ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XXI, Fasc. 2 Szczecin 1991

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Fish physiology

EFFECTS OF WATER TEMPERATURE AND pH ON SWIMMING PERFORMANCE OF CARP (*CYPRINUS CARPIO*)

WPŁYW TEMPERATURY I pH WODY NA AKTYWNOŚ ĆLOKOMOTORYCZNĄ U KARPIA (*CYPRINUS CARPIO L.*)

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Further studies on swimming performance of carp have been made in relation to temperature and pH. Under acclimation condition, swimming performance was temperature-independent. In contrast thermal stress significantly affected fish performance,- particulary at the low temperature. On the other hand, fish transferred directly to acidic conditions exhibited a sharply decline in performance, while at alkaline condition these changes were modertae.

INTRODUCTION

It is widely accepted that physiological state of aquatic organisms is continuously modified by environmental conditions. Water temperature and pH are among the most important factors and have received more attention from researches than any other factor. There is enormous literature on the physiological responses of fish to temperature changes and this including disturbances in osmotic and ionic regulation – metabolic process, growth, reproduction and behaviour (Brett, 1970; Fry and Hochachka, 1970; Fry, 1971; Hochachka and Somero, 1971).

On the other hand, pH is known to markedly affect several important physiological processes in teleosts, including release of catecholamine, osmoregulatory process and oxygen transported by the blood (Mazeaud and Mazeaud, 1981; Packer and Dunson, 1970; McWilliams, 1981).

The aim of this paper is to assess the effects of water temperature and pH on fish swimming performance under the load applied.

MATERIALS AND METHODS

Groups of carp (*Cyprinus carpio*), each weighing 84.4 ± 20.4 g on the average were brought to the laboratory and acclimated to the appropriate experimental conditions for one week. The experiments were made in a glass aquarium containing 100 liters or aerated dechlorinated tap water. Fish performance was measured with the method of Węgrzynowicz and Kłyszejko (1972).

In this method, a float of a determinated force of buoyancy was fixed to the dorsal fin. To overcome the buoyancy force of the float, the fish were constantly swimming. Four variables were recorded in the following way:

1. Swimming speed by direct measurement of the time required for the fish to swim over a gauged distance.
2. Swimming time until the signus of fatigue appeared, i.e. the fish were swimming up to the surface and remained there without any motion for some time.
3. Fish travel, as defined from the formula:

$$S = V\,T$$

where

S = fish travel (m)
V = fish speed (m/s.)
T = swimming time (s.)

4. Physical effort, is calculated from this formula:

$$L = F_w\,S\,Ctg\,\infty$$

where

L = physical effort (Kg/m)
F_w = buoyancy force of float (Kg)
S = fish travel (m)
$Ctg\alpha$ = angle between the long axis of the fish and the water surface.

The fish were divided randomly into 3 groups. The fish of the first group were kept at an acclimation temperature of 12°C and 18°C. The fish of the second group were kept at an acclimation temperature of 22°C and then abruptly transferred to 16°C and 28°C. The fish of the third group were acclimated at pH 7.2 ±0.2 and then transferred directly to pH 5.0 and 9.0. Swimming performance was recorded under the acclimation and stress conditions. To evaluate the significence of changes caused by water temperature and pH, Student's t test was used.

RESULTS AND DISCUSSION

I. Effects of water temperature

The carp acclimated at 12°C and 18°C showed the mean swimming speeds of 0.106 and 0.110 m/s.; swimming time of 8325 and 9240; fish travel of 832.5 and 976.8 m; physical effort of 41.1 and 51.5 Kg/Kg, respectively, as shown in Table 1. The increase in swimming performance the higher temperature is normally due to the increases in metabolic rate (Brett, 1964). Statistically, these changes were non-significant which mean that swimming performance under acclimation conditions is temperature-independent. The results obtained are in agreement with Blaxter and Dickson (1959); Brett (1967) who demonstrated that temperature have a minimal effect on swimming capacity. Eddy (1981) found also that acclimation to temperature within the normal environmental range generally results in small changes in blood ionic content.

Table 1

Changes in swimming performance of carp under acclimation temperature

Temperature	F_w (Kg)	S_s (m/s)	S_t (s)	F_t (m)	P_e "Kgm"
12°C	0.006	0.106	8325.0	832.5	41.1
18°C	0.006	0.110	9240.0	978.8	51.5

On the other hand, the effects of thermal stress on swimming performance are shown in Table 2. From this table we can see that, the fish acclimated at 22°C showed mean swimming speeds of 0.144 m/s.; swimming time of 7537.5 s.; fish travel of 1073.1 m and physical effort of 85.1 Kg/Kg. The fish transferred directly from 22°C to 28°C exhibited a loss of performance capability, e.g. the mean swimming speed; swimming time, fish travel; physical effort were 104.9%; 58.5%; 57.7%; 57.8%; respectively, of the control. Also, an immediate decrease in performance was

Table 2

Effects of thermal on carp swimming performance

Temperature	F_w (Kg)	S_s (m/s)	S_t (s)	F_t (m)	P_e "Kgm"
22°C	0.007	0.141	7537.5	1073.1	85.1
28°C	0.006	0.148	4410.0*	619.0*	49.2*
16°C	0.006	0.122*	2914.3*	362.4*	28.8*

observed following a decrease in water temperature to 16°C e.g. the swimming performanance was 86.5%; 38.7%; 33.8%, respectively of the control. It was suggested that the reduction in performance was caused by a disturbance in osmotic and ionic regulation (Maetz, 1972; Maetz and Evans, 1972). Statistically, these changes were significant except for the swimming speed at 28°C ($p > 0.05$).

In this study, it was evident that a sudden exposure to low temperature is more harmful than a sudden increase in temperature. This result is an accordance with Reaves et al. (1968); Stanley and Colby (1971). It was observed also that there is a direct relationship between temperature and swimming speed. This result is an agreement with Herhenradar and Hasler, (1967); Fry and Cox, (1970); Glova and McInerney, (1977); Schaefer, (1986).

II. Effects of water pH

As shown in Table 3, the carp acclimated at pH 7.2 showed mean swimming speeds of 0.144 m/s.; swimming time of 9228.3 s.; fish travel of 1266.7 m and physical effort of 100.3 Kg/Kg. An immediate decrease in performance was observed following an increase in pH directly to 9.0. The mean swimming parameters of fish

Table 3

Effects of pH on carp swimming performance

pH	F_w (Kg)	S_s (m/s)	S_t (s)	F_t (m)	P_e "Kgm"
7.2	0.006	0.144	9228.3	1266.7	100.3
9.0	0.005	0.138	9000.0	1113.6	92.6
5.0	0.005	0.136 *	570.0*	78.2 *	6.1*

F_w = buoyancy force of float.
S_s = swimming speed.
S_t = swimming time.
● = average of 8 fish.
F_t = fish travel.
P_e = physical effort.
★ = significant differences.

perrformance were 95.8%; 97.5; 87.9%; 92.3%, respectively, of the control. Statistically, these changes were non-significant, which mean that an increase of pH had a limited effect on fish performance. On the other hand, fish transferred directly from pH 7.2 to 5.0 exhibited a sharp decline in performance e.g. the mean swimming parameters of fish performance were 49.4%; 6.2%; 6.1%, respectively of the control. Statistically, these changes were significant. The results obtaioned are in accordance with Graham and Wood, (1981); MacFarlane, (1981); Hunter and Scherer, (1988).

It is suggested that impairement of swimming performance at low pH is related to a disturbance in branchial gas exchange (Packer, 1979; Ultsch et. al. (1981), as well as to hypoxia condition (Packer and Dunson, 1972).

CONCLUSIONS

1. Swimming performance under acclimation condition was temperature-independent.
2. Thermal stress significantly affect swimming performance, particulary at low temperature.
3. The fish showed a direct relationship between temperature and swimming speed.
4. At pH 9.0, there were moderate changes in swimming performance, while at pH 5.0 these changes were highly siginificant.

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WPŁYW TEMPERATURY I pH WODY NA AKTYWNOŚĆ LOKOMOTORYCZNĄ U KARPIA (*CYPRINUS CARPIO* L.)

STRESZCZENIE

Przeprowadzono badania wpływu temperatury wody i pH na aktywność lokomotoryczną u karpia, przy zastosowaniu metody obciążenia ryb ogólnym wysiłkiem fizycznym.

U ryb aklimowanych nie stwierdzono istotnych różnic w zakresie aktywności lokomotorycznej, natomiast u ryb poddanych stresowi termicznemu (28°C ← 22°C → 16°C) wystąpiły istotne zmiany, szczególnie w przypadku obniżenia temperatury. Ryby przebywające w wodzie o podwyższonym pH różnic nie wykazywały, zaś przetrzymywane w obniżonym pH = 5 zareagowały znacznym obniżeniem aktywności.

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Received: 1990.11.13