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PREMIERS RÉSULTATS DE L'ÉLEVAGE INTENSIF DE LA PERCHE EUROPÉENNE *(PERCA FLUVIATILIS)* EN BASSIN : EFFET DE LA TEMPÉRATURE ET DU TRI SUR LA CROISSANCE.

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RÉSUMÉ

Malgré un marché potentiel important, peu d'études ont examiné les possibilités de développement de l'élevage intensif de la perche (*Perca fluviatilis*) en bassins ou en cages. L'objectif de cette étude initiale était d'évaluer l'effet de la température et du tri en fonction du poids corporel sur la croissance de perches élevées en conditions intensives. Les essais ont été réalisés avec des alevins de perche sevrés (1,9 g) sur une alimentation artificielle, placés en bassins alimentés par de l'eau du système de refroidissement d'une centrale nucléaire. La croissance est légèrement supérieure (+ 14,5 %) à une température de 26,5 °C par rapport à celle enregistrée à 22,9 °C. Cette différence est non significative (p>0,05), probablement parce que ces 2 températures se situent dans la gamme des températures optimales pour la croissance de la perche. Une infestation (taux de contamination : 24,5 %) par le cilié *Heteropolaria* sp est apparue à une température de 26,5 °C. Les perches, triées et séparées en 3 groupes distincts en fonction du poids corporel au début de l'expérience, ont présenté, après 234 jours d'élevage, une augmentation du polymorphisme de la croissance dans chaque groupe se traduisant par une superposition partielle des distributions des poids corporels. Une analyse de covariance indique que les 3 groupes ont présenté des vitesses de croissance comparables (F = 1,2). En élevage intensif, il apparaît que la perche présente une grande variabilité de croissance, ce qui renforce la nécessité de trier fréquemment les poissons.

Mots-clés : *Perca fluviatilis*, élevage intensif, taux de croissance, température, tri, dominance sociale, *Heteropolaria* sp.

FIRST RESULTS OF EUROPEAN PERCH *(PERCA FLUVIATILIS)* INTENSIVE REARING IN TANK : EFFECT OF TEMPERATURE AND SIZE GRADING ON GROWTH.

ABSTRACT

Despite an important potential market in Europe few researches have examined the possibilities of intensive perch (*Perca fluviatilis*) culture in tanks or cages. This initial study investigated the effect of temperature and size grading on the growth of perch reared intensively in tanks supplied with warm water from the cooling system of a nuclear power plant. The trials were conducted with weaned perch fingerlings (1.9 g). Increasing the temperature from 22.9 °C to 26.5 °C resulted in a slight (+14.5 %) growth increase, although it was not significant (p > 0.05), probably because both temperatures were within the optimal thermal range of perch. At 26.5 °C, a high infestation (prevalence : 24.5 %) by the ciliate *Heteropolaria* sp. was recorded. Perch graded and divided into three size groups presented increasing growth polymorphism in each group and the body weight distributions overlapped between groups at the end of a 234-day experiment. Analysis of covariance indicated there was no significant difference in growth rate between the groups (F = 1.2). The potential for very variable growth, as shown in our trials, stresses the necessity of frequent grading of young perch for intensive rearing purposes.

Key-words : *Perca fluviatilis*, intensive culture, growth rate, temperature, grading, social dominance, *Heteropolaria* sp.

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INTRODUCTION

Despite an important potential market estimated at 5,000 to 10,000 tons in Europe (HOUGH and GABRIEL, 1993 ; TAMAZOUZT *et al.*, 1994), few investigations have been performed on the intensive culture of perch (*Perca fluviatilis*) in tanks or cages. Yellow perch (*P. flavescens)* has been more thoroughly investigated in artificial conditions (MALISON *et al.*, 1990 ; STARR, 1991 ; DABROWSKI *et al.*, 1993). Some attempts at artificial rearing of *P. fluviatilis* have been done with variable success (MÉLARD and PHILIPPART, 1984). However, recent studies have shown the possibility of adapting the European perch to artificial conditions (FONTAINE *et al.*, 1993 ; MÉLARD and KESTEMONT, 1993 ; TAMAZOUZT *et al.*, 1993). The development of an intensive perch rearing system involves : i) the control of spawning, ii) rearing larvae up to the weaning size (i.e. the size at which the fish accept dry food) and limiting cannibalism, and iii) the determination of optimal conditions for growth and survival such as temperature, food rations, fish density and grading frequency in relation to the known variation in size resulting from competitive and genetic factors (CRAIG, 1987).

This preliminary study investigated the effect of temperature and size grading on the growth of weaned perch reared intensively in tanks.

MATERIAL AND METHODS

This study was conducted at the experimental aquaculture station of the Laboratory of Fish Demography and Aquaculture of the University of Liège (Tihange, Belgium). The water supply was obtained from the cooling system of the nuclear power plant of Tihange on the River Meuse. An automatic regulating system made possible the maintenance of year-round water temperatures between 20.0 °C and 28.0 °C by mixing the warm water from the power plant (20 °C - 45 °C) with the water from the river. During the study, the daily mean water temperatures ranged from 22.1 °C to 26.5 °C. The dissolved oxygen level in the water was maintained between 6.9 and 7.9 mg l^{-1}. The trials were made in square polyester tanks of 2.1 m^2 / 0.5 m^3 for the first experiment and of 4.0 m^2 / 1.0 m^3 for the second one. The water exchange rate was once to twice per hour depending on fish biomass.

The perch fingerlings (1.9 ± 0.4 g, mean ± standard deviation, SD) were obtained from preliminary semi-intensive larval rearing trials performed in small fertilized ponds (10 m^2). During this period, the larvae were fed progressively with artificial diets (56 % protein and 11 % lipids) and weaned (i.e. exclusively fed with artificial diets) after 35 days. After 2 months, surviving weaned fingerlings (± 5 % survival ; MÉLARD and KESTEMONT, 1993) were fed an exclusively artificial diet. In the first experiment (effect of temperature), the initial stocking density was 364 fish $tank^{-1}$ (2.1 m^2 / 0.5 m^3) ; in the second trial (effect of grading), the initial stocking densities were 323, 229 and 152 fish $tank^{-1}$ (4.0 m^2 / 1.0 m^3) for groups 1, 2 and 3 respectively.

The fish were fed daily with commercially available salmonid formulated feeds ; for fish from 1.9 g to 20 g, the protein and lipid contents were 57 to 50 % and 9 to 10 %, respectively ; for fish from 20 g to 250 g the protein content was reduced to 48 then 44 % (and lipids from 9.0 to 4.5 %). The feeds were distributed by automatic feeders over 12 hour periods during daytime. The feeding rate (F.R., % d^{-1}) was calculated from previous results (MÉLARD and KESTEMONT, 1993) that related feeding rates to individual fish body weight (W, g) and gave a food conversion ratio ranging from 1.5 to 2.0 : $F.R. = 6.54\ W^{-0.26}$.

Possible cannibalism was estimated from comparisons between overall (difference between initial and final counts) and observed mortalities (dead fish found in tanks). Fish growth and productivity were measured every two weeks (fish count and total biomass). At the end of each experiment, a sample of 100 fish was weighed individually for analysis of variance (Anova 1). Analysis of covariance (Ancova) was performed to compare, after a log-log transformation, the relationships between growth rate and body weight in the 3 fractions of the population (experiment 2). Null hypotheses were rejected at $p < 0.05$.

RESULTS

Effect of temperature

Figure 1 and Table I show a slight positive effect of temperature on the growth of perch fingerlings. The final mean body weight of perch in group A (temperature : 26.5 °C) was 14.5 % higher than in group B (temperature : 22.9 °C). These results corresponded to mean specific growth rates of 1.86 for group A and 1.76 for group B respectively. Due to the high variability of individual fish body weight within each group (coefficients of variation of 73.8 and 60.0 % for groups A and B respectively ; see also Fig. 2), the mean weights in the two groups were not significantly different (Anova, F = 1.99 ; df : 1 and 198). The survival rate was higher ($\chi^2 = 25.2$, $p<0.05$) at 22.9 °C (91.5 %) than at 26.5 °C (83.2 %), may be as a result of the latter group being infected by *Heteropolaria* (formerly *Epistylis*) *sp*, an ectosymbiotic ciliate fixed in colonies on the cteni of perch scales. At the end of the experiment, no *Heteropolaria sp* was detected in the batch reared at 22.9 °C while its occurrence at 26.5 °C was 24.5 %. During this experiment, no mortality resulting from cannibalism was observed.

Tableau I : Synthèse de l'effet de la température et du tri sur la croissance, le coefficient de conversion alimentaire et la survie de la perche.

Table I : Effect of temperature and size grading on growth, food conversion and survival rate of perch.

Treatments	Temperature		Grading		
	Group A	Group B	Group 1	Group 2	Group 3
Duration (d)	144	144	234	234	234
Mean water temperature (°C)	26.5	22.9	22.2	22.1	22.2
Mean dissolved oxygen (mg l^{-1})	6.9	7.2	7.7	7.6	7.9
Survival rate (%)	83.2	91.5	74.6	81.2	78.9
Initial body weight (W_i, g) (SD)	1.9 (0.4)	1.9 (0.4)	16.1 (3.8)	29.6 (6.4)	48.3 (12.3)
Final body weight (W_f, g) (SD)	27.7 (20.4)	24.2 (14.4)	124.2 (61.8)	178.3 (71.9)	261.5 (86.5)
Mean biomass (kg m^{-3})	9.1	8.8	17.6	40.0	38.7
Mean fish density (fish m^{-2})	158	166	71	52	34
Specific growth rate G_W (% d^{-1})	1.86	1.76	0.87	0.77	0.72
Mean growth rate (g $fish^{-1}$ d^{-1})	0.18	0.16	0.46	0.64	0.91
Mean production (kg m^{-3} d^{-1})	0.11	0.10	0.11	0.11	0.10
Mean feeding level (%)	1.7	1.7	0.9	0.8	0.7
Food conversion rate	2.82	2.95	2.92	2.73	2.65

$G_W = \frac{(\ln W_f - \ln W_i \times 100}{\text{time (d)}}$; (standard deviation)

Anova on mean body weight between groups 1-3 : F = 943.6, p < 0.05 ; df: 2 and 937)

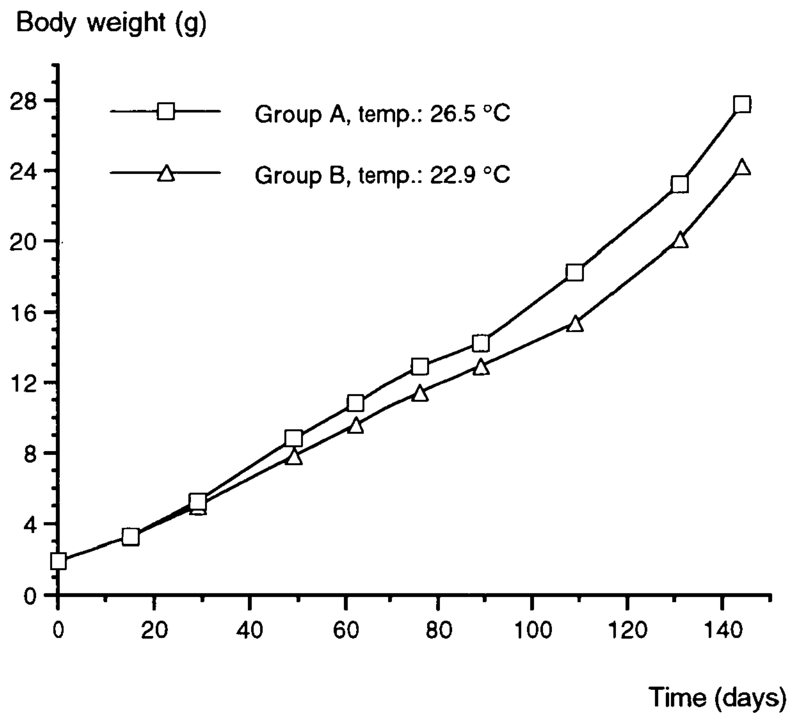

Figure 1 : Effet de la température de l'eau sur le taux de croissance de la perche en situation d'élevage intensif.

Figure 1 : Effect of water temperature on the growth rate of perch reared in intensive culture conditions.

Effect of grading and selection

Figure 2 illustrates the large variation in body weight within a perch population of the same age and origin (individual body weight from 7.1 g to 88.7 g ; n = 400). To compare the growth rate in the different size classes of this population, all perch fingerlings obtained at the end of the first trial were graded and divided into 3 groups after a two week adaptation period at 22-23 °C (Fig. 2, Table I). The initial mean body weights of the 3 fractions of the population were significantly different. The coefficients of variation of fish body weight distributions in the 3 groups ranged from 21.6 to 25.4 %.

After a 234 day rearing period at 22.2°C, there was still a significant difference between the mean body weight of the 3 groups (Anova ; F= 116.6 ; p<0.05 ; df : 2 and 297), despite high variability between individuals within each group (coefficients of variation ranging from 33.1 to 49.7 %) (Table I ; Fig. 3). This strong variability is reflected in the distribution of body weight frequencies in the 3 groups (Fig. 4). This figure also shows that the body weight distributions in the 3 groups - that were completely separated at the beginning of the grading experiment - largely overlapped after 234 days (73.7 and 63.2 % respectively for groups 2 and 3 vs group 1). The survival rates (74.6 - 81.2 %) did not differ significantly between groups (contingency table ; $\chi^2 = 3.2$; p>0.05 ; df : 2) during this experiment.

Relationships between growth rate and body weight were established for the 3 fractions of the population to compare specific growth rates :

group 1	growth rate (g $fish^{-1}$ d^{-1}) = 0.036 $W(g)^{0.633}$	$r^2 = 0.811$
group 2	growth rate (g $fish^{-1}$ d^{-1}) = 0.027 $W(g)^{0.706}$	$r^2 = 0.723$
group 3	growth rate (g $fish^{-1}$ d^{-1}) = 0.052 $W(g)^{0.587}$	$r^2 = 0.676$

with groups 1, 2 and 3 as defined in table I and W standing for mean body weight (g).

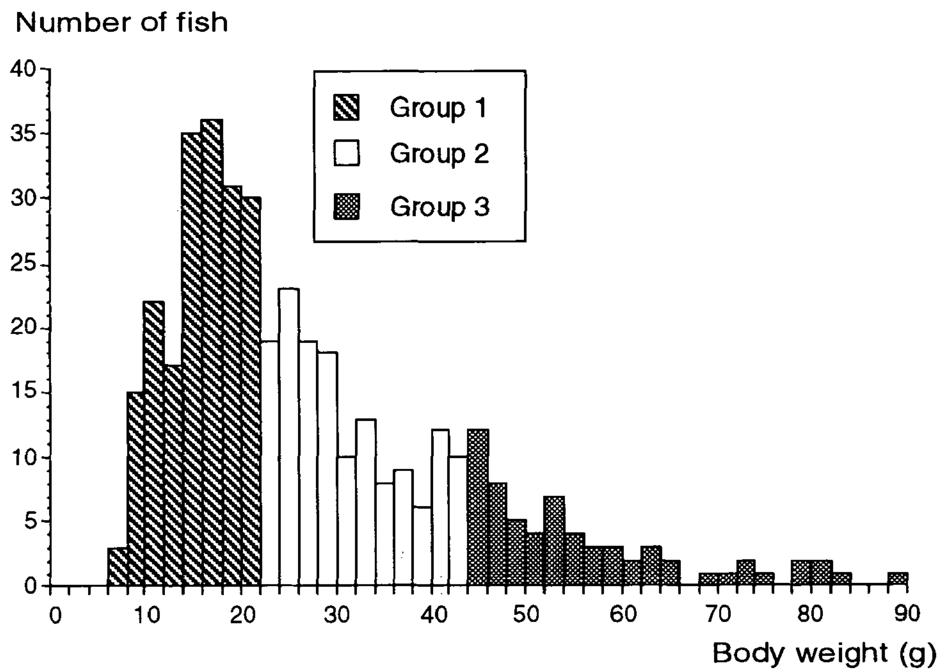

Figure 2 : Distribution des fréquences de poids corporel (g) de l'ensemble de la population (n = 400) des alevins de perche à la fin du premier essai (effet de la température). Constitution des trois groupes de poids corporels relatifs au deuxième essai.

Figure 2 : Body weight (g) frequency distribution of the whole population (n = 400) of perch fingerlings after the first experiment (different rearing temperatures) which were divided as shown into three body weight related groups for experiment 2.

After a log-log transformation of the equations, covariance analysis showed that the 3 fractions of the population had a similar growth rate and could be considered homogeneous (F = 1.2 ; df : 2 and 47). In our experimental conditions (intensive rearing, maximal feeding and T = 22.2 °C), a maximal mean growth rate of 1.36 g fish^{-1} d^{-1} was recorded with 130 g mean body weight fish.

DISCUSSION

The absence of a significant effect of temperature (22.9 to 26.5°C) on the growth rate of *P. fluviatilis* (body weight ranging from 1.9 to 27.7 g) reared in intensive conditions could result from the fact that the chosen temperatures probably were within the optimal range of temperature for perch growth. This hypothesis is supported by the observations of KARAS and THORESSON (1992) for *P. fluviatilis* in natural conditions and of HOKANSON (1977) and KITCHELL *et al.* (1977) for *P. flavescens*, who showed a maximum food consumption of perch between 23 and 28 °C. A problem that may arise at high temperatures is an infestation by *Heteropolaria sp.* observed on the fish reared at 26.5 °C while none was detected at 22.9 °C. This ciliate induced continuous mortality and may have affected growth performance in cultured perch. Optimal temperature for intensive rearing purposes should thus be chosen considering this problem.

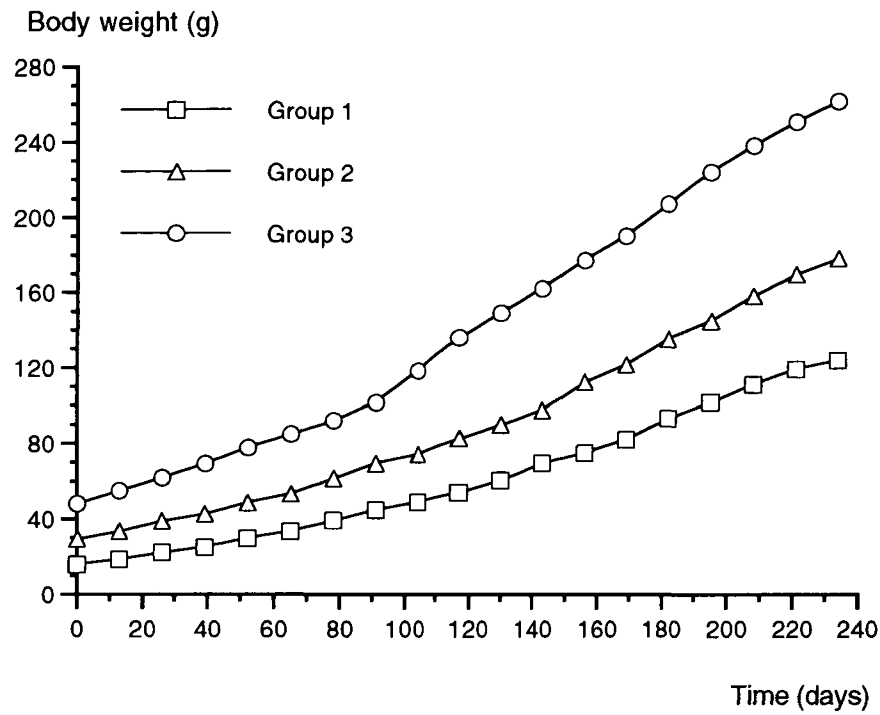

Figure 3 : Comparaison des courbes de croissance des trois fractions (groupes de poids corporels) d'une population de perches élevées en conditions intensives. Température moyenne de l'eau : 22,2 °C.

Figure 3 : Comparison between the growth curves of three fractions (body weight related groups) of a perch population reared in intensive culture conditions. Mean water temperature : 22.2 °C.

In each experiment, the variability of individual body weight in the same population was high, even after a first grading selection. In our artificial conditions, no cannibalism was recorded. Thus the cannibalism observed in natural environment (STARMACH, 1983 ; CRAIG, 1987) could not explain the variability of size and growth in our trials. As it was reported in numerous species, growth polymorphism in perch could originate from genetic and /or sexual growth dimorphism (SCHOTT *et al.*, 1978 ; CRAIG, 1987). We identified males and females in the upper fraction of the population but the precise sex-ratio was not determined. Behavioural factors like appetite, territoriality or dominance hierarchies (e.g. LI and BROCKSEN, 1977 ; JOBLING *et al.*, 1993 for salmonids), that reduce accessibility to food and increase stress, may also have an important effect on growth polymorphism. At the end of the experiment with graded fish, we observed an increase of growth polymorphism in each group and an overlapping of fish body weight distributions. These results suggest that growth polymorphism in perch does not originate exclusively from genetic characteristics : it could also be a consequence of social growth inhibition in a part of the population that could thus express more completely their growth potentialities. With respect to production standards, further experiments are needed aiming at comparing the overall growth of graded and ungraded populations : in some species (e.g. Arctic charr *Salvelinus alpinus*), frequent size-sorting does not give any marked growth gain (JOBLING and REINSNES, 1987) or may cause a deficit in growth (BAARDVIK and JOBLING, 1990 ; JOBLING *et al.*, 1993).The absence of cannibalism in intensive rearing conditions (starting from weaned 2 g fingerlings) strengthens the interest of this voracious fish for intensive culture.

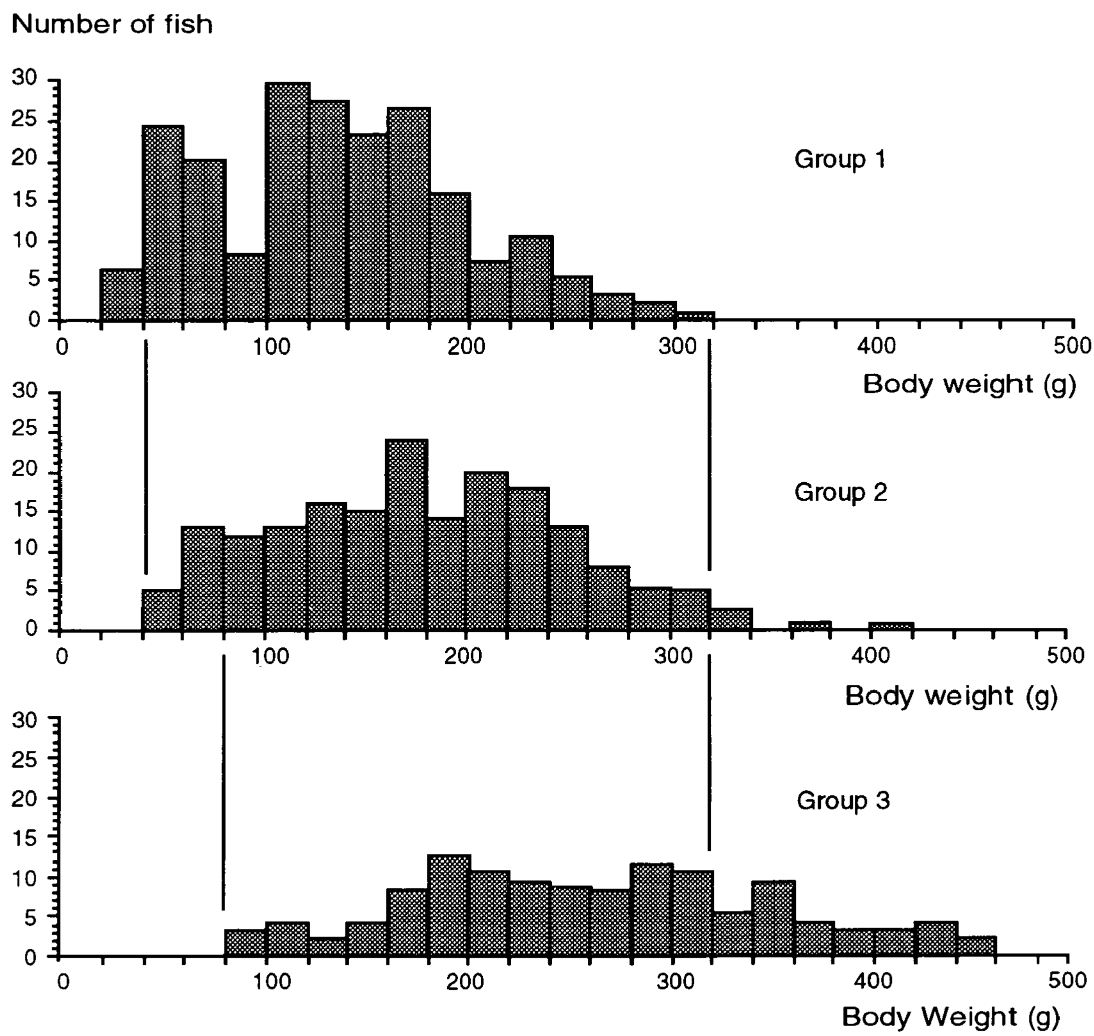

Figure 4 : Distribution des fréquences de poids corporel (g) à la fin de l'expérience (234 jours) au sein des trois fractions différentes d'une population de perches élevées en conditions intensives. Température moyenne de l'eau : 22,2 °C.

Figure 4 : Body weight (g) frequency distribution at the end of the experiment (234 days) in the three different fractions of a perch population reared in intensive culture conditions. Mean water temperature : 22.2 °C.

CONCLUSIONS AND PERSPECTIVES

These first rearing trials demonstrated the possibility of producing European perch on formulated diets, under tank intensive culture conditions. In a controlled environment at a temperature of 22.5 °C, perchs averaged 170 g in 16 months starting from the eggs (37 % of fishes above 200 g body weight). FONTAINE *et al.* (1993) obtained similar results with perch reared in a recirculating system but at very low densities. Similarly, the absence of cannibalism in intensive rearing conditions (starting from 2 g fingerlings) strengthens the interest of this voracious fish for intensive culture. Further trials conducted over a wider range of temperature (from 10 to 27 °C) and body weight (0.5 to 500 g) at different feeding levels and timings of food delivery would be necessary to establish the relationships between growth rate and these important factors. Similarly, complementary studies would be necessary to determine the individual growth response of perch to different environmental and social situations, involving wider body weight range, more frequent size grading at different stocking densities and investigation of fish behaviour under culture conditions. These experiments would allow the determination of the respective contributions of genetic characteristics and environmental factors in controlling the growth rate of perch.

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