index (HSI) in response to different feeding regime

If at the VSI level there were significant differences only in carps reared in CP pond compared to that raised in PP pond and PCP pond, in case of the hepatosomatic index there were no significant differences ($p>0.05$) in any of the carp species reared in those two systems (PCP and CP-PP) (Figure 11).

During the entire production cycle the mean highest values of HSI were registered for common carp in CP pond (4.03±2.44%), for bighead carp and grass carp in PP pond (1.26±0.47%, respectively 2.45±0.59%) and for silver carp in PCP pond (1.44±0.08%).

Gastrosomatic index (GaSI %)

The gastro-somatic index (GaSI) was used to determine the feeding intensity of fish (Kurbah & Bhuyan, 2018).

The results of GaSI index are presented in Figure 12. Regarding to the results obtained at the level of GaSI index a significant differences ($p<0.05$) between PCP and PP pond was registered in case of grass carp. The highest mean value of GaSI were recorded for common carp in CP-PP pond (4.24±0.44% - CP, respecttively 3.31±0.90% - PP) and for bighead carp (2.21±0.81%), silver carp (1.98±0.47%, respectively for grass carp (4.47±0.86%) in PP pond.

The higher values of GaSI obtained in PP part of CP-PP pond may be due to the gravitational current of water (the water supply of the pond is made near to CP and the evacuation near to PP part of the pond) which led to the movement of nutrients from CP to PP resulting in PP a better development of natural feed.

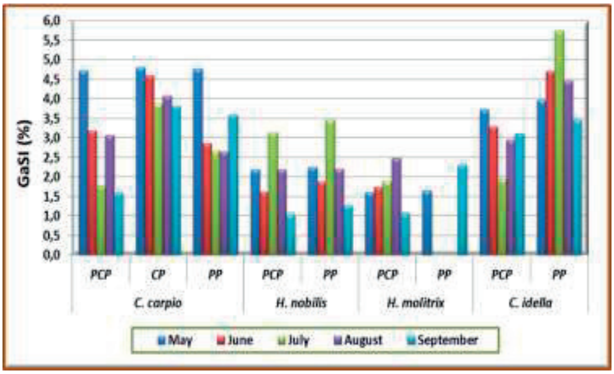

Fig. 12. Changes of the gastrosomatic index (GaSI) in response to different feeding regime

Although feed (mix of cereals) was administered in PCP, compared to PP pond, we can say that the fish were satisfied only with the food received and were no longer tempted to consume a large amount of natural feed. This aspect can explain the fact that the GaSI index was higher in case of Asian cyprinids in PP pond, because they had to eat only natural food, showing in the literature are presented that the consumption of only natural feed leads to gut increase in length and also in the weight than in the case of fish for which was administered feed (Koundal et al., 2013; Biswas, 1993).

At the same time, there was appeared the competition between carp species for the administered feed in PCP pond, for this reason the GaSI values were higher in the case of the common carp from CP pond.

Relative gut length (RGL)

Food and feeding habit of fish are important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in association and to utilize all the available food (Dewan & Saha, 1979).

The relative gut length of the species may vary according to the difference in the food habits in different life stages (Biswas, 1993). The food preferences depend greatly on the nature of food available in the living habitat, environmental conditions, size or sexual stages of fish as well as inter and intra specific competition (Zacharia & Abdurahiman, 2004). Relative gut length (RGL) has been widely used to determine the feeding habits of fish such as herbivorous, carnivorous, omnivorous, herbi-omnivorous or carni-omnivorous (Koundal et al., 2013, Dasgupta, 2002).

The food items of common carp is mostly omnivorous in nature. Among the food items zooplankton and debris and detritus were most dominant followed by the aquatic plant parts, phytoplankton, zooplankton, debris and detritus, insects and semi-digested food materials (Manon & Hossain, 2011). In our case fish is omnivorous because also feeds with zooplankton in culture ponds.

Regarding to the RGL the results are presented in Figure 13. A significant differences ($p<0.05$) between PCP and PP pond, at the level of all cyprinids, was registered in case of grass carp. The mean value of RGL obtained during the entire production cycle were 2.31±0.41 in CP, 2.04±0.61 in PP, respectively 2.11±0.43 in PCP pond for common carp, 6.29±1.51 in PP and 6.18±1.63 in PCP pond for bighead carp, 7.76±1.03 in PP and 7.64±1.18 in PCP pond for silver carp, 3.37±0.24 in PP and 2.89±0.32 in PCP pond for grass carp.

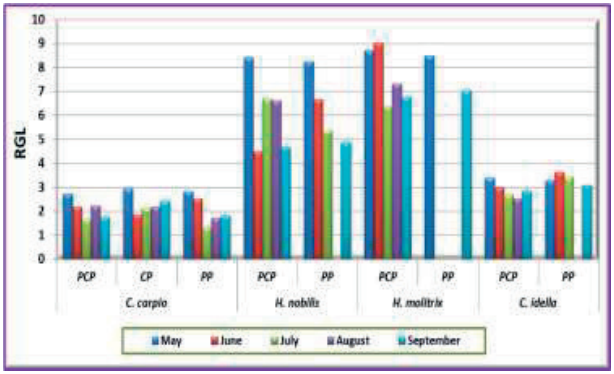

Figure 13. Changes of the relative gut length (RGL) in response to different feeding regime

Shafi et al. (2012) showed that the relative contribution of animal matter in the food of common carp clearly indicates that it is omnivorous in its feeding habit, which is also supported by its RLG which was present with a mean value of 1.87, value close to those obtained by us in case of common carp.

The analysis of gut content, Gastro-Somatic Index (GaSI) and Relative Length of the Gut (RLG) will definitely help in achieving basic information on overall biology of this fish species. Also, that organosomatic index is an appropriate bioindicator for endocrine disruption in fish consequent of chemical exposure (Dogan & Can, 2011).

CONCLUSIONS

Based on the obtained results of RGL, these cyprinids are considered as a omnivorous fish because the values are greater than 1.

Regarding to the GaSI value was observed low feeding intensity for cyprinids growth in polyculture carp pond (PCP) this is due to the emergence of food competition as opposed to those from the polyculture pond (PP part of CP-PP pond) who each had their own trophic niche as long as no additional food was administered.

In conclusion, this shows us that cyprinids can adapt to the natural feeding conditions in case of feed absence, a cereals mix in our case.

Also, these results of organosomatic indices can be considered useful as baseline data for further monitoring the fish condition, nutrition data and also inspirited the researchers to do further research in this area.

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