TEMPERATURE INFLUENCE ON FISH ENERGETIC METABOLISM

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Abstract. Temperature represents one of the most important features at which the living organisms had to adapt in order to maintain their vital functions at an optimum level. The energetic metabolism represents the genesis and the use of potential chemical energy of the alimentary substances. The relationship between metabolism and temperature is a complex one, showing answers characteristic at different temperatures of the standard metabolism and the activity one; the metabolism of the intact fish adjusts by growing or lowering, according to the temperature changing. The study of the relationship between the oxygen consumption, as an index of the energetic metabolism, and the weight, is justified by the necessity of finding a way of a realistical appreciation of the energetic metabolism compared values at animals. Our research showed inversely proportional correlation for the same species (*Carassius auratus gibelio* BLOCH) at the same temperature (18-20^{0}C) between the weight and the intensity of the energetic metabolism as shown by the physiological index of the oxygen consumption, the achieved results confirming the well-known "law of weight". Following temperature influence on the same physiological index (the oxygen consumption) both on the food conditions and on the progressive starvation, one has concluded that by increasing the temperature, the oxygen consumption increases, with the difference of the absolute values of the oxygen consumption (at the starved fish the oxygen consumption is lower than at the normally fed fish).

Keywords: fish, temperature, energetic metabolism, food, starvation/ inanition, oxygen.

Rezumat. Influenţa temperaturii asupra metabolismului energetic la peşti. Temperatura constituie unul dintre cei mai importanţi factori de mediu la care organismele vii au trebuit să se adapteze pentru a-şi asigura menţinerea la un nivel optim al funcţiilor vitale. Metabolismul energetic reprezintă geneza şi utilizarea energiei chimice (potenţiale) a substanţelor alimentare. Relaţia dintre metabolism şi temperatură este foarte complexă, evidenţiind răspunsuri caracteristice la diferite temperaturi ale metabolismului standard şi de activitate, metabolismul peştelui intact se ajustează spre creştere sau scădere, urmând schimbarea temperaturii. Studierea relaţiei dintre consumul de oxigen, ca indice al metabolismului energetic, şi greutate, îşi vădeşte justificarea în necesitatea găsirii unei modalităţi valabile de apreciere a valorilor comparate ale metabolismului energetic în seria animală. Cercetările noastre au constatat într-o corelaţie invers proporţională pentru aceeaşi specie (*Carassius auratus gibelio* BLOCH) şi la aceeaşi temperatură (18-20^{0}C) între greutatea corporală şi intensitatea metabolismului energetic exprimat prin indicele fiziologic al consumului de oxigen, rezultatele obţinute confirmând cunoscuta „lege a taliilor". Urmărindu-se influenţa temperaturii asupra aceluiaşi indice fiziologic (consumul de oxigen) atât în condiţii de hrană cât şi de inaniţie progresivă, s-a constatat că odată cu creşterea temperaturii creşte şi consumul de oxigen, deosebirea constând în nivelul absolut al valorilor consumului de oxigen (la peştii aflaţi în inaniţie consumul de oxigen este mai scăzut decât la peştii hrăniţi normal).

Cuvinte cheie: peşti, temperatură, metabolism energetic, hrană, inaniţie, oxigen.

INTRODUCTION

Starting from the first observations of Robert Boyle (1670) (quoted by MARINESCU, 1971; DRĂGHICI, 1976) until nowadays, breathing and implicitly fish energetic metabolism represented one of the fertile fields of scientific research. In this large context, a special attention was paid to the thermic factor and to influence of its variations on the animal organism and behaviour, obtaining till now a rich informative material (BOTNARIUC & VĂDINEANU, 1982; BREZEANU & SIMON-GRUIŢĂ, 2002; BREZEANU et al., 2011; GAVRILESCU, 2008).

Temperature represents one of the most important environment features at which the living organisms had to adapt in order to maintain their vital functions at an optimum level, of course on the condition of providing the necessary food and the oxygen to the aerobic organisms. At fish, vertebrate poikilotherm organisms, one knows various regulator or adapted physiological reactions (PRECHT et al., 1973).

The energetic metabolism represents the genesis and the use of potential chemical energy of the alimentary substances. Energy is released at the cell level (especially at the mitochondria) by carbohydrate and lipid oxidation reactions and, occasionally, by protein oxidation reactions. This energy is saved at first as a highly energetic chemical link (phosphate-macroenergetic links of ATP and CP). Each cell uses ATP as a primary energy source to complete its characteristic functions, such as muscle contraction, excitability and conductivity, synaptic transmission, thermoregulation, and so on, working as real transformers of the chemical energy into mechanical osmotic thermic electrical energy, etc.

The study of the relationship between oxygen consumption, as an index of the energetic metabolism, and weight, extremely approached lately, is justified by the necessity of finding a way of a realistical appreciation of the energetic metabolism compared values at animals.

Numerous research, the oldest ones probably belonging to WELLS (1935a, b), showed that after a sudden new temperature, the intact fish metabolism adjusts by growing or lowering, according to the temperature changing. A new research of the Canadian school pointed out the idea that the relationship between the metabolism and the temperature is a complex one, showing answers characteristic at different temperatures of the standard metabolism and the activity one (DRĂGHICI, 1979).

Emphasizing the influence of heating variations on the *Carassius auratus gibelio* BLOCH capacity of oxygen consumption adjustment, ŞANTA & MARINESCU (1970) observed that the fatal effect of suddenly passing from 23.5 ^oC to 3.5^o C appears during winter after a couple of days (the oxygen consumption lowers 10 times) and after less than an hour in summer.

The living mechanisms by which fish survive the environment temperature changings, especially those which allow the capitalizing on the niche environment characteristic to every single species (the temperature interaction with others factors such as: food, season, nyctemeral rhythm, oxygen resource, light), were analysed and information regarding this can be found at different synthesis work authors (PRECHT et al., 1973; MARINESCU et al., 1994).

Temperature influences on the respiratory metabolism, both in natural variation conditions and in laboratory experiments and it represents a very important factor for fish breeding. Optimal growing rhythms, avoiding losses, which especially in the first phase of ontogenetic development can be very big, and, above all, a highly efficient food worth, are directly dependent on deep knowledge of the heating factor effect on organism (MARINESCU, 1971; PRECHT et al., 1973).

MATERIAL AND METHODS

The research have been realized on the *Carassius auratus gibelio* BLOCH because it adjusts well to captivity conditions from the aquarium, it tolerates huge temperature loggers and it is resistant to a low oxygen level, possessing a low hypoxic lethal limit. It is a species of an economic interest, spread in the Romanian internal waters.

The representatives of *C. auratus gibelio* BLOCH were from the Olt river, Slatina region, considering the physiological state, body integrity and size. The aquarium used during the intoxication experiment had 20-30 litres, possessed shaking, and aeration installations. These recipients have been cleaned and sanitized.

The fish have been introduced in the aquarium a month before starting the experiment, in order to adjust themselves to the new conditions. From the three general methods of estimating the quantity of the oxygen existing in the water (iodometric, gasometrical, polar graphic methods), in the experiment one has used the Winkler iodometric method (unmodified) as described at the end of the last century (WINKLER, 1888), being considered the safest way of estimating the quantity of the oxygen existing in the water. In order to establish the oxygen consumption, one has used the confined space technique (explained by STROGANOV, 1962), which allows us to exactly establish the right quantity used by the fish in a previously determined time, by the difference obtained between the oxygen from a witness-boll ant that achieved at the end of the experiment. All the determinations we have made on fish have been rigorously controlled.

The long-time experiments or those needing different days series have been always realized in a narrow nyctemeral limits (the same hours of the day), avoiding thus a possible circadian variation influence on the energetic metabolism.

The specimens used in different experiments have been chosen according to weight, in order to avoid or, in the contrary, emphasize the individual body weight factor. Following the achievement of some experimental conditions as close as possible to those existing in nature, one has kept and used in the experiment natural photoperiodism fish. Although a direct relationship between the energetic metabolism and the light has not been proved, one has taken into account the light importance while determining some functional conduct. A big interest had the fish manipulation effect in the pre-experimental phase, which can modify the determination results (FRY, 1957; MARINESCU, 1968, 1971). In the case of the experiments made with the confined space technique, where fish disturbance by manipulation could not be avoided, one has tried its limitation. Thus, one has chosen for the experiment low mobility species of fish (*C. auratus gibelio* BLOCH) and "blind" trials before the experiment was made.

RESULTS AND DISCUSSIONS

In a first variant experiment, the weight influence on the oxygen consumption has been followed, all process being made at room temperature (18^0 -20^{0}C) (Fig. 1). It has been established that for a 6.55 g weight it has been obtained the highest average values (244.87 ml O_2/kg/h) and at the parcel with the biggest weight, 34.58 g, there have been obtained smaller values (185.58 ml O_2/kg/h).

These results confirm the Weight Law, according to which, as other authors have shown: RUBNER (1902), MARINESCU (1971), there is reverse proportion report between the weight and the level of the metabolism expressed by the oxygen consumption index.

In figure 2, it is presented the temperature influence on the same physiological index (oxygen consumption) both in food and starvation conditions. The normally fed groups show that at 16^{0}C the average is 245.13 ml O_2/kg/h and at 20^{0}C is 282.16 ml O_2/kg/h, the oxygen consumption increasing in the same time with the temperature.

In a different variant, it has been observed the temperature influence on the oxygen consumption at fish partially starved. At 13^{0}C the oxygen consumption level has been 37.82 ml O_2/kg/h, while at 18^{0}C it has been 130.5 ml O_2/kg/h. It can be observed that together with temperature oxygen consumption has grown (MARINESCU, 2000).

One is able to notice that the temperature influence on the investigated species is present in starvation conditions, too, with the single difference of the absolute level of the oxygen consumption values (at the starved fish the oxygen consumption is lower than that of normally fed fish).

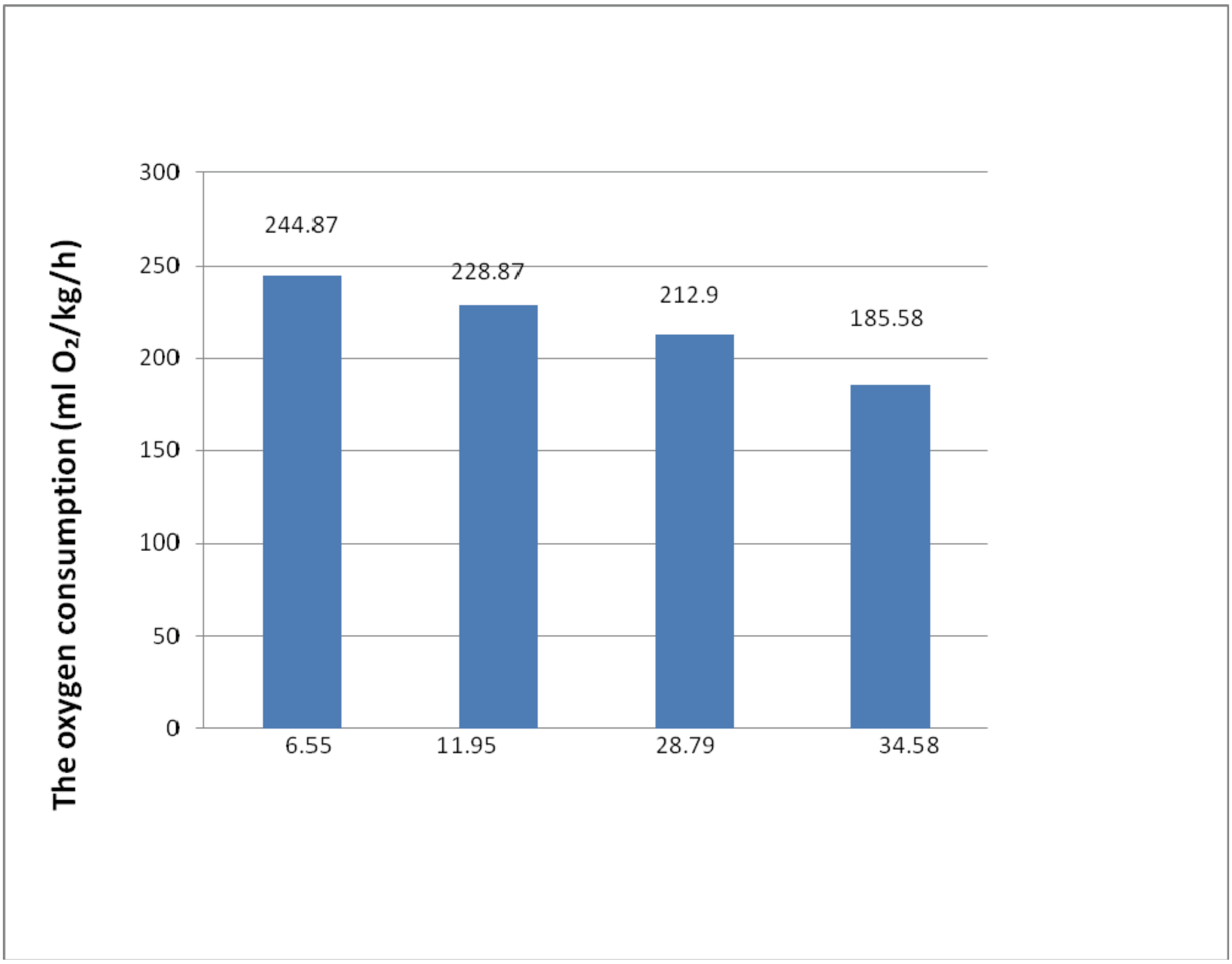

Figure 1. Weight influence on the oxygen consumption at *Carassius auratus gibelio* BLOCH.

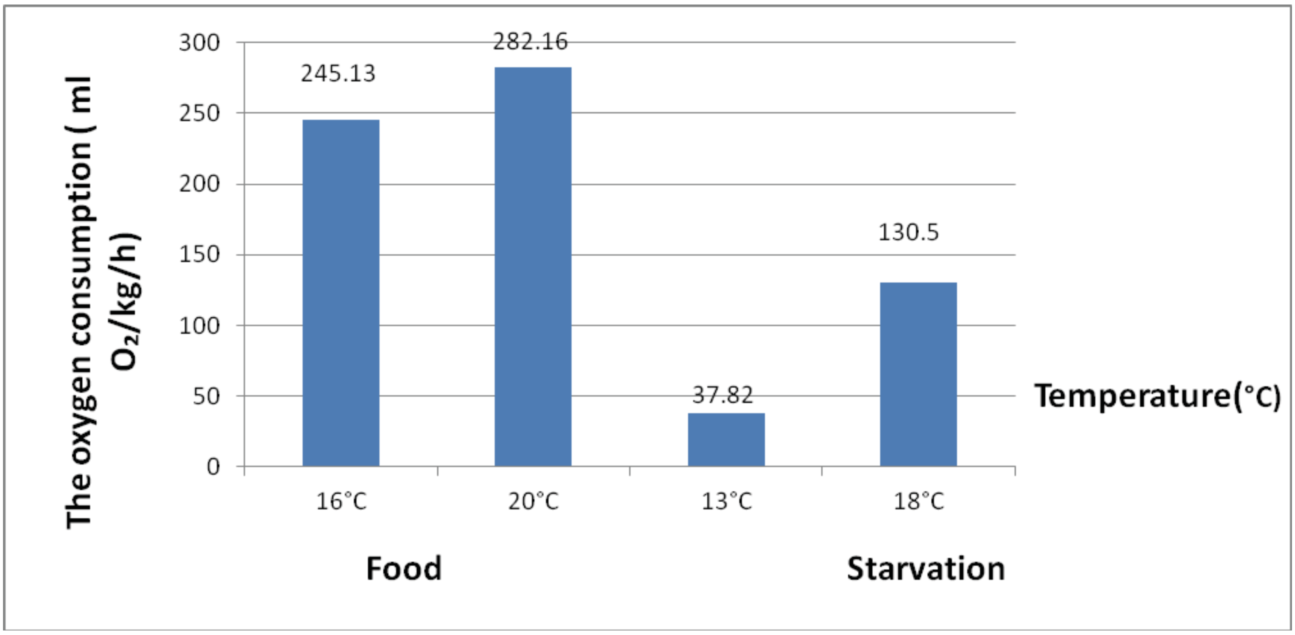

Figure 2. Temperature influence on the oxygen consumption at *Carassius auratus gibelio* BLOCH
in food and starvation conditions.

CONCLUSIONS

Our research have established a reverse correlation for the same species (*Carassius auratus gibelio* BLOCH), and at the same temperature (18-20^{0}C) between weight and energetic metabolism intensity shown by the physiological index of the oxygen consumption, the results achieved strengthening the well-known Weight Law. Thus, for weights between 6.55 and 34.58 g, it has been achieved a reverse report, the value of the oxygen consumption lowering from 244.87 to 185.58 ml O_2/kg/h. Temperature influence on the oxygen consumption at *C. auratus gibelio* BLOCH has been determined in an experimental variant both on fed fish and on progressively starved fish.

For the "food" parcel, there has been a difference at the 16^{0}C temperature (245.13 ml O2/kg/h) and 20^{0}C (282.16 ml O_2). These data are fit for the so-called normal curve of KROGH (1914). In the variant with starved specimens, for the 13^{0}C temperature it has been achieved the value 37.82 ml O_2/kg/h, while for the 18^{0}C temperature the value 130.5 ml O_2/kg/h, the oxygen consumption increasing in the same time with temperature increase.

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