PRELIMINARY INVESTIGATIONS ON COMPENSATORY GROWTH IN PRUSSIAN CARP (*CARASSIUS AURATUS GIBELIO*)

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Abstract. The present paper analyzes the results of some recent investigations on fish compensatory growth, developed on experimental batches of Prussian carp (*Carassius auratus gibelio*). It is generally known that blocking unfed fish' growth is not irreversible, so that, when feeding is resumed, the growing processes are also reactivated. More than that, the growing rhythm of such fish is accelerated, a catch-up growing of the normally-fed individuals being observed, from the part of the intermittently-fed ones.
Differentiated feeding, for 85 days, of four parallel batches of Prussian carp, under aquarium conditions, permitted the observation that, in the group to which a regime of partial inanition had been applied in the first 35 days of the experiment, the fish records a weight-less of 66 mg/piece/day while, in the post-inanition period, when all lots receive identical rations, growing gets accelerated, the fish coming to catch up the continuously-fed ones. Thus, in the first 30 days of normal, post-starvation feeding, in the discontinuously-fed fish, the growing rhythm is 22% higher than that of the reference variant while, in the following 20 days, the differences reaches a ratio of 92%. In the first post-inanition stage, the food conversion ratio is 30% lower in the intermittently-fed lots, comparatively with the reference while, in the final stage of the test, the amount of food necessary for attaining a 1 kg growth increase is 41% lower in the compensatory growth variant, comparatively with the reference one, in which the fish had been continuously fed for 85 days.

Keywords: compensatory growth, Prussian carp, discontinuously-fed fish, weight gain, FCR.

Rezumat. **Cercetări preliminare privind creşterea compensatorie la caras *(Carassius auratus gibelio)***. Lucrarea prezintă rezultatele unor investigaţii privind creşterea compensatorie la peşti, efectuate pe loturi experimentale de caras *(Carassius auratus gibelio).* Este cunoscut faptul că, blocarea creşterii peştilor nehrăniţi nu este ireversibilă, astfel încât, după reluarea hrănirii se reactivează şi procesele de creştere. Mai mult, ritmul de creştere al acestor peşti se accelerează, având loc chiar o ajungere din urmă (catch-up growing) a exemplarelor hrănite normal de către cele hrănite cu intermitenţă.
Hrănirea diferenţiată timp de 85 zile a unor loturi paralele de caras în condiţii de acvariu a dus la constatarea că, la varianta la care s-a aplicat un regim de inaniţie parţială în primele 35 zile de experiment, peştii înregistrează o pierdere de greutate de 66 mg/ind./zi, iar în perioada post-inaniţie, când loturile ambelor variante au primit raţii identice, creşterea se accelerează, peştii tinzând să ajungă din urmă congenerii care au fost hrăniţi fără intermitenţe. Astfel, în primele 30 de zile de hrănire normală post-inaniţie, la peştii hrăniţi discontinuu sporul de creştere este superior martorului cu 22%, iar în perioada următoare de 20 zile diferenţa creşte la 92%. Coeficientul de conversie a hranei, în prima etapă post-inaniţie este cu 30% mai mic la varianta hrănită intermitent comparativ cu martorul, iar în etapa finală a testului, necesarul de furaj pentru obţinea unui kg spor de creştere este cu 41% mai mic la varianta cu creştere compensatorie în raport cu varianta martor, la care peştii au fost hrăniţi fără intermitenţă timp de 85 zile.

Cuvinte cheie: creşterea compensatorie, caras, hrănirea discontinuă, spor de creştere, bioconversia hranei.

Introduction

As generally known, in both natural growing conditions and -especially- in an artificialized environments, animals are frequently confronted with a drastic reduction -or ever, temporary interruption- of feeding, induced by discontinuities -caused by multiple factors -in providing food. As organisms with continuous bodily growth, the fish are directly affected by the effects of temporary starvation, which are reflected in the inhibition - or even total interruption - of growing or, in situations in which food's interruption is prolonged - in a visible reduction of their bodily weight. For example, it

has been scientifically demonstrated that, along only one inanition day, the trout looses a weight equal to the weight increase recorded in 3 days of normal feeding (Decei, 1978).

The present investigations have started from the real situations of the aquaculture farms, in which discontinuities may sometimes appear in feeding of the fish effectives. Growth of the discontinuously-fed fish slows down or it is even blocked while, in the case of prolonged inanition periods, a progressive decrease of individual weight may be recorded.

Fortunately, the process is reversible, so that, when feeding is resumed, the process of growing is re-activated and even accelerated. In this respect, both somehow older studies (Wilson & Osburn, 1960; Dobson & Holmes, 1984), along with some relatively new data (Jobling & Johansen, 1999, Hornick *et al*., 2000, ALI *et al*., 2003) have evidenced that the growing rhythm of fish previously subjected to inanition gets accelerated, up to catching up of the normally-fed ones, from the part of the intermittently-fed individuals. The phenomenon -observed in other groups of animals, too– is known under the name of "*compensatory*" or "*catch-up*" *growing*, while knowledge on the manner in which this process is manifested in the case of fish may have important practical consequences in aquaculture.

The present investigations aims at evidencing and evaluating the compensatory growth in the 2 year-old Prussian carp (*Carassius auratus gibelio*), under aquarium conditions, after a period of partial starvation of 35 days, as well as at analyzing the index of survival and of fish general condition, along a 85-day experiment, the coefficients of metabolic utilization of the food consumed by the normally -and intermittently- fed fish, included.

Material and Methods

The fish experimental effectives, taken over from the Ezareni accumulation, situated in the south-western part of the city of Iasi in the autumn of 2005, was kept under conditions of aquarium until March 15, 2006, when tests of controlled feeding have been initiated. The experiments were developed between March 15 and June 10, 2006, in the experimental aquaria of the Laboratory of Animal Ecophysiology, at the "Al. I. Cuza" University of Iasi.

Two experimental variants have been considered, each one with two repetitions of 25 individuals, placed in an aquarium with an useful volume of 100 L water. The fish was fed with granulated yeast for trout, produced by the Trouvit Company (Italy), containing 41% raw protein, 12% lipids, 2.5% cellulose and 7.8% ash, as follows:

- variant A, formed of batches 1 and 2, to which, in the first 35 days (15.03 – 19.04.2006), food has been administered only one day a week, while, in the following 50 days, normal feeding of fish was performed;
- variant B, formed of batches 3 and 4 (reference), to which fish feeding has been permanent.

Feeding of all batches was made normally, with identical daily rations representing 0.5% of fish bodily weight, administered in 1 - 2 shares/day.

Determination of the growing rhythm was made once each two weeks, which involved weighing of the whole effective of each batch.

Results and Discussion

A first observation to be made is that, although the temperature of the water in the aquaria ranged between 18 and 20°C, the level of food's acceptance from the part of fish was quite low, which might be possibly explained -on one hand- by the specific receipt for salmonides and -on the other- by the long inanition period of the whole fish effective between December 2005 - March 2006, that is, prior to experiment's launching.

Secondly, it was noticed that, after 85 days of experiment, the survival ration of fish from all the 4 batches was of 100%.

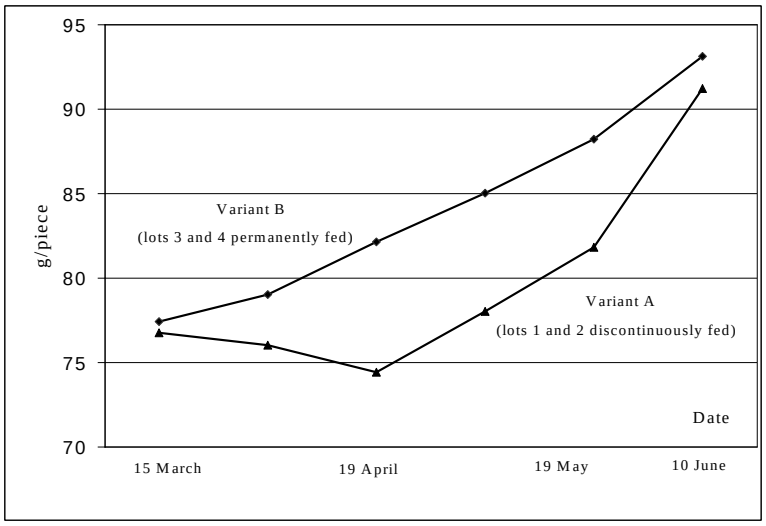

Figure 1. Compensatory growth in differentiatedly-fed Prussian carp.

Along the partial inanition period of the first 35 days of experiment, lowering of the average bodily weight of the fish of variant A, up to 2.34 g/piece, *i.e.*, about 67 mg/piece/day, is to be observed.

Further analysis of the growth curve for the fish of variant A evidences resuming of the process of bodily gravimetric accumulation, starting with the moment of inanition's stopping and resuming of normal feeding. The descending slope of the graph of variant A is interrupted, the two curves evolving only apparently parallel, the more and more pronounced tendency of the graph of variant A of becoming similar to that of the reference variant (Fig.1).

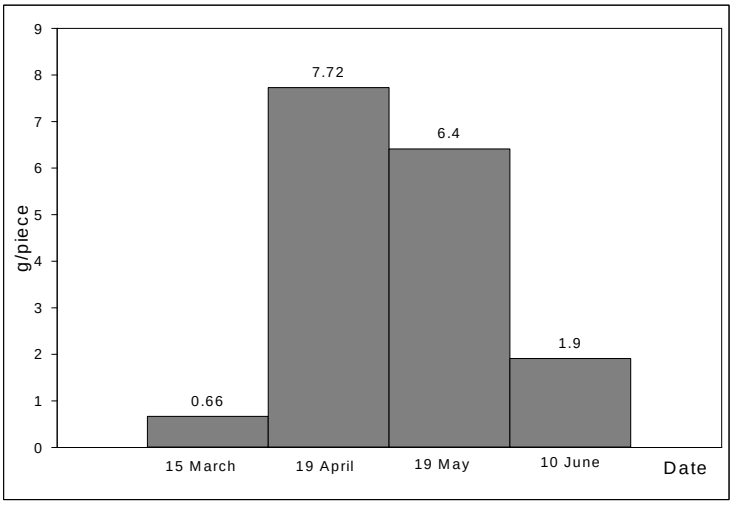

Figure 2. Evolution of gravimetric differences (g/piece) between the two variants.

In other words, the gravimetric differences between the individual average weights in the fish of the two variants decrease, as the experiment comes to its end. Fig.2. already illustrates this situation, namely that, during the control weighing of April 19, the fish of variant B were -on the average- heavier with 7.72 g/piece, comparatively with the fish of variant A. The latter ones gradually reduce this difference, which decreases up to 6.40 g/piece on the weighing of May 18, and up to only 1.90 g/piece, respectively, in the end of the period taken into study.

One may therefore assert that, beyond any doubt, the behavior of the fish from variant A reflects what the literature of the field calls "*compensatory growth*".

A comparative analysis of the growth rhythm in the fish of the two variants demonstrates that, in the stages following inanition, *although the daily ratios of food had been identical in the two variants*, the fish of variant A exceeded each time the fish of the reference batch A, as to the individual growth gain. Such differences, explaining the "*catching up*" phenomenon, which defines compensatory growth, attain a value of 22% in the second stage of the test, in favor of variant A, and of 23%, respectively, in the third experimental stage (Fig.3).

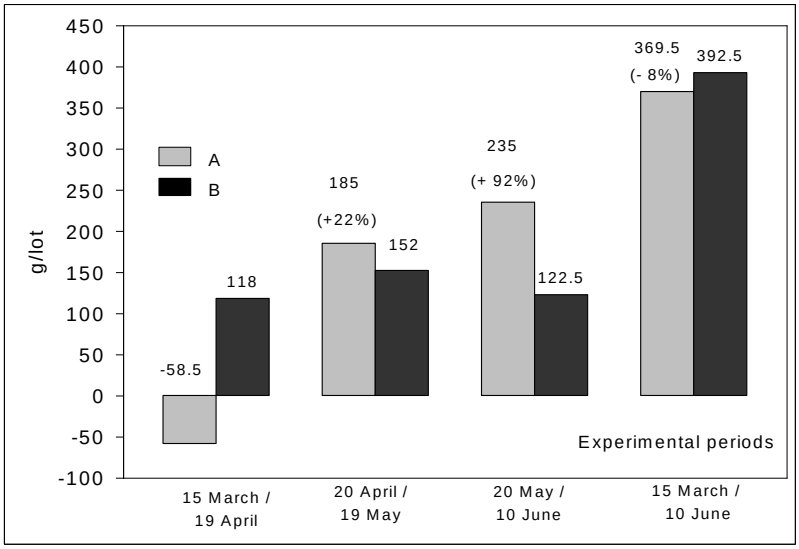

Figure 3. Evolution of total weight gain (g/lot) in differentiatedly-fed *Carassius auratus gibelio*.

Some literature data show that the physiological mechanisms of compensatory growth may assimilate on the whole the gravimetric difference produced by temporary inanition, although several cases of partial recovery had been recorded. In the present experiment, catching-up is not integral, as the growing increase over the whole experimental period remains, in variant A, 8% lower than the value recorded for the reference (Fig. 3).

One may therefore assume that prolongation of the feeding period might have led to a total covering of the differences induced by the experimental starvation process.

All these considerations suggest the manifestation of an additional metabolic mobilization in the temporarily-starving fish (variant A), so that, in a subsequent moment, over the same time interval and for the same fodder consumption, these individuals are capable of evidencing higher bodily gains comparatively with those of the reference sample. This is especially evident from the comparative analysis of the coefficients of food conversion (Fig.4).

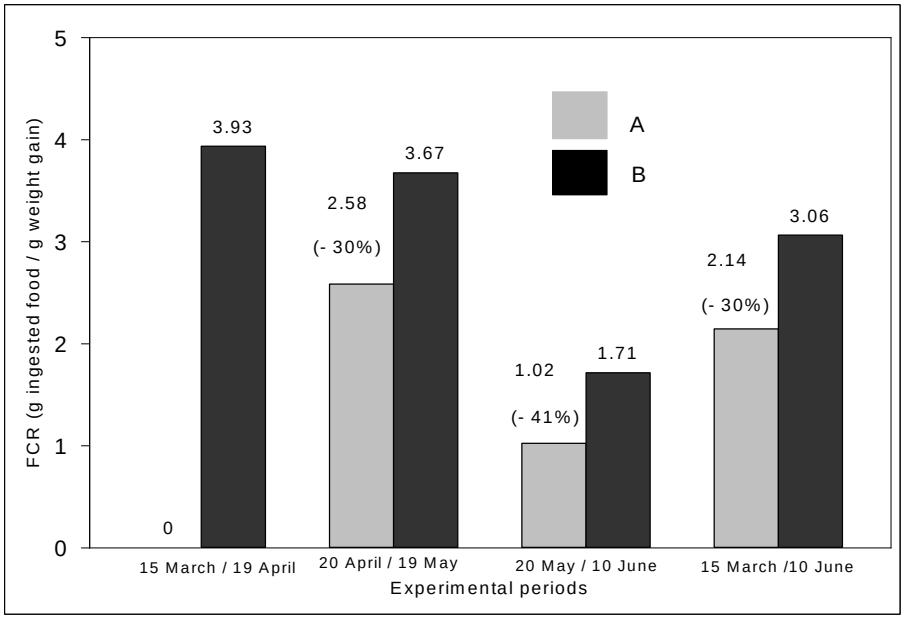

Figure 4. Food conversion ratio (FCR) in differentiatedly fed *Carassius auratus gibelio.*

The data show that, for attaining an 1 kg gain, the fish of variant A consumes 30% less food than the fish in the reference variant, in the first post-starvation experimental period and, respectively, 41% less in the 2nd stage, which means an efficiency of food's bioconversion, in variant A, *versus* the reference, almost 12% higher in the first stage and, respectively, 39.6% in the final stage of the experiment (Fig.5).

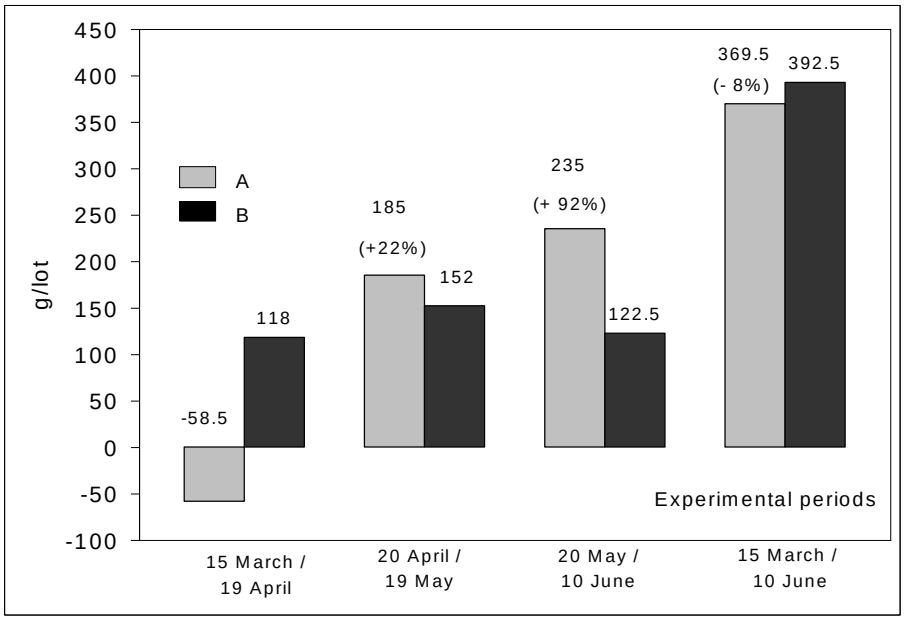

Figure 5. Food conversion efficiency (FBE%) in differentiatedly fed *Carassius auratus gibelio.*

From this perspective, along the whole experimental period, the food necessary for attaining a 1 kg growth gain is 30% lower in variant A, while the efficiency of food's conversion is 14% higher than that recorded in the batch reference.

These values may possibly suggest that such an important conversion might be related to some differences in the metabolic rhythm, between the first restricted and then normally-fed animals, on one hand, and the permanently-fed ones, on the other.

Several theories have been devoted to the physiological substrate of the compensatory growth. Thus, Wilson and Osbourn (1960) suggest that, in the period immediately following a restrictive period of a free feeding regime, animal's metabolic rhythm cannot suddenly return to the level recorded for a permanently normally-fed one. In other words, re-adaptation to normal feeding may take time, while the low ratios of energy consumption may be maintained even if the animals are no longer fed in a restrictive manner.

Other hypotheses suggest a possible de-coupling between the anabolic and the catabolic processes, so that the ratios of energy synthesis and consumption rapidly increase, while tissues' division is delayed at the levels recorded for the continuously-fed animals. Therefore, rapid growth and food' s efficient conversion, appearing after resuming of normal feeding, seem to result from the larger difference between anabolism and catabolism in the individuals whose food had been first limited and subsequently resumed (as a result of the low rate of tissues' division), comparatively with the permanently fed ones (Jobling, 1993).

Nevertheless, at least up to now, no hypothesis has fully and most suitably explained all modifications observed during the recovery period, following food' s interruption as undoubtedly, several mechanisms are here involved. They may be represented by the occurrence of hyperphagy, modification of the energetic consumption and efficiency of energy' s utilization, modification of tissue composition in the starved fish, comparatively with the continuously fed one, a.s.o.

Conclusions

1. After a 35 day-period of partial starvation (when food was administered only one day a week), the fish of variant A recorded a weight loss of 66 mg/piece/day;

2. Along the post-starvation period, feeding with identical ratios of the fish from the two variants induces the manifestation of the compensatory growing, phenomenon, as evidenced by:

- reduction of the weight difference among the fish of the two variants from 7.72 g/piece on April 19 to 6.40 on May 19 and 1.90 g/piece on June 10, 2006, respectively.

- realization of some additional weight gains -*versus* the values recorded in the reference variant- of 22% in the first post-inanition stage and of 92%, respectively, in the final stage of the test.

3. In the variant under study, the conversion of food evidences 30% lower values than the reference, in the first post-treatment stage, and 41% lower ones, respectively, in the final stage.

4. In the discontinuously-fed variant, the percent FBE (food bioconversion efficiency) values are 11% higher than those of the reference in the first post-starvation period and, respectively, 39% higher in the final stage of the test.

5. All these results demonstrate the high functional plasticity of the *Carassius auratus gibelio* species, challenging other investigations, dedicated to the modification of tissue composition in partially starving fish, comparatively with the permanently-fed one, a.s.o.

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