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Effect of Detergent on the Response to Temperature and Growth of Grass Carp, *Ctenopharyngodon idella*

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The increase in urbanization in the last decades has produced an increase in discharges of domestic and industrial residues. During this period, detergents have become a severe problem in aquatic systems. These substances are rarely found in concentrations lethal to aquatic organisms; however, they cause stress and interfere with their fitness.

Sublethal concentrations of surfactants harm the gill epithelium of fish by changing the lipid composition of the tissue and affecting the production of mucus. They also partially destroy the epithelium chloride cells (Schmid and Mann 1961; Abel and Skidmore 1974). The deterioration of the gill epithelium alters the respiratory function and the hydromineral balance in these organisms (Rosas et al. 1988). The presence of detergents in the environment has also been seen to harm the peripheral nerve receptors of fish which in turn causes changes in feeding and thermoregulatory behavior (Bardach et al. 1965; Olgivie and Anderson 1965). Changes in the energy balance of Ctenopharyngodon idella (Val.) subjected to sublethal concentration of detergents have been recently reported (Espina et al. 1986). These responses together with selection and avoidance of temperature have survival value as they affect the functional relationships between the organism and its environment, and are ecologically meaningful as a result (Sprague 1971; Prosser and Nelson 1981).

Several authors have observed changes in the selection of, as well as in the tolerance to temperature on the part of fish subjected to sublethal concentrations of contaminating agents. However, little is known about the effect of detergents on fish responses. The effect of a detergent of domestic use on the thermic responses of the juveniles of the herbivorous carp C. idella was

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evaluated in this work.

This species was selected as a test organism because of its importance in aquaculture in this country.

MATERIALS AND METHODS

Juveniles of the herbivorous carp C. idella (1.03-2.60 g wet weight) obtained from a commercial hatchery were kept in the laboratory in glass aquaria at a density of ten fish per 30 L, in dechlorinated, aereated water with an alkalinity of 136-139 mg $CaCO_3$/L. Fish were maintained at 24 $\pm$ 1°C for 1 wk after which the temperature was raised 1°C/per day up to 29 $\pm$ 1°C. This temperature is directly related to the carp's thermal preferendum when measured against a horizontal gradient in the laboratory (Alcaraz 1989). Fish were fed (8% of their body weight per day) ground carp pellets combined with lucern (75:25). Photoperiod was maintained at 12 h of light:12 h of darkness.

Sublethal concentrations of commercial detergent (41.9% sodium alkyl aryl sulphonate, AAS) of 0.0 (control), 5.0, 8.0 and 12.6 mg/L were used. Thirty fish were exposed (21-25 d) in separate 30 L aereated aquaria at 29°C, and two thirds of the water volume was changed daily after feeding (Espina et al. 1986).

Behavioral responses of fish to temperature were evaluated along a horizontal thermal gradient (Alcaraz 1989). Gradient was established in an asbestos tube. Fish were introduced into the gradient (19-38°C) sector at a temperature similar to that of acclimation (29°C) and observations started 40 min later. The fish positions along the thermal gradient and the temperature were recorded for the control and experimental groups every 10 min for approximately 3 hr. Five carps were measured at a time. Four replications of each treatment were conducted (n=80) at the same time of day in order to avoid diel fluctuation effects on fish preferenda.

Superior incipient lethal temperature (SILT) was established according to Kilgour et al. (1985) to evaluate thermal tolerance of the juvenile grass carps, which is the same temperature at which 50% of the test fish died. Ten fish of all experimental conditions were abruptly transfered from water at 29°C to aereated water baths at seven different temperatures. Fish that remained alive for more than 120 min were discarded. Resistance times were registered for individual fish in each bath. Data were used to calculate mortification rates according to the above mentioned authors.

Growth rates from fish subjected to different detergent concentrations (0, 5, 8 and 12.6 mg/L), were calculated from the difference between the initial and the final wet weight after 21 days. Values were expressed as mg/day.

For the statistical analysis, median values of fish thermal preference and confidence intervals (95%) were calculated using the STATGRAPHICS statistical program (1985). This program also facilitated calculation of the regression line parameters fitted by the least squares method used in the SILT calculation. In order to identify significant differences the Kruskal-Wallis non parametric test was carried out (Zar 1974).

RESULTS AND DISCUSSION

A survival of 100% was registered during the maintenance period as well as during the time the fish were subjected to the different detergent concentrations. However, exposure (21 d) to the detergent affected growth and changed the responses to temperature of the juveniles of the herbivorous carp C. idella.

The final temperature preferendum of the unexposed fish measured by the acute method was 29°C. A tendency to prefer higher temperatures as the detergent concentration in the environment increased was observed (Table 1), although only at the greatest concentration were the differences between the control group and the other experimental groups significant ($P < 0.05$).

Superior incipient lethal temperature (SILT) of C. idella subjected to the detergent significantly decreased ($P < 0.05$) with an increase in the detergent concentration in the environment (Table 1). The value of SILT was different from that of the control at each concentration ($P < 0.05$).

There were not any differences in the initial fish weight of control and experimental groups ($P>0.05$). The growth rate (mg/day) of the fish in the control group was significantly greater ($P<0.05$) than that of the carps subjected to the contaminating agent (Table 2). Among these it was possible to observe an important decrease in growth when the detergent concentration increased. For the control group a 31% increase in weight was registered in 21 d, in contrast a 16% increase in weight the carps subjected to a concentration of 5 mg/L of detergent, and a 4.7 and 3.7% increase in weight those subjected to the greatest concentrations (8 and 12.6 mg/L).

Table 1. Median values and 95% confidence limits of preferred temperature (PT) and superor incipient lethal temperature (°C) of C. idella exposed 21 d to different detergent concentrations (mg/L). Number of fishes in parentheses.

Detergent	PT	SILT
0.0	30.00	39.50
	29.7 - 30.3	39.2 - 39.8
	(20)	(10)
5.0	30.97	36.80
	30.5 - 31.4	* 36.6 - 37.0
	(20)	(10)
8.0	30.00	38.60
	29.6 - 30.4	* 38.1 - 39.1
	(20)	(10)
12.6	31.50	35.40
	* 31.2 - 31.8	* 35.2 - 35.6
	(20)	(10)

The significant differences ($P < 0.05$) are marked with an asterisk (*).

The thermal preferences of ectothermic organisms characterize their capacity to respond to the directing influence of temperature. Reynolds and Casterlin (1977) have mentioned that fish, together with other vertebrates, exhibit this capacity by occupying a narrow range when placed in an ample thermal gradient in the laboratory. This is interpreted as a reflection of the precision of thermoregulator behavior. Any change in the favorite temperature of the fish serves as an indicator of alterations caused by changes in the environment, such as thermal stress or the presence of pesticides (Olgivie and Anderson 1965). This latter is due to the precision and specificity of thermoselection in fish. The above mentioned authors demonstrated that salmon (Salmo salar) selects lower or higher temperatures when subjected to DDT depending on whether the concentration of the contaminating agent is high or low. Peterson (1973) proved that S. salar preferred temperatures 5 to 7°C higher than the controls when subjected to the greater concentrations of several pesticides, and observed similar effects in Salvelinus fontinalis.

The juveniles of the herbivorous carp selected temperatures higher than those at which the animals acclimatized. The acute preferendum that characterized thermoselection was 29°C. The value of the selected temperature increased as the detergent concentration in the environment increased. A concentration of 12.6 mg/L of active agent brought about significant ($P < 0.05$)

differences with respect to the control. This is

Table 2. Growth rate (mg/day) of C. idella exposed to different detergent concentration for 21 days (mean values). N = number of organisms.

Detergent	N	Initial weight (g)	Final weight (g)	/weight (mg/day)	
0.0	30	1.35	1.77	20.00	
5.0	30	1.68	1.95	12.86	*
8.0	30	1.69	1.77	3.81	*
12.6	30	1.34	1.39	2.38	*

The significant differences ($P < 0.05$) are marked with an asterisk (*).

interpreted as a symptom of stress since the preferred temperature represents the thermal gradient interval in which the fish carry out their functions more efficiently (Kellog and Gift 1983). The difference was only of 1.5°C but indicated thermal disorientation.

Fish growth rate was calculated in order to establish the degree of stress caused by the detergent, as growth responds specially well to the selected temperature. Compared with the control, a 36.9% decrease in the growth rate of fish subjected to the lesser concentration and a decrease greater than 88% in that fish subjected to the greater concentration were registered. In a previous paper (Espina et al. 1986) the energy balance of juveniles of C. idella was found to be altered by alkyl aryl sulphonate.

The difference between the selected temperature and the SILT is 9.5 °C in the control groups of juveniles of C. idella and it decreases to 5.8 °C and to 3.9 °C at the lower and higher concentration of the contaminating agent respectively. The effect of the detergent is also evident in the decrease in the superior incipient lethal temperature, and this decrease depends on the concentration of the detergent in the environment.

The exposure of the organisms to sublethal concentrations of detergent altered the responses to the directing influence of temperature as well as temperature acts as a modulating factor.

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REFERENCES

Abel PD, Skidmore JF (1974) Toxic effects of an anionic detergent on the gills of rainbow trout. Water Res 9:759-765

Alcaraz, G (1989) Alteraciones producidas por el detergente en las respuestas fisiológicas y de mportamiento en la carpa herbívora Ctenopharyngodon idella en relación con la temperatura. Tesis de Licenciatura. Facultad de Ciencias Universidad Nacional Autónoma de México, 38 pp

American Public Health Association (1985) Standard Methods for Examination of Water and Waste Water 16th ed, Washington, DC 1266 pp

Bardach JE, Fujiya M, Holl A (1965) Detergent: Effect on the chemical senses of the fish Ictalurus natialis (Le Suer). Science 148:1605-1607

Espina S, Díaz F, Rosas C, Rosas I (1986) Influencia del detergente sobre el balance energético de Ctenopharyngodon idella a través de un bioensayo crónico. Contam Ambient 2:25-37

Kilgour DM, McCauley RW, Kwain W (1985) Modeling the lethal effects of high temperature on fish. Can J Fish Aquat Sci 42:947-951

Kellog R, Gift R (1983) Relationship between optimum temperatures for growth and preferred temperatures for the young of four fishes. Trans Amer Fish Soc 12:424-430

Olgivie DM, Anderson JM (1965) Effect of DDT on temperature selection by young atlantic salmon, Salmo salar. J Fish Res Bd Can 22:503-512

Peterson RH (1973) Temperature selection of Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) as influenced by various chlorinated hydrocarbons. J Fish Res Bd Can 30:1091-1097

Prosser CL, Nelson DO (1981) The role of nervous system in temperature adaptation of poikilotherms. Ann Rev Physiol 43:281-300

Reynolds WW, Casterlin ME (1979) Behavioral thermoregulation and the "Final Preferendum" paradigm. Amer Zool 19:211-224

Rosas C, Espina S, Díaz F, Curts J, Rosas I (1988) Effect of sublethal detergent upon gill permeability of Ctenopharyngodon idella (Pisces, Cyprinidae). Water Air and Soil Poll 42:253-260

Schmid OJ, Mann H (1961) Action of a detergent (Dodecylbenzene-sulphonate) on the gills of the trout. Nature 192

Sprague JB (1971) Measurement of pollutant toxicity to fish. III- Sublethal effects of "safe" concentration. Water Res 5:245-266

Zar JH (1974) Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, NJ 619 pp

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