Bernard KŁYSZEJKO

Fish physiology

INFLUENCE OF AMMONIA ON PERFORMANCE ABILITY
OF THE COMMON BREAM (*ABRAMIS BRAMA* L.)

WPLYW AMONIAKU NA AKTYWNY WYSILEK LESZCZA
(*ABRAMIS BRAMA* L.)

Department of Fish Physiology, Agricultural University of Szczecin, Poland

Influence of NH_3 in doses of 0.1–0.5 mg/dm³ on performance ability of the common bream was studied at 15 and 20°C using a method of burdening the fish with predetermined physical effort. The ergometric readings revealed, that within the range of 0.12–0.13 mg of NH_3 /dm³ there was no effect of ammonia on lowering the performance ability of the fish. Within the concentration range of 0.37–0.39 mg of NH_3 /dm³, at 15°C the value of work declined to 54% and at 20°C—to 22% of the respective values of control group.

INTRODUCTION

Ammonia originating from urea—the ultimate product of protein metabolism—occurs in small amounts in aquatic environment. It breaks down to nitrates in the process of nitrification and it does not pose a threat to fishes. Among the sources that may contribute to elevated concentrations of ammonia in water are: sewage—particularly municipal and agricultural—and too-intensive nitrogen-phosphorus fertilization—in the conditions of pond culture (Kempińska 1968; Lloyd 1971).

Ammonia in water occurs in balance with ammonium ion ($\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$) and in higher concentrations it is highly toxic to fishes. Undissociated ammonia is harmful to fishes and its percentage in the overall content of ammonia is determined chiefly by pH and the water temperature (Batters and Pinching 1950; Lloyd 1971; Trussel 1972).

The highest sensitivity for ammonia is exhibited by salmonid fishes (lethal concentration 0.12–1.1 mg NH_3 /dm³). More resistant are non-salmonid fishes. The lethal concentration determined for them—dependant on the species, developmental phase, and chemical parameters of aquatic environment—are within the range of 0.28–0.5 mg NH_3 /dm³ (Ball 1967; Peterson 1974).

Direct reaction of fishes for increased content of ammonia in the environment is demonstrated by signs of distress (motional activation, accelerated pace of respiration, touching the water surface, enhanced mucous secretion, and other signs) which are similar as the symptoms of other toxicant action (Grindley 1946; Flis 1968 a, b; Kłyszczko 1992). Longer exposure of fishes to ammonia, lasting several days or weeks, caused perturbations in hormonal processes (Ball 1967; Donaldson 1981), qualitative changes of free amino acids in the brain and muscles (Levi et al. 1974; Knapp and Wieser 1981; Dąbrowska and Własow 1986), perturbations in water exchange (Lloyd and Orr 1969; Arillo et al. 1981), decrease in erythrocyte count (Redner and Stickney 1979), necrotic and histopathologic changes in the gills, skin, kidney, liver, and alimentary tract (Flis 1968 b; Lloyd 1971; Smart 1976) and it caused elevated susceptibility of fishes to bacterial diseases (Ferguson 1992).

The aim of the present paper was to study the impact of ammonia on the functional reaction of common bream expressed in physical performance ability. Impact of the sub-lethal and lethal concentrations of ammonia was studied. According to Ball (1967) the lethal concentration for this species is $0.5 \text{ mg NH}_3/\text{dm}^3$.

The experiments were conducted at 15 and 20°C using a physical performance test, which can be useful when prompt assessment of the impact of toxic factors is necessary (Węgrzynowicz et al. 1975; Kłyszczko 1992).

MATERIAL AND METHODS

The experiments were performed in spring on 156 common bream, weighing 390–450 g. The fish came from Dąbie Lake near Szczecin. The bream were placed in 200-dm^3 glass tanks with automatic regulation of the temperature and constant aeration system of the water.

The source of ammonia was ammonia water (NH_3 aqua pro analysis) containing 246 mg of NH_3/cm^3 .

Required concentration of NH_3 in experimental aquarium was obtained through adding the right amount of ammonia water on the beginning of each experiment.

The concentration of general ammonia was determined using the method of direct nesslerization (Hermanowicz 1976), while the concentrations of non-ionized ammonia was calculated from the formula developed by Lloyd et al. (1971)

$$\text{NH}_3 = \frac{100}{1 + \text{antilog}(\text{pka} - \text{pH})} (\%)$$

where: pka—water dissociation constant

Analysis of the impact of ammonia on the bream was based on a physical performance test (Węgrzynowicz and Kłyszajko 1972 a). The test involved fixation to the base of the dorsal fin a float of a predetermined displacement force. Defense reflex against pulling towards the surface, forces the fish to perform a work, the can be calculated based on the following formula:

$$L = F_w \cdot s \cdot \operatorname{ctg} \alpha \cdot 9.807 \text{ (J)}$$

where:

F_w —displacement force of the float (N)

s —distance covered by the fish

α —angle between the surface and longitudinal axis of the fish

Experiments were preceded by the empirical determination of the norm for a workload in clean water. It is reflected by coefficient R , which can be calculated according to the following formula:

$$R = \frac{F_w \text{ (N)} 100}{\text{fish weight (kg)}} (\%)$$

where: F_w —maximal displacement force of the float, which can be overbalanced by a fish for 2 hours without signs of fatigue in clean water (Węgrzynowicz and Kłyszajko 1972 b).

The fish were used for experiments only once. Level of the statistical variability of the acquired results was measured using t-Student test at the confidence level of $Q = 0.95$.

RESULTS

All the results are presented in Tab. 1. A total as 30 randomly selected fish served for empirical determination of the norm of workload. This included two control groups: one studied at 15°C and the other—at 20°C. The highest value of the coefficient R —as it was determined through gradual increase of the displacement force of the float permitting constant 2-hour action of the fish without signs of fatigue—was 3.9%. Under such load the fish were moving at average speed of 0.125 m/s, inclined against the surface at an angle of $20 \pm 2^\circ$ which represented a work of 851.9 J/kg of body weight /2h at 15°C and 748.9 J/kg of body weight /2h at 20°C.

The presently determined coefficient $R = 3.9\%$ was assumed as a work load norm and the values of work determined for the control groups were assumed as 100% values of work possible at 15°C and 20°C.

Test results of the impact of ammonia on the bream revealed that concentrations of 0.12–0.13 mg NH_3/dm^3 did not cause statistically significant value changes of the work performed at 15°C nor 20°C. Lowering the physical performance ability of the fish was

observed for the concentrations exceeding $0.2 \text{ mg NH}_3/\text{dm}^3$. Within the concentration range of $0.37\text{--}0.39 \text{ mg NH}_3/\text{dm}^3$ the value of work at 15°C decreased to 54% of the norm established in the control groups. At 20°C it was as low as 25% of the norm. The lethal concentrations ($0.48\text{--}0.51 \text{ mg NH}_3/\text{dm}^3$) lowered the performance ability of the fish to 15% at 15°C and to 6% of the norm at 20°C .

Table 1

The effect of ammonia on performance ability of common bream (*Abramis brama* L.)

Water	Number of fish	Ammonium in water		Work performed	
		H4 + NH3 ($\text{mg}/\text{dm}^3 \pm \text{SD}$)	NH3 calculated ($\text{mg}/\text{dm}^3 \pm \text{SD}$)	(J/kg of body weight/2h $\pm \text{SD}$)	%
Temperature $15 \pm 1^\circ\text{C}$ O ₂ $9.5\text{--}9.7 \text{ mg}/\text{dm}^3$ pH $8.1\text{--}8.2$	15	0.2 ± 0.07	0.006	851.9 ± 22.3	100*
	15	3.7 ± 0.21	0.12	834.6 ± 19.8	98**
	14	6.0 ± 0.30	0.25	792.3 ± 17.3	93
	16	8.9 ± 0.61	0.37	460.0 ± 17.3	54
	16	15.2 ± 1.26	0.48	127.7 ± 34.7	15
Temperature $20 \pm 1^\circ\text{C}$ O ₂ $8.2\text{--}8.9 \text{ mg}/\text{dm}^3$ pH $8.2\text{--}8.4$	15	0.3 ± 0.09	0.007	748.9 ± 18.3	100*
	14	1.8 ± 0.11	0.13	741.8 ± 21.2	99**
	17	3.7 ± 0.23	0.24	647.4 ± 25.8	86
	18	5.5 ± 0.45	0.39	187.4 ± 32.1	25
	16	5.8 ± 0.61	0.51	42.6 ± 11.4	6

* - control group.

** - statistic insignificance (in comparison to control group).

SD- standard deviation.

DISCUSSION

The present results confirmed earlier findings (Kłyszajko 1992; Węgrzynowicz and Kłyszajko 1972 a, b), that physical performance potential in the conditions of clean, aerated water is not constant for the same experimental material and it depends on the temperature. In the case of the bream, the value of work (Tab. 1) decreased by 12 percentage points (851.9 to 748.9 J/kg of body weight /2h. along the increase of the temperature from 15 to 20°C . It seems that the direct cause of the worsening of the performance can be an increased oxygen demand accompanied by a lowering of the efficiency of the compensatory respiratory mechanisms, that occur in fishes when the water temperature rises (Schenker et al. 1967; Crawshaw 1976; Crawshaw 1977).

The common bream has been assigned to the group of fishes less sensitive for ammonia and thus the lethal concentration for this species ($\text{LC}_{50/48 \text{ h}}$) is $0.5 \text{ mg NH}_3/\text{dm}^3$ (Ball 1967). The test carried out in the present work revealed statistically significant lowering of the physical performance potential of the bream when the concentration of ammonia in the water reached values about $0.2 \text{ mg NH}_3/\text{dm}^3$. While approaching the lethal con-

centrations, the value of work declined and this change was more distinct at 20°C compared to the values at 15°C (Tab. 1).

The results of the test confirmed indirectly high toxicity of ammonia stated in the other studies (Schenker et al. 1967; Flis 1968 a, b; Arillo et al. 1981; Donaldson 1981).

The method used permitted also demonstration how ammonia influences motional reaction within the range of sub-lethal concentrations.

CONCLUSIONS

1. Physical performance of the common bream in clean water declines by 12 ± 2 percentage points along with the water temperature increase from 15 to 20°C.
2. Ammonia concentrations within 0.25–0.48 mg NH₃/dm³ (temp. 15°C) and within 0.24–0.51 mg NH₃/dm³ (temp. 20°C) lowers the physical performance potential of the bream from 93 to 15% and from 86 to 5% respectively compared to the norms determined in clean water.

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Bernard KŁYSZEJKO

WPŁYW AMONIAKU NA AKTYWNY WYSIŁEK LESZCZA (*ABRAMIS BRAMA* L.)

STRESZCZENIE

Leszcze o masie 390–450 g poddano testowi wysiłkowemu w stężeniach 0,12–0,51 mg NH_3/dm^3 (niezdysocjowanego amoniaku) w temperaturze 15 i 20°C. Zastosowano metodę własną obciążania ryb aktywnym wysiłkiem fizycznym.

Stwierdzono, że natychmiastową reakcją ryb był spadek możliwości wysiłkowych proporcjonalny do wzrostu stężenia amoniaku i wzrostu temperatury wody. W temperaturze 15°C, w porównaniu z normą ustaloną dla grupy kontrolnej (851,9 J/kg masy ciała /2h = 100%) wartość pracy w koncentracjach 0,25; 0,37 i 0,48 mg NH_3/dm^3 obniżyła się statystycznie istotnie do odpowiednio 93; 54 i 15% normy. W temperaturze 20°C (norma pracy grupy kontrolnej 748,9 J/kg masy ciała/2h = 100%) wartość pracy w koncentracjach 0,24; 0,39 i 0,51 mg NH_3/dm^3 obniżyła się statystycznie istotnie do odpowiednio 86, 25 i 5% normy.

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Author's address:

Bernard Kłyszajko PhD DSc
Associate Professor
Department of Fish Physiology,
Agricultural University of Szczecin
Kazimierza Królewicza 4, 71-550 Szczecin, Poland