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# ABSTRACT

# INNOVATIVE TECHNOLOGIES FOR FARMING OF COMMON CARP JUVENILES (*CYPRINUS CARPIO*, LINNAEUS 1758), BASED ON THE USE OF EXTRUDED AND EXPANDED PELLETED FEEDS

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# CONTENT

***KEY-WORDS: common carp juveniles, natural food, extruded and expanded pelleted feeds, stocking densities, feeding level, growth performance, economic efficiency, innovative technologies.***

## INTRODUCTION

Fish is an excellent source of feed, due to the high quality of the meat, being the most desired aquatic organism by consumers. Fish meat is rich in essential nutrients, such proteins, essential fatty acids, minerals and vitamins.

In developing fish breeding technologies, mettes of the culture system and the degree of intensification must be taken into account triad *race, home and feeds.* Choosing the race is the starting point; but not every species has a high growth potential to provide economic profitability. From all of the 33,300 fish species discovered and described so far, the same statistics FAO from 2016 listed 1,600 species, and of these, only 23 species make the object of intensive fishing in the seas and oceans of the world, respectively a quantity of 33.4 million tonnes, representing almost 41% of world catches. Aquaculture grows approximately 500 species around the globe , and 30 species out of these are in the FAO evidence, which gives more than 300,000 tons annually, totalling about 47.16 million tons in 2014, accounting for 64% of fish for human consumption.

Common carp (*Cyprinus carpio*) is the most farmed species with the highest economic importance to the fisheries sector from Romania. Originally from Southeast Asia, it has spread rapidly in Europe, then on all continents. For hundreds of years, the carp is the main grown species from Europe and Central and Southeast Asia. In the world's aquaculture top production, carp is situated on the third place after two other cyprinids reared with great success in China, i.e. the grass carp (*Ctenopharyngodon idellus*) and the silver carp (*Hypophthalmichthys molitrix*) (FAO, 2016).

The purpose of the PhD thesis meets the innovative approaches of the Romanian fish farms, being a real contribution to the improving of the technology of breeding carp in fish farms. We take into account the shortening of the production cycle by one year, thus obtaining the best growth performance. So, starting from juvenile fish with body weight of 250-300 g /fish in the first summer, at the end of the second summer, growth should achieve marketable weights of 1.5-2.0 Kg / fish. Shortening the production cycle will have the effect of reducing costs and will contribute to the profitability of the fish farms. The approached objectives during the three years of research were as follows:

- *The influence of environmental and feeding conditions on growth performance of carp juveniles;*
- *The influence of environmental condition and stocking densities on growth performance of carp juveniles;*
- *The influence of environmental condition and feed quality on growth performance of carp juveniles;*
- *The influence of environmental condition and feeding level on growth performance of carp juveniles;*
- *Developing a new technology to increase juvenile carp, in order to shorten the production cycle of carp from two and a half years to one and a half.*

# PART II: EXPERIMENTAL WORK

## CHAPTER 4
## THE INFLUENCE OF THE FEEDING CONDITIONS ON THE GROWTH OF CARP JUVENILES IN PONDS

### 4.1. Farming carp juveniles in ponds under feeding and unfeeding conditions, stimulating the natural trophic chain potential by using organic fertilizers (manure)

#### 4.1.1. Introduction

The natural food chain potential of the hatcheries depends on the availability of natural food in the form of plankton biomass, benthic biomass and immersed and submersed aquatic vegetation biomass. By controlled distribution of mineral and organic fertilizers, the natural fish productivity of ponds may be maintained at optimal values in view of acquiring improved productions.

#### 4.1.2. Materials and methods

The experiment was conducted along five months, June through November 2014. Four ponds (area = 6000 $m^2$, average depth = 1.2 metres) were used as rearing units. Their flooding was performed in the first days of June, approximately ten days before the populating time. The ponds were stocked with 15,000 carp juveniles/ ha with average bodyweight of 1 gram per specimen.

Two feeding versions were tested, both with two repetitions:

- V1, by using extruded pelleted feeds with crude protein of 48% in the first 30 days of rearing (stage 1) and then feeding only natural food for 120 days (stage 2).
- V2, by using extruded pelleted feeds with crude protein of 48% in the first 30 days of rearing (stage 1) and then feeding with expanded pelleted feeds with 30% crude protein for 120 days (stage 2)

#### 4.1.3. Results and discussions

The analysis of phytoplankton revealed that the highest value was recorded in June, in V1R1 (BR5) (25760 specimen/l). The minimum was recorded in V2R2 (BR4), with 2,130 specimen/l (Fig. 4.1)

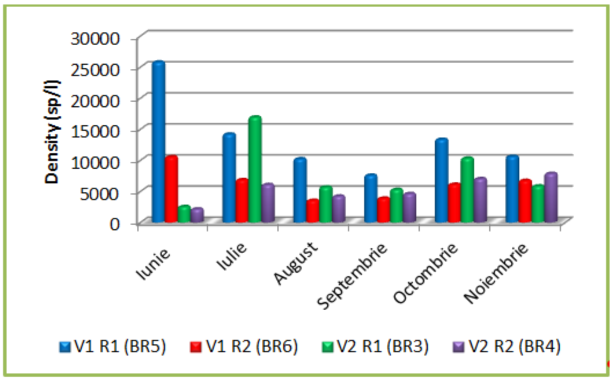


*Figure 4.1. Phytoplankton Density*

Algae biomass also recorded quantitatively higher values in V1R1 (BR5) (122.81 $g/m^3$, in June) (Figure. 4.2).

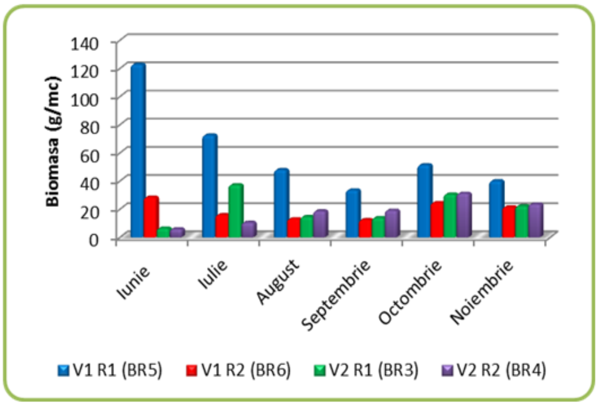


*Figure 4.2. Biomass of phytoplankton organisms*

Zooplankton recorded its maximum density in October in V1R1 (BR5) with 1,128 sp/l (figure 4.3). In point of numbers, in most samples analysed, copepods were prevailing, followed by cladocera and rotifers.

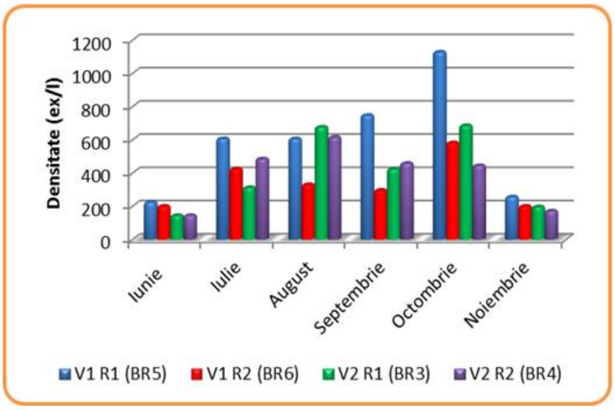


*Figure 4.3. Zooplankton Density*

Zooplankton biomass in variant V1R1 (BR5) is at maximum levels throughout the entire research (fig. 4.4). The quantitative analysis of benthos shows that increased numeric densities were recorded in June through July in both variants, while smaller densities were recorded during the colder months (Fig.4.5).

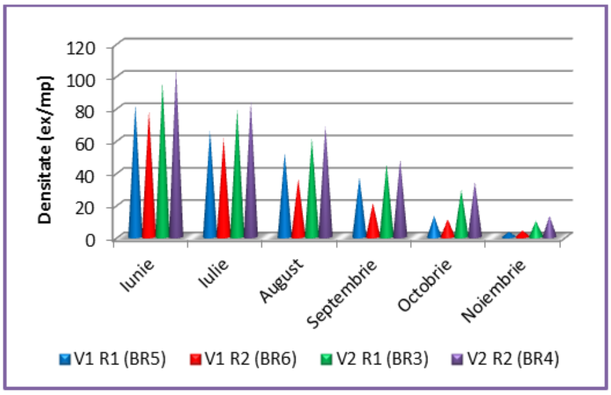


*Figure 4.5. Benthonic density*

The benthonic biomass analysis reveals an increase in bio-productive potential in June and a decrease from August through November. The maximum value of the biomass was of

2.6874 g/m$^2$ in V2 in June, to which a numerical density of approx. 100 specimen/m$^2$ also corresponds (Fig. 4.6.).

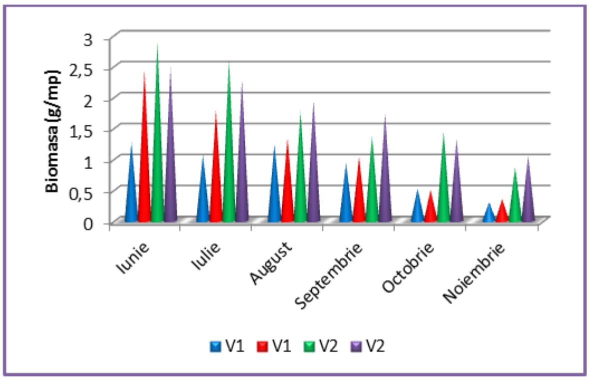


*Figure 4.6. Biomass of benthonic organisms*

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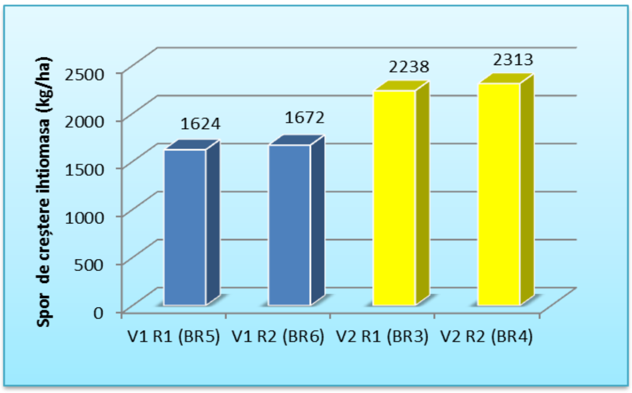


*Figure 4.7. Ichtyomass growth rate*

The daily growth rate (GR) of carp spawn, calculated as mean of the two repetitions of both variants varied from 2.34 g BW/day in V1 to 2.30 g BW/ day in V2. The mean value of specific growth rate (SGR) was of 3.91% BW/day in V1 and of 3.90% BW/day in V2 (Fig. 4.8.).

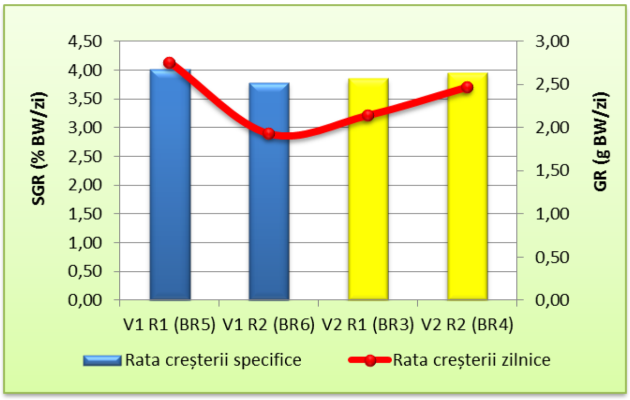


*Figure 4.8. Variation of SGR and GR coefficients*

The feed conversion ratio (FCR) calculated as mean of the two repetitions of the same variant was of 0.15 kg feed/ kg growth rate in V1 and of 1.33 kg feed/ kg growth rate in V2 (fig. 4.9.).

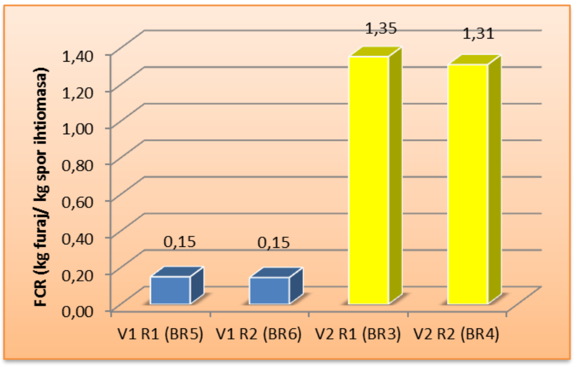


*Figure 4.9. Variation of FCR coefficient*

### 4.1.5. Conclusions

The experiments conducted have shown that feeding supplementary food (extruded pelleted feeds) positively influences the fish growth, productions of over 2.300 kg/ha being possible under small populating densities conditions. A feed conversion ratio (FCR) of 1.31-1.33 attained after 150 days of feeding with pelleted feeds is a very positive result for semi-intensive systems of fish rearing in small area fishponds.

The research has also indicated the fact that the fishponds for carp juveniles rearing have a fairly good food chain potential for at least two months, a period in which feeds can be saved for a later time. This is the reason why is advisable to use a smaller quantity of feeds at the beginning of the growth period in order to harness the natural food chain potential of the ponds. In these circumstances, it is possible to reach productions of over 1,600 kg/ ha in just five months.

## 4.2. Farming carp juveniles in ponds under feeding and unfeeding conditions, by stimulating the natural chain food potential using organic fertilizers (bird droppings)

### 4.2.1. Materials and methods

The experiments have been conducted in 2015 and 2016, for about four months a year, in the same period: June through November. Six rectangular ponds (6000 $m^2$ each, average depth of 1.2 m). The flooding of the ponds had taken place in the first days of June, approximately ten days before the populating time. Each pond was stocked with 15,000 carp juveniles/ ha with average bodyweight of 1 g/ sp. Three variants of feeding were tested, each with two repetitions.

- V1, with amendments, in unfeeding circumstances, with the use of organic fertilizers (bird droppings)
- V2, with amendments, in feeding conditions, using extruded pelleted feeds with crude protein 48% in the first 30 days of growth (stage 1), followed by the use of expanded pelleted feeds with crude protein 30% for the next 120 days (stage 2). In addition, during the entire period of fish growth, bird droppings were also administered.
- V3, with amendments, in natural unfeeding conditions, without fertilizers.

### 4.2.2. Results and discussions

In V1, in which only bird droppings were used, without feeds, mean productions of 506 kg/ ha were obtained, while in V2, with droppings and pelleted feeds, averagely large productions of 2,480 kg/ha were obtained. In V3, where neither fertilizers nor feeds were used, an average production of only 172 kg/ha was obtained. In what the fish survival rate is concerned, in V2, feeding conditions for the two repetitions, it was of 45-48%, superior to V1 (37-39%) and V3 (36-37%) (Figure 4.10).

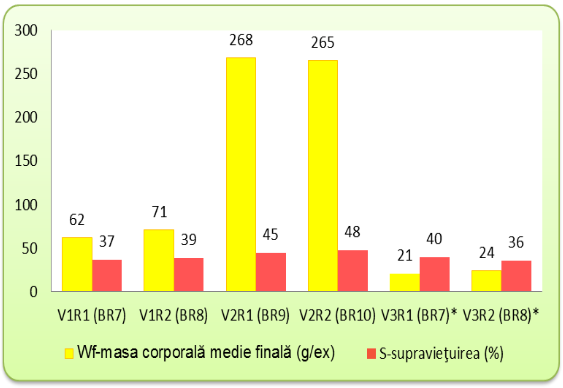


*Figure 4.10. Variation of bodyweight and survival of the carp juveniles*

ANOVA statistical analysis has revealed significant differences ($p<0.05$) between the three tested variants. The bodyweight of fish in V3 lot was significantly smaller than those of fish in V1 and V2 lots. The largest BW was obtained in V2 (265-268 g/sp.) followed by V1 lot (64-68 g) and V3 (20-24 g/ sp.) (Figure 4.11).

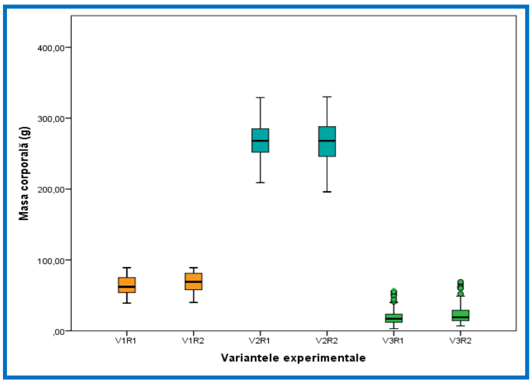


Figure 4.11. *Bodyweight variation at the end of experimental period*

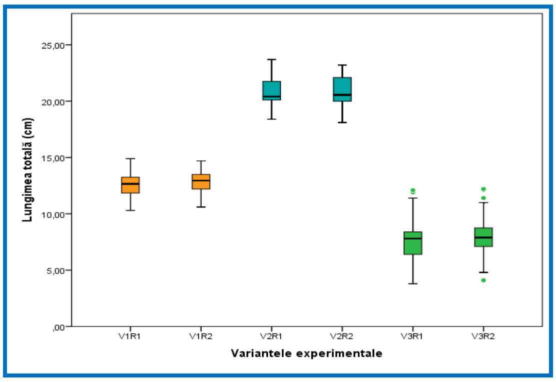


Figure 4.12. *Variation of total length at the end of the experimental period*

As expected, the smallest total length was also obtained in V3 lot (7-8 cm), followed by specimens in V1 lot (12 cm) and V2 (20 cm) (fig. 4.12). The homogeneity of carp specimens in the experimental lots in point of bodyweight and total length variables was demonstrated with the help of variation coefficient and histograms.

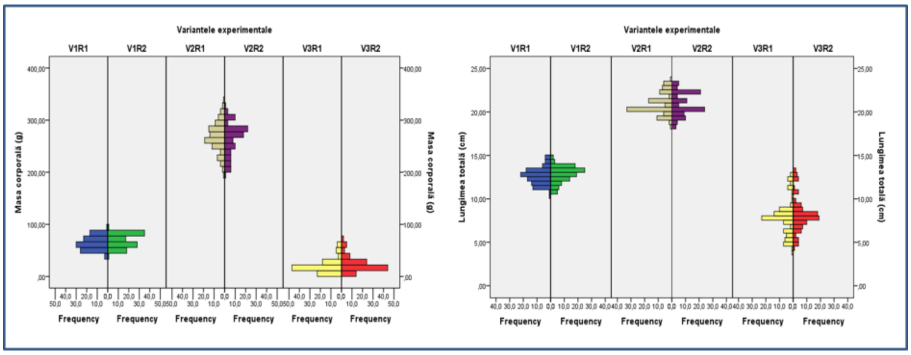


*Figura 4.13. Histogram of bodyweght and total length at the end of the experimental period*

Based on biometrics at the end of the period, the correlation between bodyweight variable and total length variable has been determined, as shown in Figure 4.14.

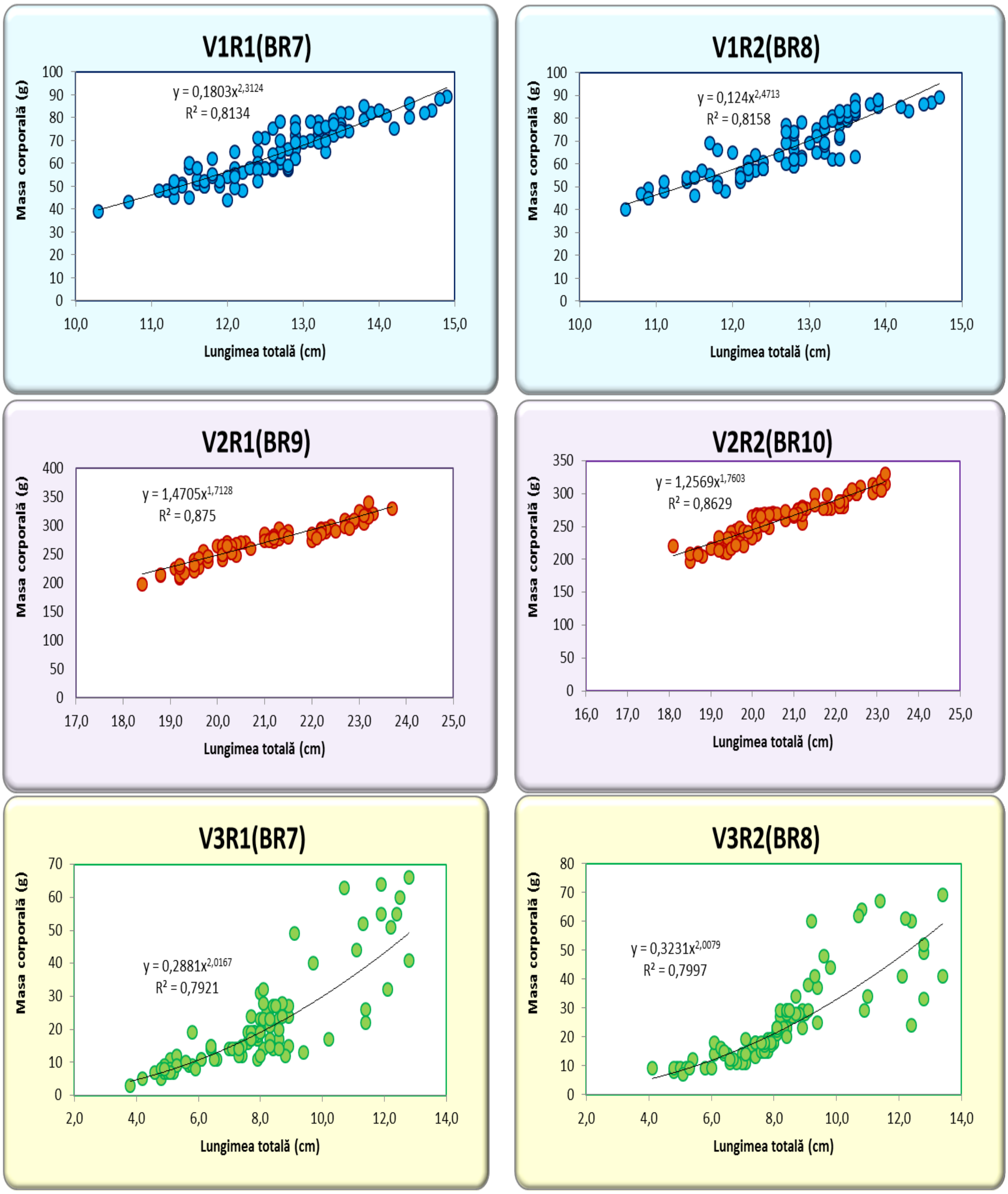


*Figure 4.14 Correlation between length and weight*

The highest values of daily growth rate (GR) were recorded in V2 variant, on repetitions, ranging from 2.38 to 2.41 g BW/day. In the unfeeding variants, much smaller values have been obtained, of 0.55-0.63 g BW/day in V1 and respectively of 0.18-0.21 g BW/day in V3 (Fig. 4.15).

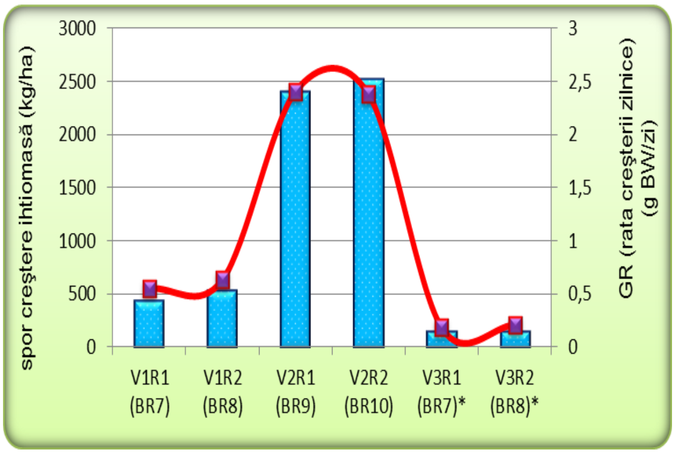


*Figure 4.15. Correlation between ichtyomass growth and daily growth rate (GR)*

Specific growth rate (SGR) was of 3.78 % BW/day in V1, 5.03% BW/day in V2 and 2.80% BW/day in V3 (Fig. 4.16). The median feed conversion ratio (FCR) in V2 was of 1.34 g feeds/kg growth. The protein efficiency ratio (PER) calculated in feeding conditions (V2) has very good value (2.33-2.45 g growth/ g ingested protein) (Fig. 4.17).

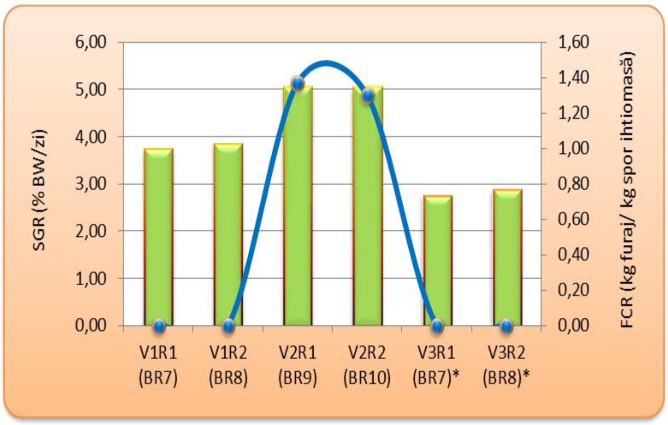


*Figure 4.16. Variation of SGR and FCR coefficients*

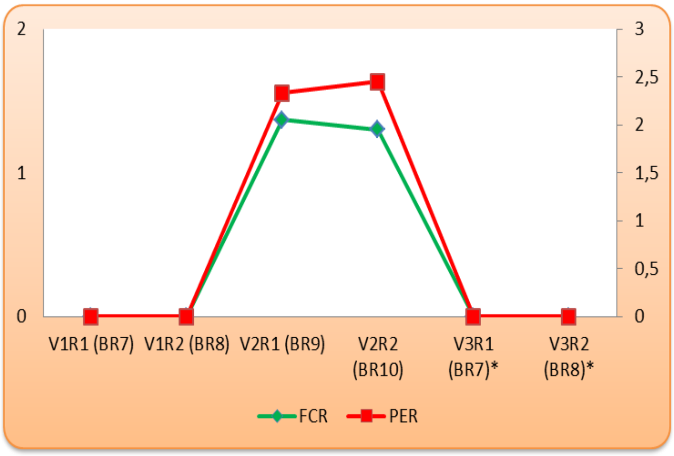


*Figure 4.17. Variation of protein efficiency ratio (PER) and reverse correlation with FCR*

### 4.2.4. Conclusions

The results of the experiment described above have accentuated the importance of supplementary feeding. It is obvious that the lack of natural and additional food decisively influences the growth rate, the survival of the fish and the level of production. The technological variants in which only amending and fertilizing the ponds are carried out, without using feeds, lead to small productions of approx. 500 kg/ha. However, when good quality feeds are administered on a daily basis, preferably extruded or expanded pelleted feeds, productions of 2,500 kg/ ha may be reached in small stocking conditions. If one only capitalizes on the natural food chain potential of ponds, without fertilizing and feeding, one risks obtaining unsuccessful productions of less than 200 kg/ ha, as actually demonstrated by the present chapter.

## CHAPTER 5
## THE INFLUENCE OF THE FEED QUALITY ON CARP JUVENILES GROWTH IN PONDS

### 5.1. Introduction

The aim of this research has been that of establishing the effects of the quality of additional food (extruded and expanded pelleted feeds in various concentrations of crude protein – 30%, 35% and 48%) on the growth performance, concomitantly with the determination of the specific consumption.

### 5.2. Materials and methods

The experiment was carried out along four months, from June through October 2014. The rearing units were four ponds (5000 $m^2$ each, average depth of 1.2 m). The four ponds were populated with 30,000 carp pre-developed juveniles per hectare, average bodyweight of c. 1g/ specimen.

Two experimental variants have been compared, each with two repetitions, the differentiating parameter being the quality of feeds, represented by the crude protein, gross energy (GE) and metabolizable energy (ME) of extruded or expanded pelleted feeds:

- V1, using extruded pelleted feeds with 48% crude protein in the first 30 days of growth (stage 1), and then feeding for 90 days with expanded pelleted feeds with 35% crude protein (stage 2);

-V2, using extruded pelleted feeds with 48% crude protein in the first 30 days (stage 1), followed by using expanded pelleted feeds with 30% crude protein for the next 90 days (stage 2).

### 5.3. Results and discussions

The higher productions of 3,810-3,900 kg/ha were, naturally, recorded in the variant in which the quality of feeds was superior. For identical quantities of feeds, the increase by 5% of protein in the intake pertaining to V1 has led to an increase of app. 300 kg/ha, i.e. with more than 8%, in comparison with V2.

Significant differences have been statistically recorded between the average bodyweight of fish in the two experimental variants (ANOVA $p<0.05$), including during the repetition stages. Post-hoc Duncan's Multiple Range test has revealed three value subsets: the mean bodyweight of fish in repetition V1R2 was significantly different from the average bodyweights recorded at the level of variants V1R1, V2R2 and V2R1 (Fig. 5.1).

As far as the body length is concerned, significant differences have been recorded between the experimental variants (Anova $p<0.05$). Post-hoc Duncan's Multiple range test has been pursued after Levene pretesting ($p> 0.05$) and has revealed three length classes as follows: the biggest mean length has also been recorded in case of variant V1R2 (20.7±2.17

cm), followed by V2R1 lot (17.4±1.94 cm) and lots V2R2 and V1R1 (16.7±2.56 cm, respectively 16.5±2.10 cm) (Figure. 5.2).

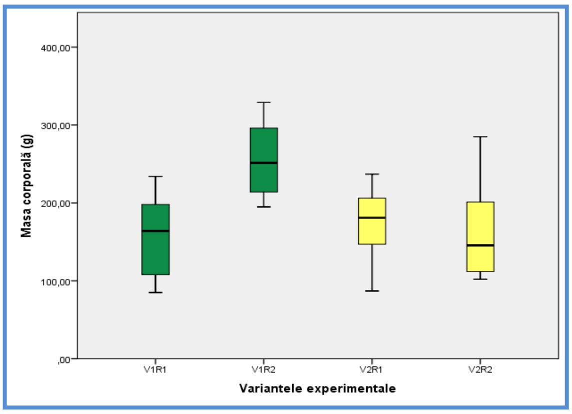


*Figure 5.1. Variation of final bodyweights (median, minimal values, maximal values and quartiles)*

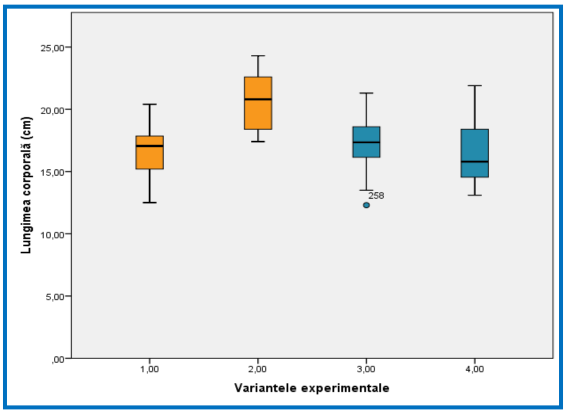


*Figure 5.2. Variation of final total lengths (median, minimal values, maximal values and quartiles)*

Following the analysis of the variation coefficient for the bodyweight variable, it has been noted that the fish lots are more homogenous in case of V1R2 and V2R1 repetitions, where variation coefficients of 17.68% and respectively 21.85% have been obtained, compared with V1R1 and V2R2 repetitions, where the variation coefficient has recorded values of 29.65% and 32.76%. The higher the values of the variation coefficient are, the more heterogeneous are the lots. The value distribution in what bodyweight (W) and total length (tL) are concerned has revealed lots with normal distribution, an aspect emphasized with the help of histograms (Fig. 5.3.).

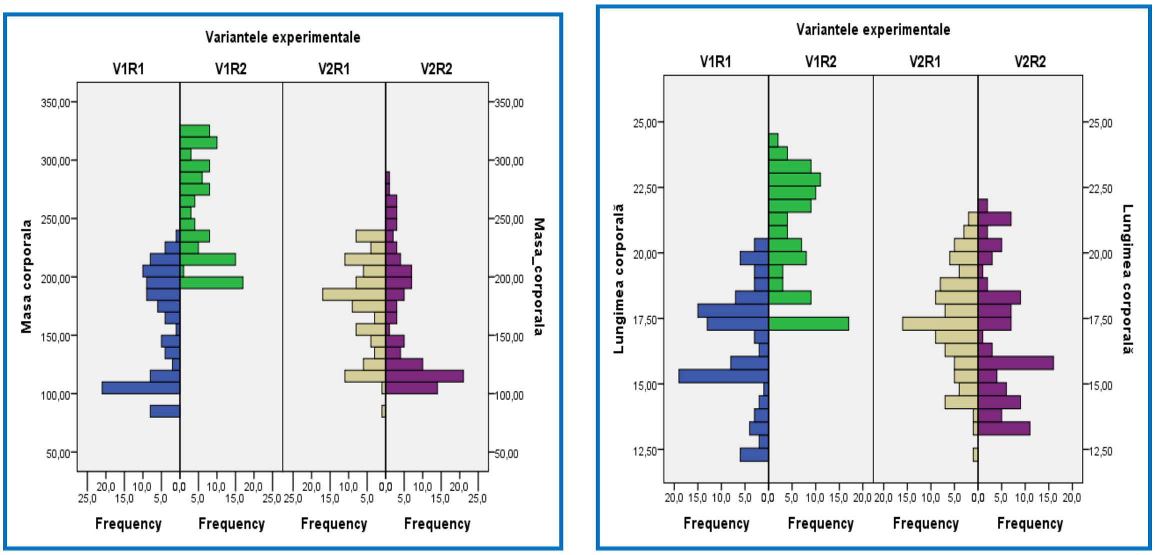


*Figure 5.3. Histogram of final bodyweights and total lengths*

The average ichtyomass growth was of 3,825 kg/ha in V1 and of 3,510 kg/ha in V2. The results are in correlation with the environmental conditions provided, with stocking density and with the quality of feeds, more favourable in case of V1. The average values of the growth rate (GR) of bodyweight similarly varied between 1.70 g BW/day in V1 and 1.39 g BW/day in V2. These differences are primarily determined by the quality of the feeds (Fig. 5.4).

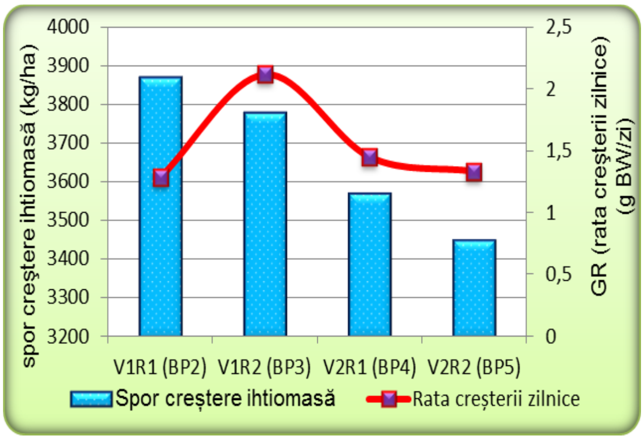


*Figure 5.4. Ichtyomass growth and the daily individual growth ratio*

Negative allometry (b<3) has been recorded for all fish lots, the bodyweight growth being below the values of the total length (Fig. 5.5).

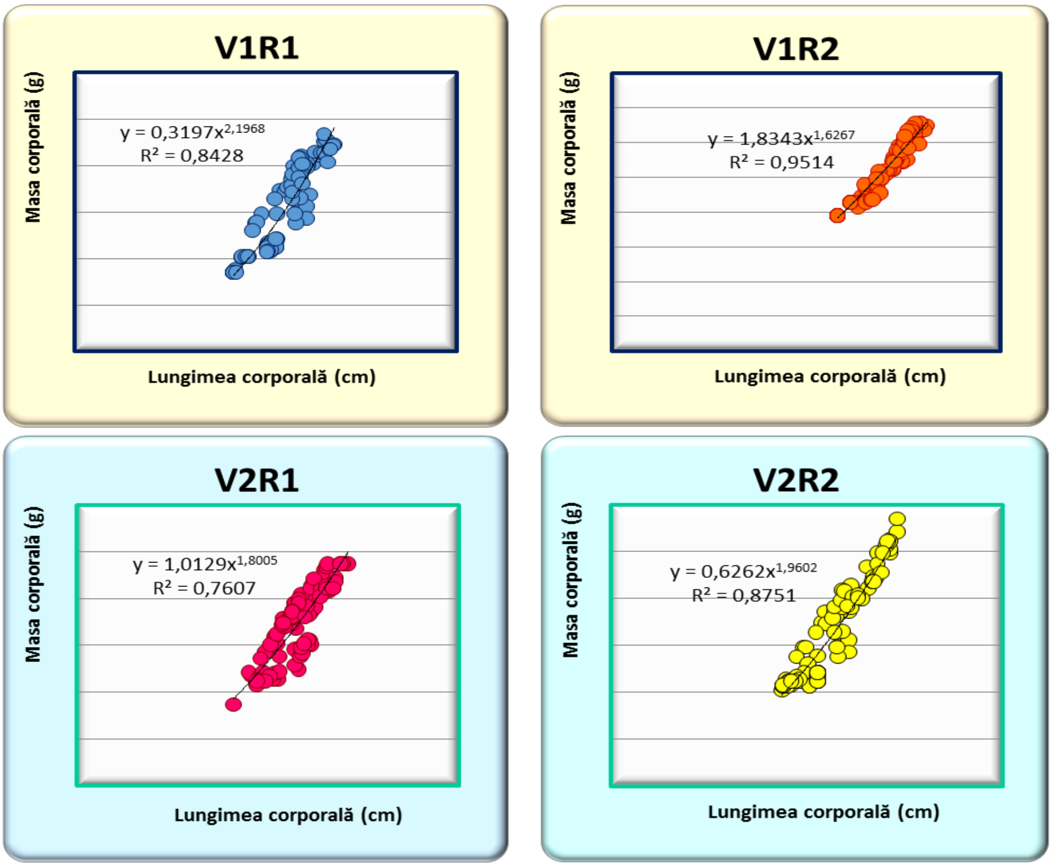


*Figure 5.5. Length-bodyweight regression for the fish lots at the end of the experiment*

The mean individual specific growth ratio (SGR) was of 4.41% BW/day in V1 and of 4.27% BW/day in V2. Both values indicate a good growth of fish. Feed conversion ratio (FCR), also expressed as mean of the two repetitions of each variant was of 1.26 kg feeds per 1 kg growth in V1 and of 1.38 kg feeds per 1kg growth in V2. It is also the quality of feeds what positively influenced the final values of FCR (Fig. 5.6).

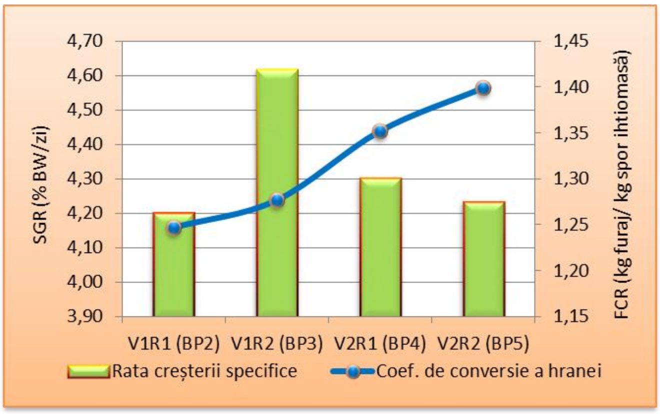


*Figure 5.6. Specific growth rate (SGR) and the feed conversion ratio (FCR)*

### 5.4. Conclusions

A successful technological management does not only entail the good command of fish nutrition and feeding, but also the competent management of the environment. As a result of metabolic processes, most nutrients in the food ingested by fish are immediately eliminated in water in the form of gas, solid or liquid excretions. Only 30 to 35% of ingested food is transformed in fish biomass. The potentially negative impact of aquaculture on the aquatic environment increases according to the selected culture system in direct ratio with the degree of intensification, food type and fish health.

Growth performance varies according to the quality of feeds, expressed by protein content and energetic value. The results of the present research are pertinent, considering that they have been obtained in real production conditions. The use of extruded and expanded pelleted feeds in semi-intensive aquaculture has proven to be positive for production growths. For farming carp juveniles in the first summer of life, pelleted feeds with 35% crude protein are recommended. Nevertheless, as the values of several biotechnological reference indices (GR, SGR, FCR, PER) have been close, it results that pelleted feeds with minimum 30% crude protein can also be used successfully.

The use of an extruded pelleted feed with 48% crude protein in the first month of growth (stage 1), followed by that of an expanded pelleted feed with 35% crude protein in the following three to four months of growth (stage 2) is a novel technical solution which allows obtaining productions of almost 4,000 kg/ha. In such circumstances, the farmer's net profit may reach lucrative values of 0.5 euro per kg or more.

## CHAPTER 6

## THE INFLUENCE OF STOCKING DENSITY ON THE GROWTH OF CARP JUVENILES IN PONDS

### 6.1. Introduction

Fish stocking density in farming units is one of the most important technological factors which must be considered regardless of the production system. The aim of the research has been that of evaluating the effects of various stocking densities on the growth performance of carp juveniles, at the same time with the assessment of feed efficiency.

### 6.2. Materials and methods

The experiment was conducted in two consecutive years, 2014 and 2015, at Bila Fish Farm in Giurgiu County. The research of 2014 lasted for 150 days, June through November. The research of 2015 was carried out along 114 days, respectively the time span between June and October. As farming units, we used eight rectangular ponds (6000 $m^2$ and 1.2 m depths each). The eight ponds were stocked with pre-developed carp juvenile with average bodyweight of c. 1 g/ specimen. Two experiments were carried out during the years 2014 and 2015, each with two density variants, in duplicate, as follows:

**<u>Experiment 1/2014</u>**

- V1, stock density of 30,000 specimens/ ha (30 kg/ ha) using extruded pelleted feeds with 48% crude protein in the first 30 days of growth (stage 1), then feeding the fish with expanded pelleted feeds with 30% crude protein for 120 days (stage 2);

- V2, stock density of 15,000 specimens/ ha (15 kg/ ha) using extruded pelleted feeds with 48% crude protein in the first 30 days of growth (stage 1), then feeding the fish with expanded pelleted feeds with 30% crude protein for 120 days.

**<u>Experiment 2/2015</u>**

- V3, stock density of 25,000 specimens/ ha (30 kg/ ha) using extruded pelleted feeds with 48% crude protein in the first 30 days of growth (stage 1), then feeding the fish with expanded pelleted feeds with 30% crude protein for 84 days;
- V4, stock density of 20,000 specimens/ ha (20 kg/ ha) using extruded pelleted feeds with 48% crude protein in the first 30 days of growth (stage 1), then feeding the fish with expanded pelleted feeds with 30% crude protein for 84 days.

### 6.3. Results and discussions
#### 6.3.1. Experiment 1/2014

Differences owed to stocking densities were recorded between the two experimental variants carried out in duplicate. It should be mentioned from the beginning that the level of the final production, in all variants and repetitions, was high, in the interval 2,253-4,350 kg/ ha. After 150 days of carp growth in summer I, the inverse ratio between fish size and stocking density was confirmed. Thus, in relation to the average bodyweight, better results were recorded in V2, with an average value of 0.346±0.02 kg/specimen at the stocking density of 15,000 specimens/ ha. In V1, at a double stocking density of 30,000 specimens/ ha, an average bodyweight of 0.251±0.03 kg specimen was obtained.

Anova statistical analysis has revealed significant differences between the values obtained ($p<0.05$). The greatest bodyweight was recorded in the case of V2, where stocking density was of 15 kg/ha (Fig. 6.1). Also, as far as the total length variable is concerned, four classes of length have been outlined (Anova $p<0.05$) corresponding to the four experimental lots (Fig. 6.2).

The homogeneity of the carp lots in the experimental lots in point of bodyweight (W) and total length (tL) variables was demonstrated with the help of the variation coefficient and histograms (Fig. 6.3). It results that the samples were homogenous at the end of the experimental period, their mean being representative for the experimental lots.

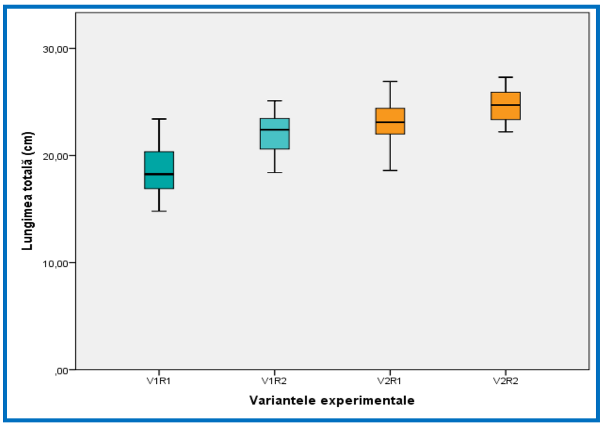


Figure 6.1. Final bodyweight

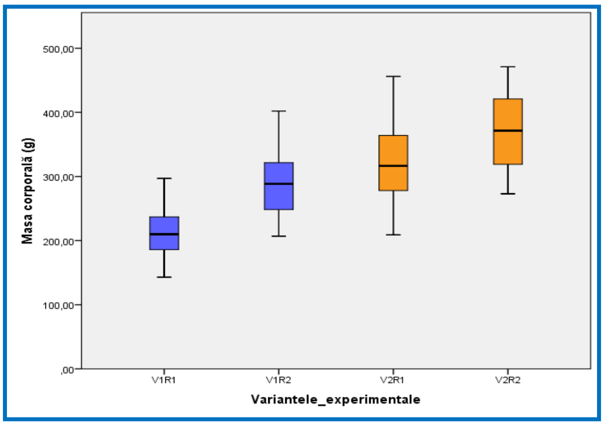


Figure 6.2. Final total length

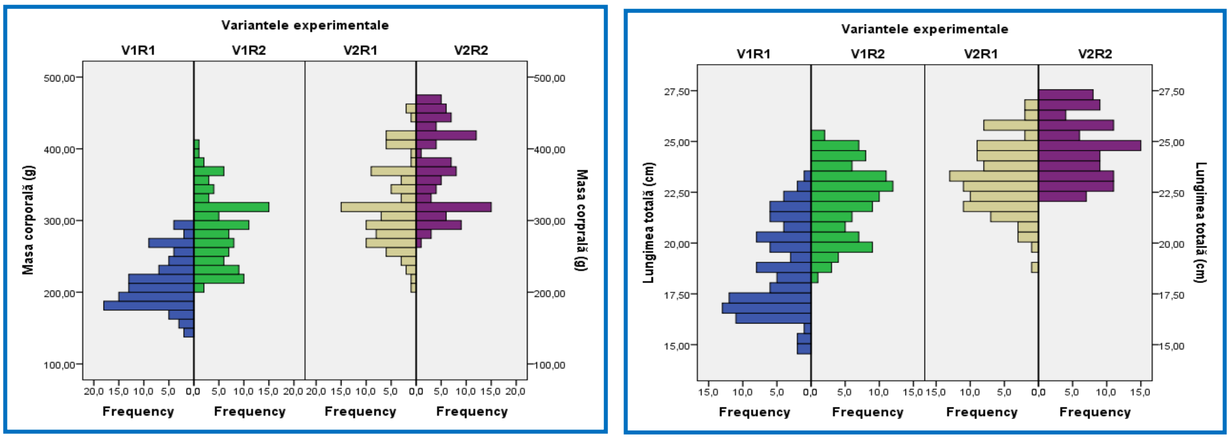


Figure 6.3. Histogram of final bodyweights and total lengths

The analysis of the length-bodyweight regression has revealed a better condition for fish stocked at 15 kg/ha density (b=2.50; b=2.35), the same lot which recorded the best values of the bio-productive indices at the end of the experiment (Fig. 6.4).

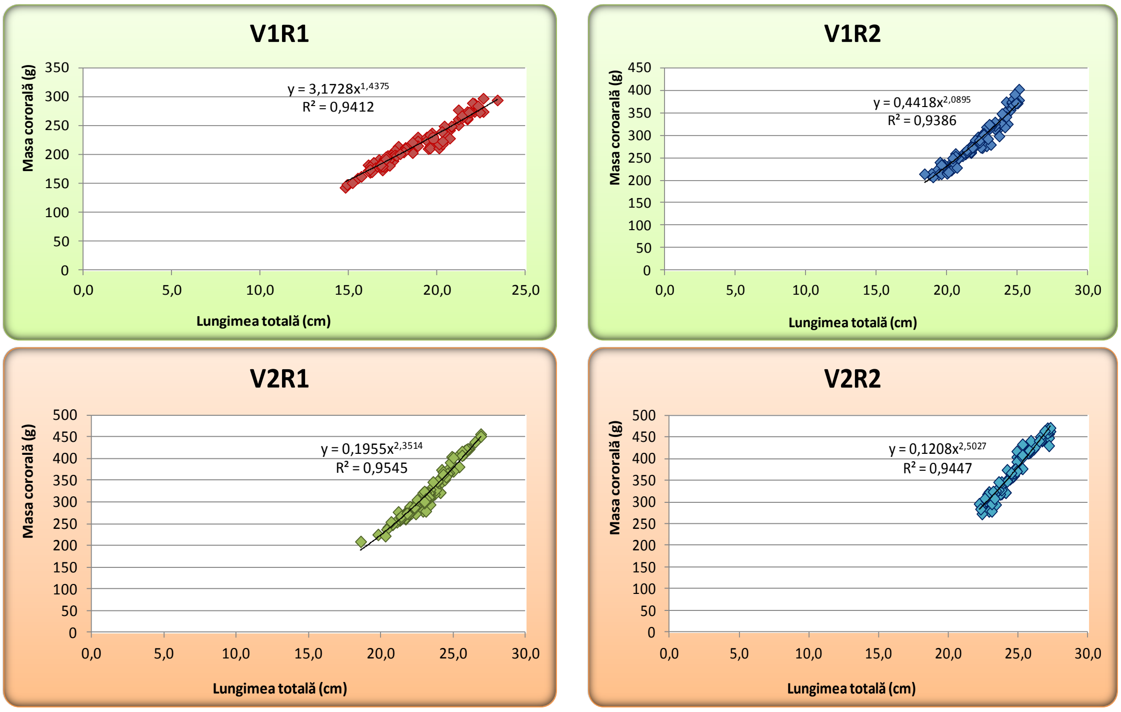


Figure 6.4. Length-bodyweight regression

In what the total final ichtyomass in ponds is concerned, the average growth of ichtyobiomass was much better in V1 (4,295 kg/ha) than in V2 (2,275 kg/ha). These values are in direct ratio to stocking density. The individual growth rate (GR) recorded a better result in V2 (2.30 g BW/day), in conditions of lower density, than in V1 (1.67 g BW/day), in which the stocking density was higher. It results that GR varies in inverse ratio to stocking density (Fig. 6.5.) Specific growth rate (SGR) expressed in average values for the two repetitions of each variant was of 3.68%/day in V1 and of 3.90%/day in V2 (Fig. 6.6). The mean feed conversion ratio (FCR) was of 1.41 g feeds/ kg in V1 and, respectively, of 1.33 g feeds/ kg in V2. Although FCR is higher by 6% in V1 than in V2, both values are very positive for the system of farming in ponds.

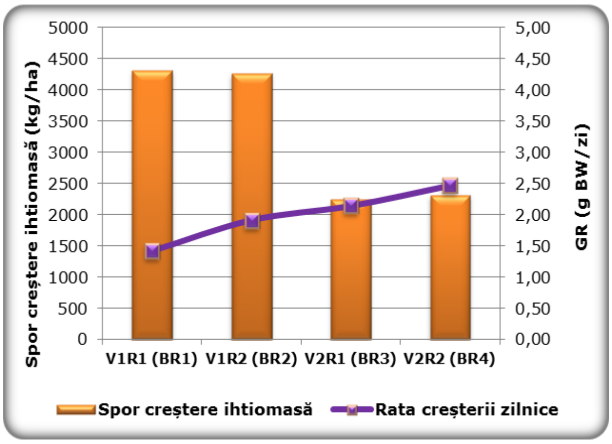


*Figure 6.5. Ichtyomass growth and daily growth rate in 2014*

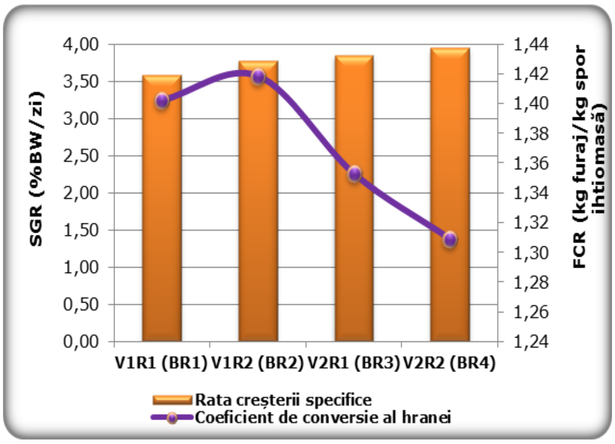


*Figure 6.6. Specific growth rate and feed conversion rate in 2014*

### 6.3.2. Experiment 2/2015

Significant differences have been recorded between the two experimental variants carried out in duplicate in direct ratio to the stocking densities used, as was the case in 2014. In what total length is concerned, Post-hoc Duncan's Multiple Range test divided the data sets into two large categories, the total length in the V4R2 variant being significantly smaller ($p< 0.05$) than those in groups V3R2, V3R1 and V4R1 (Fig. 6.7). As for bodyweight, Post-hoc Duncan's Multiple Range test divided the data sets into three distinct categories: the bodyweight of fish in V3R2 group is significantly higher ($p<0.05$) than those in groups V3R1, V4R1 and group V4R2 (figure 6.8).

Statistically speaking, the surveyed experimental lots had normal distribution (K-S test, $p> 0.05$) for both variables, i.e. bodyweight and total length (Fig. 6.9)

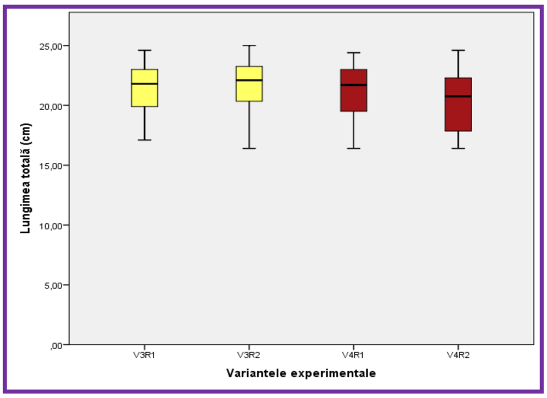


Figure 6.7. *Length variation*

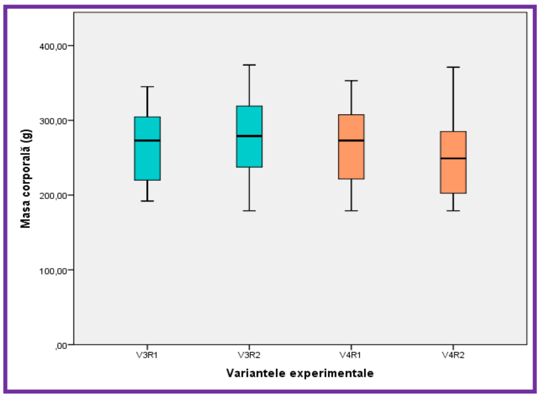


*Figure 6.8. Bodyweight variation*

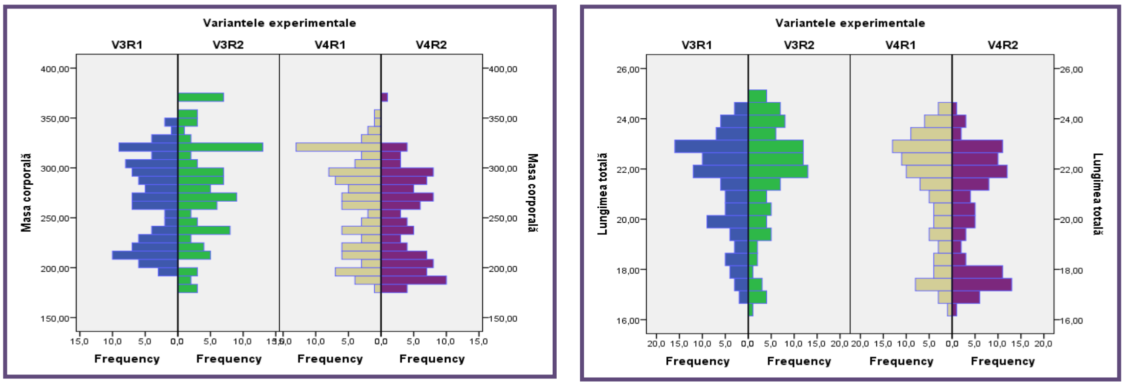


*Figure 6.9. Histogram of final individual bodyweights and lengths*

In what the final total ichtyomass in the ponds, the growth parameters indicated that the average growth of fish biomass was superior in V3 (3,446 kg/ha) in comparison with V4 (2,483.5 kg/ha). These value are in direct correlation with stocking density. Also, a similar variation was recorded in the case of GR parameter (individual growth rate), at average rates of 2.38 g/day in V3 and 2.23 g/day in V4 (Fig. 6.10).

Specific growth rate (SGR) expressed in mean values for the two repetitions of each variant was of 4.92%/day in V3 and of 4.86%/day in V4. Both values are very good, indicating that both stocking densities are favourable. The mean supplementary feed conversion ratio (FCR) was of 1.34 kg feed/ kg growth in V3 and, respectively, of 1.26 kg feed/ kg growth in V4. Both represent very good values for the farming in ponds system (Fig. 6.11).

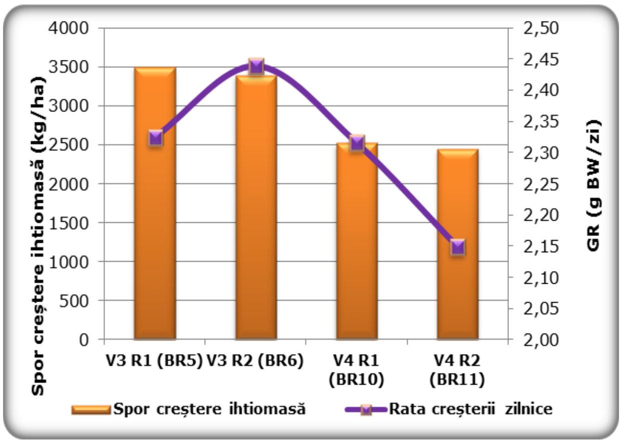


*Figure 6.10. Ichtyomass growth and daily growth rate in 2015*

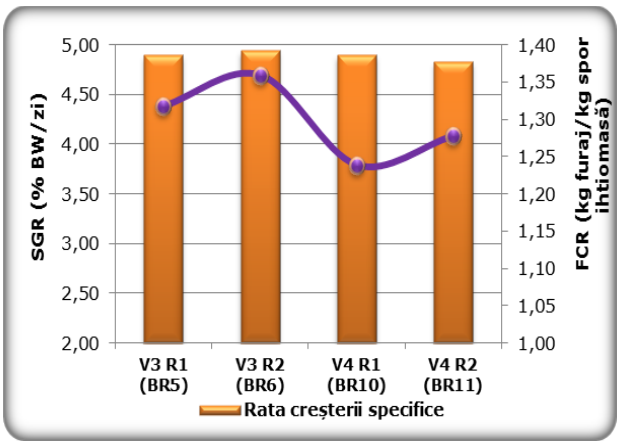


*Figure 6.11. Specific growth rate and feed conversion rate in 2015*

Following the primary analysis of the values obtained for b allometric coefficient, negative allometry (b<3) for all the lots under testing. The growth is rather in length than in bodyweight, which is normal for juvenile fish (Fig. 6.12).

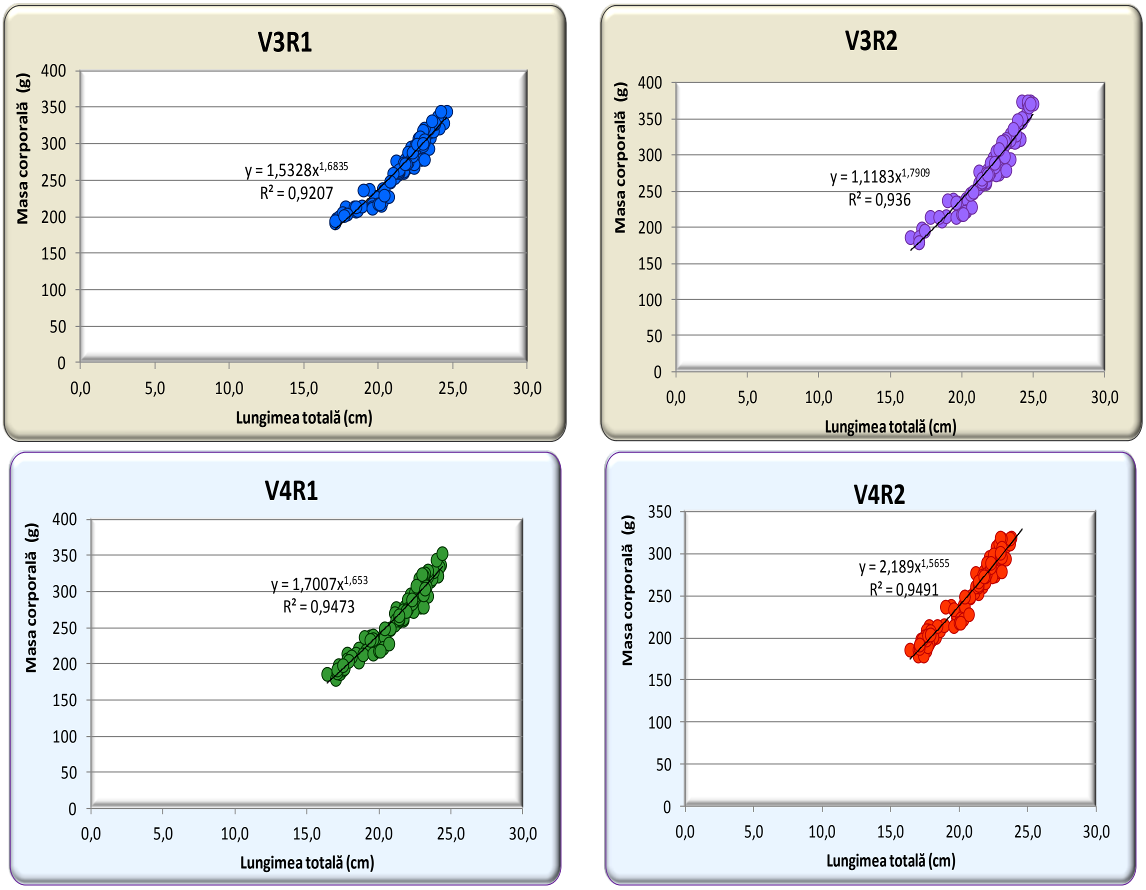


*Figure 6.12. Length-bodyweight regression for the experimental lots*

## 6.5. Conclusions

The results of the research undertaken in 2014 and 2015 confirm that the level of carp production varies in direct ratio to stocking density, while bodyweight and individual growth rate usually vary in indirect ratio to stocking density. The availability of natural food in each pond may influence the fish growth performance.

In what the growth rate and the feeding efficiency are concerned, the present research has proven the possibility of obtaining productions of 4,300 kg/ ha (at an average bodyweight of app. 250 g/ specimen for stocking densities of 30,000 specimens/ha), of 3,500 kg/ha (at an average bodyweight of more than 270 g/ specimen for stocking densities of 20,000 specimens/ ha), of 2,500 kg/ha (at an average bodyweight of 255 g/ specimen for stocking densities of 20,000 specimens/ha) and of 2,300 kg/ha (at an average bodyweight of approx. 350 g/ specimen for stocking densities of 15,000 specimens/ha). Such large productions can be obtained on condition that water is additionally aerated during the hottest months (July and August). Obtaining an average individual bodyweight of more than 250 g/ specimen in a growth period of four to five months is a technological success which represents the foundation for reaching the commercial size in the following year, without another additional year of growth, which entails significant decrease in production expenses.

In order to make profit, the level of final production is more important than the mean bodyweight. Therefore, more recommendable are stocking densities of 30,000 specimens/ha and 25,000 specimens/ha, pre-developed juveniles with bodyweight of minimum 1 g/ specimen. The hypothesis is also confirmed by the calculated net profit. In the variants presented above, a profit of 2.34-2.67 lei/kg was obtained, much more than in the case of using 20,000 specimens/ha or 15,000 specimens/ha stocking densities, in which cases the net profit was of 1.34-1.86 lei/kg.

# CHAPTER 7

# THE INFLUENCE OF DAILY INTAKE ON THE GROWTH PERFORMANCE OF CARP JUVENILES IN PONDS

## 7.1. Introduction

In intensive and semi-intensive aquaculture, the feeding costs cover the largest portion of the expenses, so that, in order to obtain relevant growth performance, it is important that the food is qualitative and capable to ensure the nutrition necessities of the farmed species. The administration of the correct food intake influences the fish growth, the feed conversion, as well as the efficiency of nutrient retention and the chemical composition of meat.

## 7.2. Materials and methods

The present research was undertaken along 111 days, from June through October. The rearing units were four ponds (5000 $m^2$ and 1.2 m depth each). The four ponds were stocked with carp juveniles with bodyweight around 1g/ specimen. Two experimental variants were further compared, each one with two repetitions, according to the following scheme:

- V1, with repetitions V1R1 (BP2) and V1R2 (BP3);
- V2, with repetitions V2R1 (BP4) and V2R2 (BP5);

The experiments in both variants were carried out under similar environmental conditions, with identical stocking densities of 30,000 specimens/ ha (30 kg/ ha). We used identical extruded pelleted feeds with 48% crude protein (48/10 Soprofish) in the first 29 days of growth (stage 1). Then, the feeding continued for other 82 days (stage 2) with expanded pelleted feeds with 30% crude protein (coded as 30/7 Profi). The only parameter which differentiated the two variants was the daily intake (feeding level) during the second growth stage, which was 0.5-2% BW higher in V1 than in V2.

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## 7.3. Results and discussions

Significant differences were recorded between the two variants, determined by the daily food intakes. The production level, in all variants, was very high, in the range of 2,753-4,427 kg/ha, higher in V1, in which daily intakes 0.5-2.0% higher than in V2 were administered. By analysing the data acquired following the individual measurements at the end of the experimental period, statistically significant differences were noted between the bodyweights and total length of the fish (Anova, $p<0.05$) (Fig. 7.1, 7.2). Thus, post-hoc Duncan's test divided the fish into three size classes, the bodyweight and total length of the fish in lots V1R1, V1R2 being significantly higher than those recorded for fish in lots V2R1 and V2R2. In relation to average bodyweight, better results were acquired in V1 than in V2.

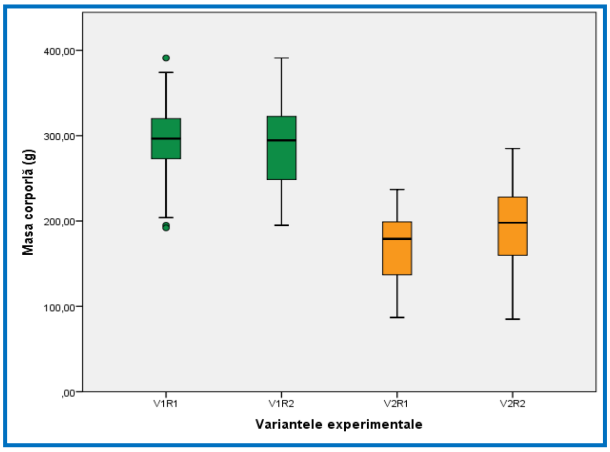


Figure 7.1. *Variation of bodyweight at the end of the experimental period (median, minimal values, maximal values and quartiles)*

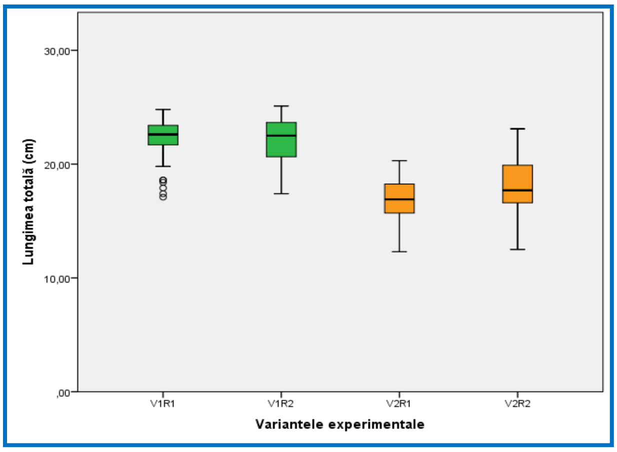


Figure 7.2. *Variation of total length at the end of the experimental period (median, minimal values, maximal values and quartiles)*

In what the total ichtyomass is concerned, the average growth was much higher for V1 (approx. 4,331 kg/ha) than for V2 (2,803 kg/ha). These values are in direct correlation with the daily intake and the total quantity of feeds distributed. The same trend was preserved for the individual growth rate (GR), expressed in average values of the two repetitions. It is only natural that a better result was recorded in V1 (2.62 g BW/day), in comparison with V2 (1.61 g BW/day) (Fig. 7.3).

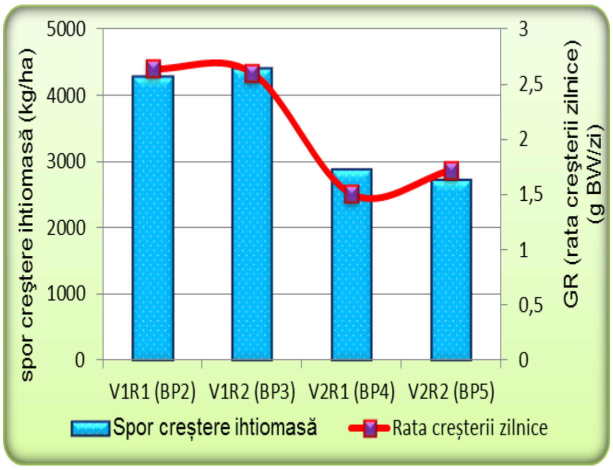


*Figure 7.3. Ichtyomass growth and daily growth rate*

The specific growth rate (SGR) expressed in mean values for the two repetitions of each variant was of 5.11%/day in V1 and of 4.68%/day in V2. Both represent excellent values which prove the bio-productive potential of the species is a remarkable one, on condition that the fish receive sufficient qualitative food. The average feed conversion ratio (FCR) was of 1.11 kg feeds/ kg growth in V1 and respectively of 1.46 kg feeds/ kg growth in V2. These represent very good values for the farming in ponds system (Fig. 7.4).

Figure 7.5 depicts the inverse correlation between FCR and the protein efficiency ratio (PER) in the sense that a low consumption of feeds results in a positive effect on the protein efficiency ratio.

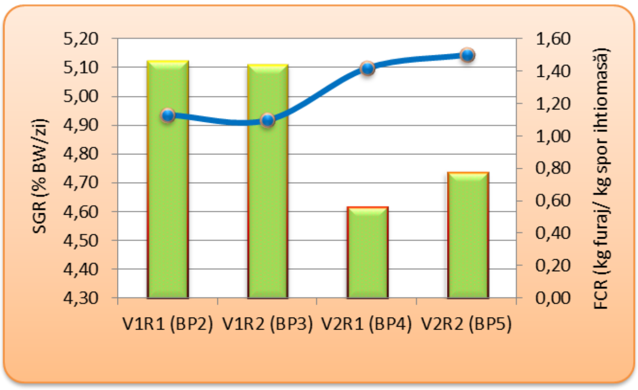


*Figure 7.4. Specific growth rate (SGR) and feed conversion ratio (FCR)*

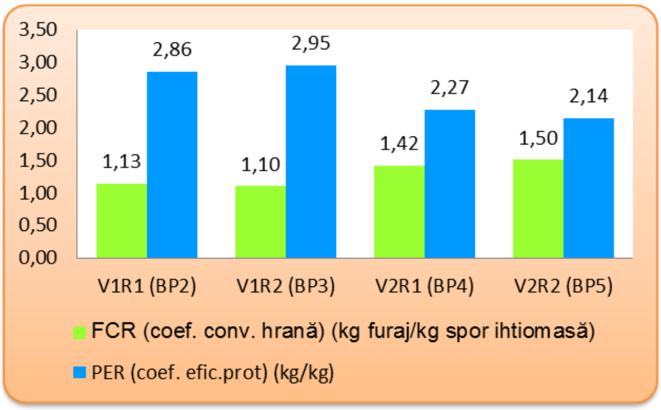


*Figure 7.5. Feeding efficiency (FCR, PER)*

## 7.5. Conclusions

The biotechnological results obtained have proven that, in point of growth performance and feeding efficiency, the variant with a higher daily intake (feeding level) allows obtaining a much larger production, of over 4,300 kg/ha. However, the daily intake cannot be randomly chosen or increased, as important quantities of feeds may be unjustifiably wasted. By control fishing, on a weekly or at least bi-monthly basis, the fish growth rhythm should be controlled.

The choice of daily intake and, implicitly, the calculation of feeds necessity should only be pursued in correlation with the fish biomass extant in the pond. The present experiment has proven that, in the first stage of growth of carp juveniles (the first 30 days), the daily intake should be weekly diminished, from 25% BW to 5% BW. The frequency of daily feeding is another extremely important technological aspect. At this stage, it is recommendable that the food is administered in five to six feeds a day.

In the second stage of growth, which usually takes place from July through October, the daily intake is selected according to water temperature and the fish biomass for each pond estimated through control fishing, also weekly or bi-monthly. The feeds should be adjusted if the fish consume or not the distributed feeds. Generally speaking, daily feeds of 2-5% BW are recommended, which are further diminished when the water temperature decreases. Also, it is recommendable at this stage that the food is administered in three to four feeds a day.

The availability of natural food in each pond may influence the fish growth. Where there is much natural food, important quantities of feeds should be saved in May and June due to the distribution of fertilizers and amendments. As the natural food is diminished or even vanishes completely (July through September), the quantity of supplementary food should be increased.

# CHAPTER 8

# INNOVATIVE TECHNOLOGIES FOR FARMING OF COMMON CARP JUVENILES (*CYPRINUS CARPIO, LINNAEUS 1758*), BASED ON THE USE OF EXTRUDED AND EXPANDED PELLETED FEEDS

As a result of our research and the fruitful collaboration with the decision-making factors of Alexandar Parc Company, two technologies of farming carp juveniles in the first summer have been elaborated:

1. **Fully fed farming of common carp juveniles (*Cyprinus carpio,* Linne, 1758)**
2. **Partially fed farming of common carp juveniles (*Cyprinus carpio,* Linne, 1758)**

The main stages of the technological process are as follows:

***Preparation of the ponds in the first summer***

During the first stage, we administered 100 kg/ha chlorine based bleach (for the control of pest and undesirable fish species left in the waterholes on the platform) and 100 kg/ha calcium hydrate in transversal lines, c. 3 meters one from the next. Other 500 kg/ha are distributed directly into water after flooding and stocking, on a weekly basis, 20-25 kg/ha per week. It is recommendable to use dosages of c. 3000 kg/ha manure or bird droppings.

***Ponds flooding and stocking***

The flooding of the growth pond is done 24-48 hours before stocking it with carp juveniles. As a warrant for large productions, of over 3,000 kg/h, stocking densities of more than 25,000-30,000 specimens/ ha should be used. At the moment of stocking, the carp juveniles should weigh at least 1-2 grams/ specimen

***Feeding the carp juveniles***

The feeding should be done in two stages:

**Stage I** spans for about a months. High quality extruded pelleted feeds, granulation: 0.2 mm, crude protein 45-48%, are recommendable.

**Stage II** should last for at least four months. Expanded pelleted feeds, granulation: 2 mm, crude protein of 30-35% are recommendable at this stage.

***Maintenance of environmental conditions***

.Several physical-chemical parameters should be monitored as they are considered of importance for fish's life: water temperature, pH, dissolved oxygen, azote, phosphor, organic substance, etc.

Many stages of the technological process of each technology coincide. The final productions that may be obtained by applying the two technologies are nevertheless different:

- **In fully-fed mode**, average productions of 4,300 kg/ha can be obtained, with feed conversion ratio of 1.3-1.4 and mean bodyweight of approx. 300-350 g/ex.

- **In partially-fed mode**, average productions of 1,600 kg/ha can be obtained, with feed conversion ratio of 0.15 and mean bodyweight of approx. 250-300 g/specimen.

The following graphs present the technological schemes for the two technologies of farming carp juveniles in the first summer (Fig.8.1, Fig. 8.2)

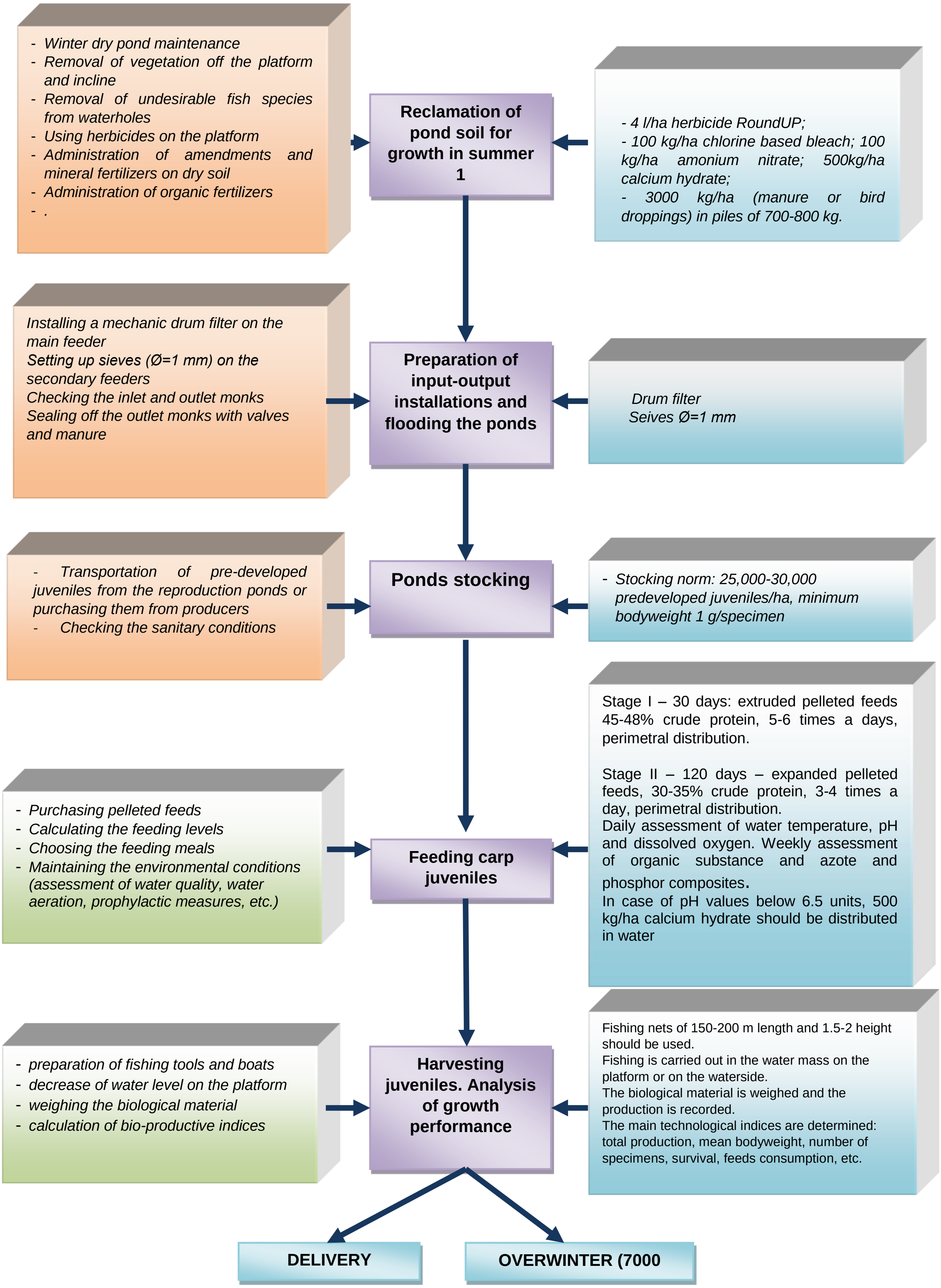


*Figura 8.1 Technological scheme of farming carp juveniles in fully-fed mode*

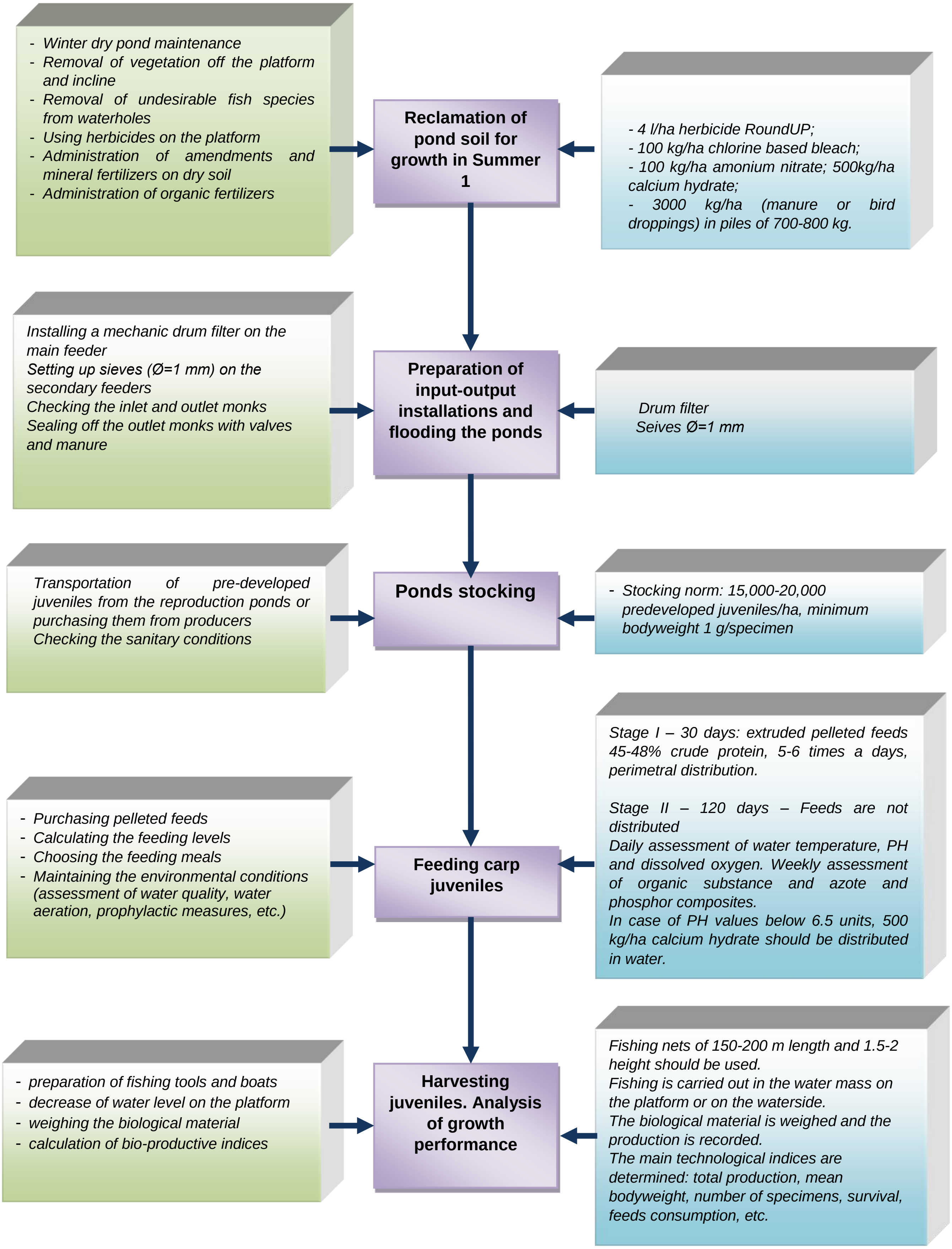


*Figura 8.2 Technological scheme of farming carp juveniles in partially-fed mode*

# CHAPTER 9
# FINAL CONCLUSIONS AND PERSONAL CONTRIBUTIONS

## FINAL CONCLUSIONS

All tests have been geared towards attaining the following objectives:

1. To choose the best management measures for the optimisation of the environmental conditions (preparing the ponds, stimulating the natural food chain potential by administering amendments, mineral and organic fertilizers, monitoring the quality of water, etc.);
2. To optimize the technology of farming carp juveniles in ponds in unfeeding conditions with the administration of mineral and organic fertilizers (manure);
3. To optimize the technology of farming carp juveniles in ponds in unfeeding conditions with the administration of mineral and organic fertilizers (bird droppings);
4. To exploit the natural food chain potential of the ponds by farming carp juveniles in unfeeding conditions, without using mineral and organic fertilizers;
5. To opt for the best pelleted feed by evaluating the growth performance of carp juveniles;
6. To establish the best stocking densities by evaluating the growth performance of carp juveniles along one summer of life;
7. To choose the optimal daily intake (feeding level) by assessing the growth performance of carp juveniles along one summer of life;

## PERSONAL CONTRIBUTIONS

***Shortening of the production cycle***

It is necessary for growth technologies to be constantly improved in view of making the fish farms lucrative. A first measure would be the shortening of the production cycle, from three to two years, and even to one year. In truth, thanks to the spectacular advance in the field of fish nutrition and feeding and that of disease control, it is possible to obtain edible fish (weighing c. 1kg per specimen) after only six or seven months of growth in summer 1. This PhD thesis has taken the first step in accomplishing this objective by shortening the production cycle from two and a half years to one and a half. In this respect, we have brought arguments based on multiple experiments of carp growth in the first summer that average bodyweights of over 200 g/ specimen can be obtained and, in some circumstances, even of 300 g/ specimen. If, in the following year the ponds are populated with carp in the second summer of life, with specimens with >200 g bodyweight, edible fish with more 1.5 kg bodyweight may be obtained, which would be the ideal weight for consumers.

***Technological innovations***

In order to obtain profitable productions of juveniles, the growth ponds must be agro-technically prepared. Amendments, mineral and organic fertilizers must be used only in correlation with the level of several physical and chemical parameters of soil and water. Firstly, the natural food chain potential should be capitalized, the administration of feeds being undertaken as the natural food is exhausted.

As demonstrated in the chapters of the present thesis, superior, economically profitable productions cannot be obtained without using extruded and expanded pelleted feeds. As fruit of my experience in production and research, my proposal is that the feeding of carp juveniles should be carried out in two stages: In stage 1, a timespan of about one month, it is advisable to use extruded pelleted feeds, 0.2 mm granulation, crude protein of 45-48% and crude energy of over 19 Mj/kg. During the second stage, which should span at least four months, expanded pelleted feeds should be used (minimum 2 mm granulation, crude protein of 30-35% and crude energy of at least 18 Mj/kg).

An element of originality is the method of calculation of the daily feeds quantities based on the fish biomass extant in ponds at a certain moment. The feeds necessity will be calculated starting with the first day of feeding and ending with the last, self-evidently considering a survival of fish of over 50%.

The eighth chapter presents the essential contribution, which answers to the main aim of the research: the innovative technology of farming carp juveniles in the first summer of life, obtaining productions of more than 4,300 kg/ha and final body weights of more than 300 g/ specimen. Although apparently the chapter details the stages of the technological process for only one technology with pelleted feeds, if feeds are dropped together with their related aspects, what also results is the technology of capitalizing the natural food chain potential of the ponds without additional feeding. This option has been described in the fourth chapter, the result being worthy of consideration: profitable productions of approx. 1,600-1,700 kg/ha may be obtained without feeds but using amendments and fertilizers (manure) in the quantities mentioned in the thesis. In this circumstance, the farmer's net profit (3.23-3.51 lei/ kg of fish) is close to that obtained using technologies based on pelleted feeds (3.36-3.51 lei/kg of fish). Nevertheless, in this latter case, the risks of not accomplishing are lower, which is the reason why we opt for the large-scale use of pelleted feeds.