

ABSTRACT

**RESEARCHES ONTO THE USAGE OF
AQUATIC VEGETATION BY SEVERAL FISH SPECIES**

Pisciculture and fishing activities within freshwaters and seas reveal significant importance, given by the quantities of meat containing high amount of qualitative proteins, easily digestible in humans' nourishment, meantime constituting a valuable source of raw matters for certain industries: mixed fodder processing, pharmaceutical activities and so on. The researches of the scientific field demonstrated that the fish meat proteins are 2-3 folds easier to be digested than those found in cattle, sheep or swine meat. Fishes also serves for fish oil extraction, which is rich in A and D vitamins, playing thus a significant role in rachitic diseases prevention.

Managed fishes husbandry is an old occupation, but with an actual high significance, knowing that providing the required food quantities for human populations is yet an unsolved problem and that $\frac{3}{4}$ of Earth surface is covered by water. In several countries, cyprinids serves as primary source of cheap proteins used to fight against malnutrition, the derived products containing those essential aminoacids which frequently lack from vegetal protein substitutes. It was also found that cyprinids better concert feed than ruminants, poultry or even than swine. Some cyprinids species consume those microorganisms that could not be directly used by humans, while other species act like real sanitary agents, consuming even the detritus. *Ctenopharyngodon idella* (grass carp) is a cyprinid which converts aquatic macroflora into valuable meat, easy to assimilate and rich in proteins.

The cypriniculture development lead to the settlement and improvement of those upstream or downstream related activity fields: processing of products issued from cypriniculture, production of feed (mixed fodders) for cyprinids, manufacturing of fishing nests, production of refrigeration installation and so on.

Fishing activity has began in antiquity on the nowadays Romania's territory and long lasted till today, mainly due to the wealth of rivers, lakes, ponds and of the Danube in fish resources.

In certain countries, the pisciculture contributes to the achievement of a relatively cheap protein source, mainly used for fight against malnutrition, the production expenses and the feed conversion being more reduced as compared to other terrestrial animals.

Ctenopharyngodon idella species, grace to its multiple qualities, imposes to be reared within carp pools, increasing thus the economical efficiency into the cyprinids farms, mainly through the valorisation of the aquatic macroflora. *Ctenopharyngodon idella* is reared across the entire world, in many countries (China, Austria, Germany, Taiwan, Malaysia, Hong Kong, Sweden, Canada, U. S.A., France, Romania, Israel, Egypt, Finland, United Kingdom), proving thus the economical significance of this species.

Valuable information has been acquired during scientific literature studies, mainly concerning the intake and the valorisation of the aquatic vegetation by both cyprinids species used in the own experiments (*Cyprinus carpio* and *Ctenopharyngodon idella*), as well as various data referring to the chemical and nutritional features of the plants used as feed.

Ctenopharyngodon idella is a species with certain preferences concerning aquatic vegetation intake, ordered as follows: *Potamogeton angustifolius*, *Ceratophyllum demersum*, *Ceratophyllum submersum*, *Elodea canadensis*, *Lemna sp*, *Phragmites communis*, *Phararis arundinacea*, *Scirpus lacustris*, *Carex vulpina*, *Typha sp.*, or even regarding terrestrial plants consumption: *Trifolium repens*, *Medicago sativa*, *Sailix sp*, acacia leafs, green mass of vetch given in certain places of the pool. It does not consume: *Heleocharis*, *Nymphes*, *Sparganium*, *Stratiotes* and *Panuncius fluitans*. Feed intake begins at 15° C water temperature and reaches its highest level at 25-30°C.

Some arguments stand for the interest of extending the rearing of this species: it consumes and valorises the macrophyte vegetal biomass which is not used by other fishes; fights against undesired aquatic vegetation without any equipments and fuel expenses; contributes to the increasing of the life conditions level for other species reared in policulture system, mainly through the improvement of the oxygen status and through the multiplying of the biogenic substances, of the planktonic and benthonic biomass.

It is well known that the productivity of aquatic ecosystems due to their primary production. Thus, within any aquatic pool, the main producers are represented by macrophyte

vegetation, by the water's algae and by the bacterial mass on the pool bed. The high occurrence of the immerse and submerge aquatic vegetation into the fisheries pools becomes an inconvenient when producing high fish quantities, due to the removal from the biological circuit of those nutritional elements from pools' soil and water or due to the solved oxygen consumption during night time.

In order to fight against macroflora, phytophagous fishes are used to consume vegetation, eg. the *Ctenopharyngodon idella* species, which consumes and converts biomass in fish meat. This species is in fact a 1st degree consumer, which provides high productivity to the aquatic pools, through the shortage of the food chain. As previously specified in scientific literature (Giurcă, 1980), a high amount of aquatic macrophytes (*Phragmites*, *Scirpus*, *Typha*, *Ceratophyllum*, *Potamogeton*, *Lemna*, etc.) or of terrestrial ones (*Trifolium*, *Medicago*, *Dactylis*, *Lolium*, *Festuca*, *Ranunculus*, etc.) provide high nutritional value which could be well valorised by the herbivore and omnivore cyprinids species.

Considering the scientific value of the own researches and of the achieved results, we notice they are of high quality level, mainly because the pisciculture researches focused onto the valorisation of the natural feed sources within the aquatic pool into fish meat production, assuring meantime the economical efficiency. Consequently, there were researched those ways to supply the supplemental feed (mixed fodders) with aquatic macrophytes from the pools containing *Cyprinus carpio* and *Ctenopharyngodon idella* populations, as well as with terrestrial vegetation usually found nearby pools' borders, which are high valorised by these fishes. There was noticed a lack of consistent data within the references, concerning the usage of aquatic and terrestrial vegetation by the species we studied. We consider the own researches brought a significant and valuable contribution to the integrity of knowledge in fishes nutrition and feeding field.

The researches run to elaborate the PhD dissertation, entitled « Researches onto the usage of aquatic vegetation in feeding of several fish species », focused on the manner in which the aquatic and terrestrial vegetation is valorised by two cyprinids species (*Cyprinus carpio* and *Ctenopharyngodon idella*), in order to produce high quality meat, while economical efficiency must be guaranteed.

The PhD dissertation paper includes two sections, respectively a bibliographical study and, the second one comprising the own researches' results.

The bibliographical study includes four chapters presenting various aspects, such as: anatomy of the digestive system and physiology of the digestion in cyprinids, nutritional requirements of fishes, the appropriate feed to be used in fishes' nourishment, respectively certain data referring to vegetation valorisation by cyprinids.

Five chapters reveal the information concerning own researches, including the experimental design, the description of the used feed and the achieved results.

The results presented within the paper issued from three experiments, two of them being run at the Iasi Station of aquaculture and aquatic ecology, while the third one was run into the Aquaculture laboratory of the Animal Science Faculty in Iasi:

- experiment I has been carried on during 29. VII – 11. IX – 2004 (45 days)
- experiment II took place between 18. VII - 5. IX – 2005 (56 days)
- experiment III passed during 20.VI – 25. VI – 2006 (6 days).

The aquatic and terrestrial vegetation used as feed has been harvested from the experimental pool or from its borders, while the mixed fodder used in control group feeding has been achieved from the FNC Iasi company.

Several data have been acquired during the experiments: the physical and chemical features of the water within the experimental pool, the hydrobiological water parameters, fishes body weight dynamics, feed intake values, liveability rate, meat quality features, haematological indexes, body indexes, respectively some data concerning feed digestibility and digestible valorisation coefficient.

During the 1st Experiment, the biological material consisted in *Ctenopharyngodon idella* specimens, aged two years, having an average body weight of 450g/individual, provided by the Falteni-Suceava pisciculture farm. It was chosen this species because *Ctenopharyngodon idella* is a herbivorous fish, well known for its high appetite for aquatic and terrestrial macrophytes.

Prior to pool brooding, fishes have been allocated in groups, gravimetry and biometry proceedings have been run, each specimen being clinically tested, weighted and measured.

Several dimensional parameters have been measured: absolute length, standard length, trunk's height, head's length, tail peduncle's circumference and length.

Formalin solution has been used for treating those specimens with mycoses, which were previously contaminated with *Saprolegnia*.

Four groups have been established and then the fishes have been then released in floatable cages, whose walls were built of fishing nests, having links of 50 mm each. Feeding tables of 60 cm diameter and 30 cm height have been built for those groups which received mixed fodder. The cages have been covered with a thin nest, every group being well delimited.

M1 group, the control one, received mixed fodder on feeding submerse tables.

E1.1A group received only macrophyte vegetation (*Phragmites communis*+*Typha angustifolia*), harvested from the pool board and spread onto the water surface.

E1.1B group has been also fed with macrophyte aquatic vegetation, respectively *Phragmites communis* and *Typha angustifolia*.

E1.2 received both mixed fodder and macrophyte aquatic vegetation (*Phragmites* + *Typha*). The feed has been given, as in E1 and E2 groups, in a single serving, each day at 8 AM.

The grass carp's health status has been found as very well across the entire experiment, while the period with low levels of solved oxygen were rare and short. All fishes revealed normal status of their ichthyopatological status.

All the experimental stages have been run in accordance with the general experimental design.

Several data have been acquired and processed during the experiment:

- physical and chemical features of the water within the experimental pool
- hydrobiological features of the water
- body weight dynamics
- feed intake and valorisation
- meat yield
- fattening degree

- liveability rate
- certain body development indexes.

The goal of this experiment was to establish the degree of vegetation valorisation by the *Ctenopharyngodon idella* species, as reported to the achieved weight gain, to the feed conversion ration as well as to any revenue input.

The results we achieved led to several conclusions and discussions.

- Best performance concerning the average body weight was achieved by the E1.2 group, fed with mixed fodder and aquatic vegetation (596g/individual and period), followed by the control group, which received mixed fodder only (595g/individual and period), while the lowest body weight value has been recorded at E1.1B group, fed with aquatic vegetation only (592 g/individual and period). Very low differences (2g) concerning body weight have been found between groups fed only with aquatic vegetation (E1.1A and E1.1B), while the largest differences have been observed in control group (mixed fodder) and E1.2 group (mixed fodder and aquatic vegetation).
- Best daily weight gain values have been achieved by the E1.2 group, fed with mixed fodder and aquatic vegetation, being 1.82% higher than that obtained by the control group (mixed fodder only), 4.12% higher than the E1.1A group value (*Phragmites+Typha*) and 4.57% higher than the E1.1B group (aquatic vegetation only).
- Concerning FCR, the best results were observed at the control group, fed with mixed fodder while the lowest ones at the E1.1A and E1.1B groups, fed with aquatic vegetation only. Considering the control group as etalon (100%), the feed conversion ratio (kg D.M./kg gain) was found 119.3% lower than the E1.1A group, 126.2% lower than the E1.1B group and 75.7% lower, as compared to the E1.2 group;
- The E1.2 group, fed with mixed fodder and aquatic vegetation, achieved best results for the fattening degree, the average value reaching 4.7, very close to the maximal one (5), proving thus an efficient feed valorisation, while the lowest fattening degree has been observed in E1.1B group.
- Finally, it must be specified that the results have been achieved after a short period of time, respectively of 45 days, better results concerning development indexes could be achieved when the entire vegetation period will be considered.

The 2nd Experiment has been carried on during the 2005 vegetation period, using two cyprinids species - *Ctenopharyngodon idella* (grass carp) and *Cyprinus carpio* (common carp), within the Iasi Station of aquaculture and aquatic ecology, lasting 56 days (18 July - 5 September).

The biological material consisted in specimens of *Ctenopharyngodon idella* species, aged 3 years and of *Cyprinus carpio* species, aged 2 years.

Two groups, with the same amount of *Cyprinus carpio* specimens having an average weight of 450 g, have been formed: control group (M) and E1 group. The fishes have been delivered into floatable cages. The specimens of *Ctenopharyngodon idella* species, aged three years and having a 900 g average weight have been also measured and equally distributed in two groups: E2 and E3.

The floatable cages have been placed within the same aquatic pool, which hosted the experiment during 2004 summer.

The **control group** received mixed fodder, given on submersed feeding tables.

The **E1 group** has been fed with terrestrial vegetation - *Trifolium pratense* (clover), harvested from the pool borders and spread on the water surface.

The **E3 group** also received terrestrial macrophyte vegetation - *Trifolium pratense* (clover).

The fishes within the **E4 group** have been fed using aquatic macrophyte vegetation - *Phragmites communis* (bulrush).

The feed has been given daily, one single time, at 8 AM. The health status was considered well for all groups and during the entire experiment.

Certain indexes have been observed during the research development:

- physical and chemical parameters of the water within the experimental pool
- body weight dynamics
- feed intake value

- meat yield
- fattening degree
- liveability rate
- several body development indexes
- biochemical composition of the meat in both cyprinids species
- several haematological indexes

The goal of the researches within this experiment was to know the manner of valorisation degree of the terrestrial and aquatic macrophyte vegetation by two cyprinids species - *Cyprinus carpio* and *Ctenopharyngodon idella*.

Several conclusions and discussions issued from the analysis of the achieved results:

- The physical and chemical parameters of the water within the pool which hosted the 2nd experiment have been found between the normal boundaries specified for the 2nd quality class of the surface waters. No minimal or maximal values which could endanger fishes life have been observed during the entire experimental period.
- The assessments concerning the chemical composition of the clover used as feed revealed some variations, related to the harvesting stage. Thus, as compared to the 2nd harvesting stage, the samples from the 1st harvest presented higher values (g/Kg) - 10.4% for the dry matter, 12.7% for the organic matter, 19.9% for the protein, 48.8% for fat content as well as lower contents – 10.2% for ashes and 7.3% for the gross fiber. It could be considered that the occurred differences issued from the vegetation status of the plants at each harvest.
- The results obtained through the calculation of certain body indexes allow us to specify that the value of 3.7 of the Body shape index (I_p) at the *Ctenopharyngodon idella* species confirms that the dorsal line is straight, while at the common carp it is more curved, as showed by the 2.3 value of the same index.

Musculature development index, with values of 18.15% at *Ctenopharyngodon idella* and of 20.86% at *Cyprinus carpio*, indicated a better development in *Ctenopharyngodon idella* species.

- The Fulton's coefficient values at *Ctenopharyngodon idella* species indicate a fattening degree continuously maintained and a well feed assimilation. Thus, the

Ctenopharyngodon idella specimens showed higher values of that index, meaning a better physiological status.

Consequently, it could be concluded that, during the experiments carried on within the Iasi Station for aquaculture and aquatic ecology in 2004, 2005 summers, the maintenance status of the fishes has been found as good, especially of the *Ctenopharyngodon idella* individuals, whose values for the Fulton coefficient showed a permanently increasing trend.

- The best values for the weight gain/individual have been recorded into the E2.1 group (mixed fodder), being thus 11.2 % higher than those achieved by the E2.2 group, which received clover.

It could be concluded that *Cyprinus carpio* species prefers and better valorise the mixed fodder toward the terrestrial vegetation (clover).

It was found that, for the grass carp (*Ctenopharyngodon idella*), best values concerning the weight gain/individual/period have been achieved by the E2.3 group, which received clover, as compared to the E2.4 group, fed with bulrush.

According to the recorded results, it could be concluded that the *Ctenopharyngodon idella* species prefers and better valorise the terrestrial vegetation (clover), as compared to the aquatic one (bulrush). This statement is based on the analysis of the weight gain values and of the used feed quantity (clover amount was half as bulrush quantity).

- Concerning the feed conversion ratio index, the best results have been achieved by the control group (mixed fodder), as compared to the groups fed with clover and bulrush. Thus, at the carp aged two years, the FCR was found 33.3% in E2.2 group (clover), than in control group (mixed fodder). For the *Ctenopharyngodon idella* specimens, aged three years, feed conversion was 190.1% lower in E2.3 group (fresh clover), as compared to the E2.4 group (fed with bulrush).

Consequently, the lowest FCR index, has been observed for the mixed fodder (3.0 kg D.M./kg gain), while the highest value has been noticed for the bulrush (13.5 kg D.M./kg gain).

- Gross energy and digestible energy contents were higher for the mixed fodder, as compared to the aquatic vegetation.
- Biochemical meat analysis, for both cyprinids species, showed that 7.4% higher protein content was found in E2.1 group, which received mixed fodder, as compared to the E2.2 group, fed with clover. It could be stated that protein content in meat increased when mixed fodder has been used, proving thus a high valorisation degree of the feed proteins.

At the *Ct. idella* groups, aged three years, protein content was found 7.4% higher in those specimens fed with clover than in those fed with bulrush, situation generated by the higher protein amount in clover and by its better valorisation.

Lipids content within *C. carpio* meat is 7.5% higher at the individuals fed with mixed fodder, as compared to those fed with clover, the fact proving that, without supplemental feeding, the carp less accumulates fat deposits. It was also observed that a higher fat content was correlated with a higher dry matter content. Lipids content in both groups of *Ct. idella*, is 6.3% higher at the specimens fed with clover, as compared to those fed with bulrush only. The overall results concerning chemical meat composition are close to those specified within other scientific references.

- Haematological analyses showed that, for *Cyprinus carpio* species, the hematocrit had average values of 7.3 g/dl during July and 9.1 g/dl during September, while for the *Ctenopharyngodon idella* species, the same parameter reached mean values of 10.2 g/dl during July and 12.0 g/dl during September. The haemoglobin assessments, carried on during 2005 Autumn, revealed values of 7.3-9.1g/dl. An increasing of the haemoglobin level could be observed and related to ageing: from 7.3 g/dl till 9.1 g/dl at *C. carpio* aged 2 years and from 10.2 g/dl till 12.0 g/dl at *Ct. idella* aged 3 years. As depending on the feed type, haemoglobin levels have been found higher in herbivorous species (*Ct. idella*) as compared to the omnivorous ones (*C. carpio*).
- Par consequence, the results concerning the levels of hematocrit and haemoglobin did not indicate sickness status at the studied cyprinids.

The 3rd Experiment has been designed in order to know the valorisation manner of the supplemental feed (mixed fodder and terrestrial vegetation), by the *Cyprinus carpio* species, mainly assessed through the study of the nutrients' digestibility.

Feed digestibility has been analysed through laboratory tests, run during 20 – 25 June 2006, using *Cyprinus carpio* fishes as biological material, provided by Movileni-Iasi pisciculture farm.

Ten aquariums with walls of 6 mm thick glass and with the dimensions of 60 cm length, 42 cm height and 30 cm wide have been used to accommodate each an individual of common carp, aged two years. Each recipient had of 60 litres capacity, filled with filtered water, lacked of natural feed.

Two experimental groups have been established, including 5 specimens/group; each group received different types of feed: mixed fodder (D1 group) and fresh clover, harvested during efflorescence stage (D2 group).

Several data have been acquired and processed during the experiment:

- the quantity of given feed and that of unconsumed remnants
- the quantity of sampled faeces
- chemical composition of the used feed
- chemical composition of the sampled faeces
- the calculation of digestibility coefficients for each studied feed source

The assessment of nutrients' digestibility could be done by running either „in vivo” experiments or either using „in vitro” laboratory techniques. Considering the biological specificity of the used species, single control period digestibility experiments have been run, using individual aquariums.

The biological material consisted in *Cyprinus carpio* fishes, aged two years; the average weight of the specimens reached 500 g, the groups being thus homogenous.

The direct method has been used to assess the digestibility of the organic matters form feed, meaning the weighting of the ingested feed, of the feed remnants and of the ejected faeces. Each specimen has been accommodated in its aquarium, covered with thin nests and endorsed with oxygenation pump.

The digestibility experiments lasted 5 days, 4 of them constituting the pre-experimental period, while the last one was included the experiment itself, according to the methodology specified into the scientific references (*Cărăușu, 1962, Stăncioiu, 1976, Guillaume, 1999*).

- Mean values of the coefficients dealing with the organic matters digestibility of the fresh clover reached 68% for crude protein, 56% for crude fat, 64% for gross fiber, 79% for the NFE and overall, 72% for the organic matters.

- Digestibility coefficients of the mixed fodder reached average values of 93% for the crude protein, 92% for the crude fat, 96% for the NFE, 59% for the gross fiber and 92% for all organic matters.

- When the digestibility coefficients of the organic matters in both used feeds are compared, it reveals that higher values issued for the mixed fodder against the clover values. Consequently, it could be concluded that the mixed fodder is better digested. Thus, the average values of the digestibility coefficient have been found 25 p.p. higher for proteins, 36 p.p. higher for fats, 17 p.p. higher for NFE and 5 p.p. lower for the gross fiber, as compared to the values observed in organic matters digestibility in fresh clover.

The chemical composition of the feed also influenced its digestibility and especially that of the proteins, this being better as the higher protein content was. Thus, for the mixed fodder, having a protein content of 378.7g/kg D.M, it was recorded a digestibility coefficient of 92%, while lower value of the same coefficient (68%) has been observed when lower protein (312,5 g/kg D.M.) feed has been used (clover).

As final conclusion, it could be stated that the common culture carp, aged two years, revealed better digestibility values for the nutrients into the mixed fodder, as compared to those from the fresh clover, the situation being explained through the chemical composition of the mixed fodder, as well as by the specificity of the enzymes equipment of the omnivorous fishes.