AACL BIOFLUX

Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Variation of growth-related values within age categories and sexes in a pumpkinseed – *Lepomis gibbosus* (Linnaeus 1758), (Teleostei, Centrarchidae) - population

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Abstract. The authors propose an evaluation of a species invasion efficacy by means of comparing different methods of evaluating growth (increase in weight and length) or body condition (Fulton body condition indices, the value of relative weight – Le Cren, several combinations of relations between body weight and length or any other liniar values, as height, volume and mathematically determined body density). The values obtained from data collecting and observations were organised into three age groups and divided by sexes, highlighting the cases where a semnificant correlation between these values and the age and/or sex parameters was observed. It is supposed that a growth model which invests in rapidly achieveing sexual maturity, by an intensive body development, will be more efficient than a slow, lengthy one.

Key Words: *Lepomis gibbosus*, pumpkinseed, condition factor, body measurements, invasion success.

Resume. Les auteurs proposent une evaluation de l'invasibilite de l'especе en comparant differentes metodes de appreciation de la croissance (poids et longueur) ou de la condition corporale (l'index de condition corporale Fulton, la valeur du poids relative – Le Cren, differentes combinaissons de relations du poids et/ou longueur ou des autres valeurs mesurables liniarement, comme hauteur, ou autre fois – volume – et densite corporale apreciee par methodes mathematiques). Les valeurs obtenues sont grupee en trois categories d'age et divisees pour les sexes, en mentionant les cases ou on observe une correlation signifiante de ecs valeurs avec les parametres age et sex. On supose que un model de croissance ou la croissance jusqu'a l'age de la maturite sexuale est realise rapidement et dans une maniere intensive est plus efficient que un autre model lente, develope dans une periode longue.

Mots clés: *Lepomis gibbosus*, pumpkinseed, facteur de condition corporale, mesurements corporales, eficacite de l'invasibilite.

Rezumat. Autorii propun o evaluare a eficienţei în invazie a speciei prin compararea diferitelor metode de apreciere a creşterii (diferenţe de greutate şi lungime) sau a condiţiei corporale (Indicele de condiţie corporală Fulton, valoarea masei relative – Le Cren, diferite combinaţii de relaţii ale masei corporale şi ale lungimii sau ale altor valori măsurabile liniar, de exemplu înălţime, volum şi densitate corporală apreciată matematic). Valorile obţinute în urma efectuării măsurătorilor sunt grupate în trei categorii de vârstă şi divizate în funcţie de sex, menţionând cazurile în care se observă o corelaţie semnificativă între aceste valori şi parametrii vârstă şi/sau sex. Se presupune că un model de creştere care investeşte în atingerea rapidă a vârstei maturităţii sexuale, realizată prin dezvoltare corporală intensă are o eficienţă mai mare decât unul lent şi de lungă durată.

Cuvinte cheie: *Lepomis gibbosus*, biban-soare, factori de condiţie corporală, măsurători corporale, eficienţa în invazie.

Introduction. Considering the importance of the impact of introduced fish to non-native water bodies, which most often triggers negative impact on the indigenous fish species within the respective stream or lake, understanding the particular features that make a fish species more successful than another, or that allows a species to rapidly substitute in

the respective environment its indigenous counterpart becomes a necesity. The freshwater bodies are among the most invasible ecosystems (Moyle & Marchetti 2006), due to the fact that water bodies ensure a less fragmented continuity of habitats, if compared to terestrial ecosystems, and freshwater fish are the most invasive vertebrates, in terms of number of species (Guiterez-Estrada et al 2000) due to the increased human interest in terms of intended introductions for aquacultural/pisciculture purpose, acting thus as a transportation vector of both species of economical interest, as specified above, or „pest" species, that manage somehow (accidentally introduced with other species) to arrive in a new location. Nevertheless, one should also consider that generally, invasive species that succeed in establishing in a new area outside their native range are robust and resistant, being able to face successfully hidrochemical variations of water parameters or temperature range. This complex makes the introduction of freshwater fish species to non-native environments one of the most important threats to biodiversity and a leading cause of animal extinctions (Vitousek et al 1997; Clavero & Garcia-Berthou 2006).

We considered thus that a model study - on a sample 30 individuals caught in a single collecting action at a single time - consisting in an age-structured comparison of values belonging to all parameters involved in growth (such as length, weight, matematically expressed or physically observed/measured volume, body density, Fulton condition factor (K) and relative weight Wr - Le Cren) would provide significant data on both age and sex ratio structures at that time in the respective population and on the value of the investment in growth of each category, facilitating thus the understanding of the model employed by the species in the growth strategy (Copp et al 2004). Similar studies involving zoogeographical and behavior characteristics have already been attempted (Marchetti et al 2004ab), as well as prediction attempts using species life history and environmental tolerances to identify potential invaders similar to past invaders (Kolar 2004).

The species (*Lepomis gibbosus*) is native to North America (Upper Mississippi Basin, The Great Lakes and all the Basin of the Atlantic Ocean, from St. Lawrence to Southern Carolina). In Europe, it has been introduced in France and Germany and from there the fish spread by natural ways from the Atlantic Coast to the Danube Delta. In Romania, the species is present in almost any slow-course water body, covered in vegetation, from the Danube course, the Criș basins, the lower courses of the Siret, Bârlad and Prut rivers and all the lakes and rivers arround Bucharest (Bănărescu 1964; Gavriloaie 2008). Once established, the species is known to form associations with indigenous fauna and sometimes generate a negative impact on native species (Klaar et al 2004). We decided to study a "Nucet" population after considering several factors: a fishery is most of the time more or less confronted with the presence of nuisance species, that affect the resources of the cultured species; those nuisance species are generally introduced by accident within importation or introduction actions, or may come by natural way in the case of extensive farming. Nevertheless, once established in the respective environment, the species is far much easier to study than in an open, natural water body, due to the opportunity of correlating growth or population linked aspects to population density, food availability or water parameters variation. Another important issue is represented by the fact that the species has more restricted possibilities of escaping and invading other natural freshwater courses.

Material and Method. 30 Specimens of pumpkinseed (*Lepomis gibbosus*) were caught in November 15, 2008, by means of electrofishing devices (Lena Model) and housed for a short period of time (24 hours) at the Research and Development Pisciculture Center, Nucet - Dâmboviţa, Romania, until they were transported to the research base of the Center for Research in Taxonomy, Ichthyology and Aquaculture, within the Faculty of Biology, University of Bucharest. Collected specimens were studied alive, during the data collection period being kept in plastic containers intended for fish transportation (1.6X0.8X0.8m) and provided with air pumps; after the necessary data has been obtained, the fish were released in large concrete maintaining tanks, located within the

research base of the Center, to be subject for future studies regarding alien/invasive species.

Collected data consisted in measurements of Total Length and Height, obtained by means of calibrated photography; pictures were then processed with special designed measurement software and obtained results were introduced in Microsoft Excel sheets. Total length was measured from tip of the snout to the tip of the caudal fin, and Height was measured from the basis of the dorsal fin to the corresponding point on the other side of the fish, generally, the insertion of the abdominal fin. Weight values employed Kern digital weighing scales (Kern TEE 150 – 1, Max=150g, d=0.1g). Several scales (6-16) were extracted from each fish, in order to establish age categories; after extraction, scales from each individual were kept in Eppendorf tubes identified by numbers corresponding to pictures and to weight and volume entries. To ease the annuli reading process, the authors employed the coloration protocol described in (Burlacu et al 2008), suitable for small size species of fish and for species with small size scales. After coloration, scales were mounted between two glass slides tightly pressed against each other and fixed with adhesive tape at ends, and observed under microscope (IOR ML - 4M, Ob. 6X0.1, oc. 5X); data were further on introduced to Microsoft Excel 2003 with XLSTAT patch sheets.

There were investigated variations in length, weight, height, volume of the fish (measured as the volume of water displaced when immersed in a graded cylinder) density (calculated as mass of the fish/volume of the fish), relative weight (calculated weight /observed weight) and K (Fulton) condition factor (calculated as 100000*observed mass/Length^3) and dependant to age classes. Averages for the obtained values were further on presented and compared.

Results and Discussion. Although several age categories were identified, corresponding to growth-ring marks on the scales, only 3 were considered (age 1+, 2+, 3+) the others, represented by ages 4+ 5+ and 6+ were represented by only one individual each.

The linear regression of length and weight for the entire statistical population (n=30) showed a b (slope value) = 3.37541, which symbolizes a quicker growth in length for the respective species.

1. Length variation provided the following data:

Average length for the:

- age 1+ =59.86 mm;
- age 2+ =76.84 mm;
- age 3+ =84.09 mm;

- ΔL (age 1+; age 2+)= 16.97 mm, representing 28.3% of initial length; if reported to the period of time, the daily growth in length for the 1+-2+ age interval is of 0.04 mm per day;
- ΔL (age 2+; age 3+)= 7.25 mm, representing 9.43 % of initial length; if reported to the period of time, the daily growth in length for the 2+-3+ age interval is of 0.01 mm per day;

This leads to the conclusion that the pumpkinseed grows almost over 3 times slower in length after the second year of life.

2. Height variation results as follows:

- age 1+ (average) =17.97 mm;
- age 2+(average) =24.18 mm;
- age 3+(average) =26.62 mm;

- ΔH (age 1+; age 2+)=6.51 mm, which is 36% of initial height; the result is a 0.01mm increase in height per day;
- ΔH (age 2+; age 3+)=2.44mm, which is 10% of initial height, resulting in a 0.006 mm per day increase in height after the second year of life;

The conclusion is that the amount of growth in height is proportional to that of the growth in length, and that investment in both linear sizes varies in a similar manner, of around 4 times slower after the second year of life.

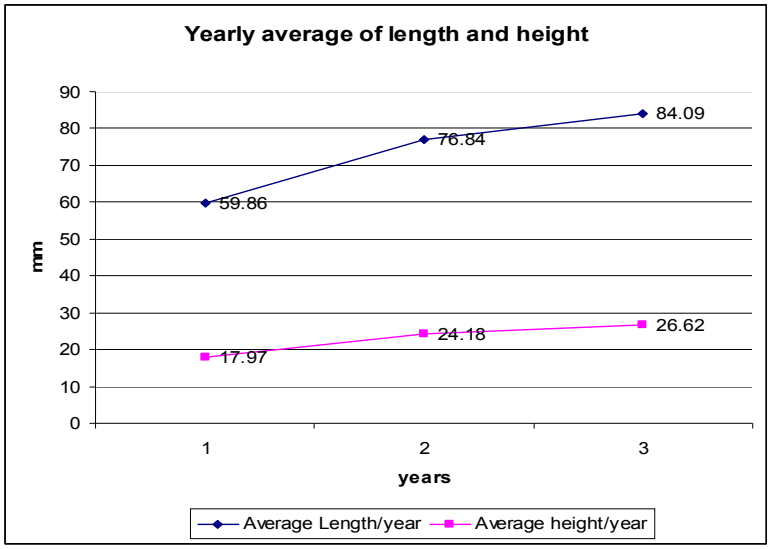

Figure 1. Variation of yearly average of length and height.

3. Weight variation results as follows:

- age 1+ (average) =2.41 g;
- age 2+(average) =5.21 g;
- age 3+(average) =7.46 g;
- ΔW (age 1+; age 2+)=2.8g, which is 116% of initial weight; results a 0.007g increase in weight per day; if translated in percents, this means a gain of 0.3% of weight per day;
- ΔW (age 2+; age 3+)=2.26 g, which is 43.36% of initial weight, resulting in a 0.006 g per day increase in weight after the second year of life; in percents, this means a gain of 0.11% of weight per day;

The results of the calculations show that weight variation is more drastic in the first year of life and still keeps a high value after the second year of life, if compared to initial values, but taken as yearly differences, the decrease towards the end of the second year is smaller (2.69 times) than that involving linear values, leading to the conclusion that investment of gain in weight is less diminished.

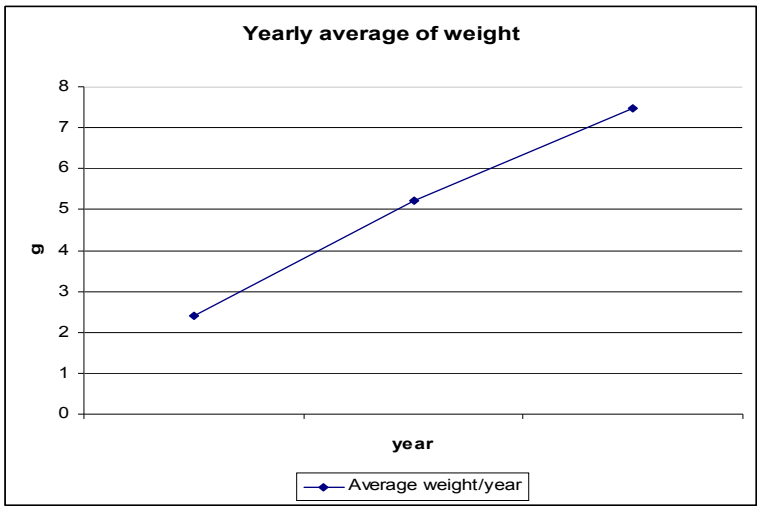

Figure 2. Variation of yearly average of weight.

Volume, measured in cubic centimeters, by means of simple immersion in water, employing graded cylinders, varied as follows:

- age 1+ (average) =2.66 cm^3;
- age 2+(average) =4.75 cm^3;
- age 3+(average) =6.57 cm^3;
- ΔV (age 1+; age 2+)=2.0 cm^3, which is 75% of initial volume;
- ΔV (age 2+; age 3+)=1.82 cm^3, which is 38.3% of initial volume;

A logical conclusion is that increase in volume is around 2 times lower in the second year of growth, preserving somehow the growth pattern of linear values (length and height), but noticeably lower that their values. For all the results presented above see also Figures 1-3.

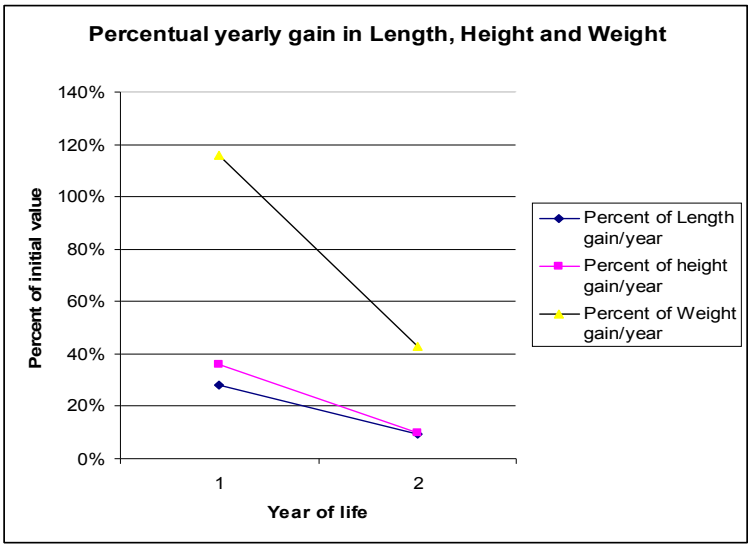

Figure 3. Percentual yearly gain in length, height and weight.

Regarding variation of the values responsible for possible interpretations of body condition, they did not vary in a significant manner.

In this respect, we considered density, as the ratio between weight and volume; considering that an organism tends to loose weight, in inappropriate life conditions, and the respective loss is made from fat reserves, if there are any, which tend to be less dense than other body structures, an increased body density would point a loss of fat, meaning a poor body condition. Density varied from 0.92 in the first year of age, to 1.10 in the second and 1.26 (g/cm^3) to the third year, showing that young fish tend to accumulate fat deposits as reserves in an increased manner during the first year of life, probably to allow them to pass unfavorable conditions over the first winter of their life.

Average Fulton (K) factor did not vary much, being included in the interval of 1 – 1.2 from the first to the third year of life.

The variation of relative weight (Wr), (described as the ratio between calculated weight (W'), obtained through linear regression of Length to Weight, and the observed weight (W) of the individual (Ureche et al 1999; Schneider et al 2000)), had low variation, being comprised between 0.98 and 1.

The constancy of the K and Wr condition factors over the life stages reflects that the species tends to keep an adequate condition over the life stages, with no significant correlation to the period of life, including thus the main growth investment, whether it is oriented towards linear (length or height) or weight gain.

In what concerns variations between sexes, females tend to be shorter than males (a total population average length of 74.5359 mm of length for males, compared to a total population average of 72.33389 for the females). Also, females tend to have a lower

height, usually representing 30% of the total length in females, while in males it may go as high as 32% of the total length. The average of the weight in males varied in their favor, being around 7.87 g for the whole study population of males, while in females it presented an average value of 5.88 g. These higher values in all measurements in the advantage of the males might be linked to the parental care behavior of the species, involving selection of larger, heavier, meaning stronger males to protect the territories where coupling and rearing of the fry takes place. The average of volume per sexes varied accordingly to linear dimensions variation, showing a 7.95 cm^3 average volume for males and a 5.15 cm^3 average volume for females. We did not notice a significant variation in what concerns the K (Fulton) condition factor, but the Wr (relative mass) showed a predisposition of increasement in the case of females. We assumed that this issue might also be related to the reproduction strategy, which involves a larger consumption of energy in males than in females. Values for the Wr in males had an average of 0.99, and in females, of 1.03.

Conclusions

- Although over the whole period of life the species shows an investment primarily focused on length, illustrated by the value of b (the slope of the linear regression), analysis of growth patterns for each age category shows a preferential investment of growth in weight over the second (1+ to 2+) year of life, which decreases after age two; an explanation for this is the fact that the length-investment of growth continues for the whole life cycle, but the weight gain is accelerated during the initial period, then drops to a constant level, which, as a sum, is inferior to the investment in length;
- The massive investment in growth during the first 3 years, prior to sexual maturation of the specimens, shows the advantage of quickly attaining a size that not only provides reproductive success of the fish (in terms of attracting the opposite sex or preserving a territory) but also ensures a size - in length and height as well as weight - that would make them less vulnerable to predators;
- A relatively premature attain of reproductive capacity (3 years, compared to indigenous fish species, that have an average of 4-6 years in reaching sexual maturity) determines the species to massively invest in growth during the first stages of life;
- The specific accelerated growth over the first and second year of life shows the non-sexual growth of the pumpkinseed, while the decrease, quite significant if related to its dimensions, in the third year of life, indicates that from that moment on, energy investment is oriented towards sexual development;
- The lower body density of younger specimens indicates the presence of larger fat deposits, which represent an advantage in overcoming the harsh conditions of their first cold seasons, when young still have small sizes and body condition decrease might have radical implications;
- Special investment in height gain for males has the purpose of protecting them from predators: being more active and more colorful, this makes them more exposed; but being higher than females advantages them in being harder to swallow by predator species;
- Differences among sexes preserve somehow the pattern of parental care perch-like fishes (Perciformes), where males tend to be larger both in size and weight than females; on one hand, this makes them more efficient in protecting their territory, and allows them higher losses of weight (higher energy consumption) and on the other hand, advantages the females by making them less exposed.

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Received: 19 January 2009. Accepted: 27 January 2009. Published: 30 January 2009.
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How to cite this article:
Burlacu L., Radu C. F., Gavriloaie I.-C., Sahlean T., Crăciun N., Bucur C., 2009 Variation of growth-related values within age categories and sexes in a pumpkinseed – *Lepomis gibbosus* (Linnaeus 1758), (Teleostei, Centrarchidae) - population.
AACL Bioflux 2(1):63-70.
Printed version: ISSN 1844-8143
Online version: ISSN 1844-9166 available at: http://www.bioflux.com.ro/docs/2009.2.63-70.pdf