Dept. of Animal Medicine,
Faculty of Vet. Med., Assiut University,
Head of Dept. Prof. Dr. M.F. Raghib.

EFFECT OF THERMAL POLLUTION ON SOME NILE FISH
(With 2 Tables)

By
A. SHEHATA
(Received at 17/3/1990)

تأثير التلوث الحرارى على بعض الأسماك النيلية

عـادل شحاتـه

تم في هذا البحث دراسة تأثير ارتفاع درجة حرارة المياه على بعض الأسماك النيلية. واظهرت النتائج أن درجات الحرارة التجنبية (AT) والبدائية المميتة العليا (ULLT) والقصوى الخطيرة (CTM) على التوالي عند درجة أقلمة ٢٤ درجة مئوية هي درجة حرارة مياه النيـــل بلغــت (٣٥، ٣٤، ٩ر٣٩م) للبلطي النيلي ، (٣٤، ٣٤، ٦ر٣٦ م) في اللبيس، (٣٤، ٣٤، ٢ر٣٨م) في الجامبوزيــا، كما أظهرت النتائج ارتفاع هذه الدرجات الحرارية بارتفاع درجة حرارة أقلمة الاسماك وبــدأت الاعراض الظاهرة على الاسماك عند التعرض للحرارة بزيادة في نشاطها العام ثم أعقبه سباحة عنيفة ثم فقدان التوازن قبل النفوق مباشرة - ومن مقارنة درجة حرارة مياه النيل عند مصب مياه التبريد لمحطة الكهرباء بأسيوط (٣٣ - ٣٥ م) ونتائج درجة الحرارة البدائية المميتة العليا وهي (٣٤ - ٣٦ م) للبلطي ، ٣٤ م لاسماك اللبيس ، ٣٤ - ٣٥ م لاسماك الجامبوزيا يتضح مدى خطورة تعرض هذه الاسماك لدرجات حرارة مياه التبريد. ودلت دراسة تأثير ارتفاع درجة الحرارة (٣٢م) على أسماك البلطـي النيلي لمدة أسبوع أن هناك تغير واضح في صورة دم الاسماك حيث سجلت النتائج ارتفاعا معنويا في كل من نسبة الهيموجلوبين وعدد كرات الدم الحمراء ومتوسط حجم الكرات (MCV) ومتوســط الهيموجلوبين في كرات الدم الحمراء (MCH). ومن مراجعة المراجع العلمية يتضح أن صورة تغير الدم وسبب النفوق في الأسماك مرتبط بالنقص الواضح في الأوكسجين الذائب في الماء نتيجة إرتفــاع درجة الحرارة وعدم قدرة الأسماك على الاستفادة منه نتيجة هذا التغير البيئي . ومما سبق يتــضح أن للتلوث الحرارى أثاره الضارة والمميتة على الأسماك التي تعتبر من من أهم مصادر الغذاء ويكمن هذا الخطر في عدم الرؤية لآثاره الضارة أو الاحساس بها.

SUMMARY

The present study was carried out to investigate the effect of high temperature levels on three species of Nile fish; Tilapia nilotica, labeo nilotica; and Gambosia affinis. The avoidance temperature (AT), critical thermal maximum (CTM), and upper incipient lethal temperature were recorded at three levels of acclimation temperature. The effect of increased temperature levels on haematological picture (Hb, RBCs count, PCV, MCV, MCH, and MCHC) of Tilapia nilotica fish for one week were investigated.

INTRODUCTION

Ecology of streams and rivers. considered factors affecting animal distribution patterns and community dynamics in running water environments.

Qualitative and quantitative changes in composition of water streams were found to be influenced by fluctuations in its thermal, hydrological, and physical characteristics.

Increased use of colding water by power generating stations and the resultant addition of waste heat to natural water has stimulated studies into the assessment of environmental effects of thermal effluents. Amongst the most numerous investigations are those defining lethal temperatures for fish (ALABASTER and DOWNING, 1966; ALABASTER and LLOYD, 1980), although other workers have investigated the full range of temperature tolerance of selected species (NEILL and MAGNUSON, 1974; KUTTY, et al. 1980).

Under laboratory conditions the lethal temperature of fish can be determined in many ways. Some workers have measured the average survival time at a given constant temperature (GIBSON, 1954) and the temperature reached at death or incapacitation when the animals are heated at a constant rate, i.e. the critical thermal maximum (CTM), as reported by LOWE and HEATH (1969) and SYLVESTER (1973).

For any particular acclimation temperature, each species of fish has a temperature range within which "existence" for an indefinite period is possible. This range has an upper limit, the thermal death-point or upper incipient lethal temperature (UILT), and the lower limit or the colling death point. Above the UILT, the fish can not live indefinitely but survives for a limited period (FRY, 1971). The length of time an animal can resist the effects of a lethal level of temperature is termed the resistance time. The resistance time shortens with a progressive rise in temperature until a point is reached at which the fish is killed instantaneously on transference from water at the acclimated temperature (BRETT, 1956).

In Assiut city, a large generating power station used water for cooling. The cooling water of the station is drained through the river Nile, and elevate the water temperature in wide area of the river. The objects of this research is to determined the critical thermal maxim (CTM) and the upper incipient lethal temperature (UILT) of three economic important Nile fish (Tilapia nilotica, Labeo nilotica and Gambosia affinis). Also some blood parameters were investigated.

MATERIAL and METHODS

Tilapia nilotica juveniles (5-10 gm), Lebeo nilotica juveniles (3-5 gm), and Gambosia affinis (1-2 gm) were used in this study. The fish were obtained from the river

Nile at Assiut governorate. Fish were acclimatized to the laboratory conditions at least two weeks before experimental testing. Teteramine fish feed (Tetra, Dr. Baensch, Malle, West Germany) was twice daily ad libidum and withold three days before introduction to bioassay to empty the gut, according to United States Department of Interior fish and Wildlife Service Report (1964).

For determining the thermal death point of each species, three levels of temperature (24, 28, 30°C) were selected for acclimating the test species. These levels of temperature which selected were within the ambient temperature variation. The test fish were acclimated in these temperature levels for a minimum of one week in the glass basin aquaria. After the temperature acclimation times were completed, ten fish from every acclimated temperature were transfered into a new aquarium with the same temperature, then water temperature was gradually increased 0.5°C every minute. The temperature at which fish showed avoidence reaction (AT), and that at which fish lost their sence of balanc (CTM) were recorded for the three juvenile types at the three acclimation temperature levels (MENASAVETA, 1981).

The UILT was determined as the temperature at which the fish could not survive more than 48 hours, but did survive for. 24 hours (MENASAVETA, 1981). For UILT determination various groups of each type (10 juveniles each) were subjected to different temperatures with range of 1°C apart. The UILT of every species were recorded.

Clinical signs of the three species of fish were reported during the whole period of the experiments.

Haematological investigation:

Tilapia nilotica fish (30-50 gm) was divided into two groups, the first group (40 fish) was subjected to temperature level of 32°C and the second group (10 fish) was at ambient temperature level of 24°C (control) for 7 days. Blood samples from every 5 fish were taken from the caudal artery after 1, 2, 3, 4, 5, 6 and 7 days.

The average of triplicate microhaematocrits were used to determine the red blood cell volume (LARSEN and SNIESZKO, 1961). Erythrocyte count and haemoglobin concentration were determined after GRADWHOI (1956).

The morphologic indices of mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated after WEINBERG, et al. (1972).

Temperature levels of river Nile water were recorded arround the drainage outlet of Assiut electric generating station.

RESULTS

The results of avoidence temperature (AT), critical thermal maximum (CTM) and upper incipient lethal temperature (UILT) were recorded in table 1. The haematological values values (RBCs count, Hb concentration, PCV, MCV, MCH, and MCHC) were recorded in table 2.

The temperature levels of river Nile water arround the outlet of Assiut electric generating station were 33-35°C. The temperature of Nile water was 24°C.

DISCUSSION

It is comparatively easy to determine that Tilapia nilotica, had the highest thermal resistance among the three examined species, Labeo nilotica the lowest with Gambosia affinice in the middle range. At the acclimation temperature (24°C) which is normally the ambient river Nile water, the AT, CTM and UILT temperatures respectively, were 35, 39.9 and 34°C for Tilapia nilotica, 34, 36.6 and 34°C for labeo nilotica and 34, 38.2 and 34°C fro Gambosia affinis.

It is evident from the data obtained in this study that, AT, CTM and UILT were affected by the acclimation temperature for all species. The same results were obtained by MENASAVETA (1981) for 24 species of fish in the sea-water of Thailand Gulf. Increased acclimation temporature resulted in increased mean AT, CTM and UILT. The clinical signs recorded in this investigation are the same observed by MENASAVETA (1981) and BETTOLI, et al. (1985).

The comparison between the high temperature levels (33-35°C) recorded at the polluted area of the river Nile, and the results of this study insured the great loss occurring in fish.

The results of haematological investigation of Tilapia nilotica fish subjected to high temperature level (32°C) for one week, revealed a significant increase in Hb concentration, RBCs count, MCV, MCH and MCHC. This change was irregular, but in case of RBCs count and MCH a constant elevation was recorded during the whole period of the experiment.

A higher temperatures oxygen solubility in water is lowered, whereas the oxygen consumption of fish is greater owing to the higher matabolic rate. Therefore, an elevation of water temperature paralleled by an increase in oxygen requirement, diminishes both available amount of oxygen in water and the efficiency of its binding with haemoglobin (KORWIN-KOSSAKOWSKI and JEZIERSKA, 1985).

The constant relation between increased temperature levels of water and hypoxia in fish, explaine the haematological response recorded in this study. This results are close to those reported by SCOTT and ROGERS (1981). Prolonged hypoxia may allow fish sufficient time to make the physiological adjustments necessary to compensat for reduced oxygen availability and eleminate the need for an increase in erythrocytes (KIRK, 1974).

It is obvious from previous research that thermal pollution has an adverse effect on fish survival, growth and hatching of eggs (KWAIN, 1975; JOBIASG, 1981 and PIPE and WALKER, 1987). In correlation the results of our study should be warned about the unnoticed dreaded effects on fish, which considered as one of the main sources of protein supplement in our food.

REFERENCES

Alabaster, J.S. and Downing, A.L. (1966): A field and laboratory investigation of the effect of heated effluents on fish. Fishery Invest., London, 6 (4): 23-35.

Alabaster, J.S. and Lloyd, R. et al. (1980): Water Quality criteria for freshwater fish. 1st ed. Boston and London: Butterworths.

Bettoli, P.W.; Neill, W.H. and Kelsch, S.W. (1985): Temperature preference and heat resistance of grass carp, bighead carp, and their F_1 hydrid. J. Fish Biol., 27: 239-247.

Brett, J.R. (1956): Some principles inthe thermal requirements of fishes. Q. Rev. Biol., 31: 75-87.

Fry, F.E.J. (1971): The effect of environmental factors on the physiology of fish. Fish Physiology. 1st ed. Vol. 6, Academic Press. London.

Gibson, M.B. (1954): Upper lethal temperature relations of the guppy, Lebistes reticulatus. Can. J. Zool., 32: 393-407.

Gradwohl, R.B.H. (1956): Clinical laboratory methods and diagnosis. 5th Ed. C.V. Mosby company St. Louis, U.S.A.

Jobiasg, M. (1981): Temperature tolerance and the final preferendum - rapid methods for assessment of optimum growth temperature. J. Fish. Biol., 19: 439-455.

Kirk, W.L. (1974): The effects of hypoxia on certain blood and tissue electrolytes of channel catfish, Ictalurus punctatus (Rafinesque). Trans. Am. Fish Soc., 103: 593-600.

Korwin-Kossakowski, M. and Jezierska, B. (1985): The effect of temperature on survival of carp fry, Cyprinus carpio L., in acidic water. J. Fish Biol., 26: 43-47.

Kutty, M.N.; Sukumaran, N. and Kasim, H.M. (1980): Influence of temperature and salinity on survival of the freshwater mullet, Rhinomugil corsula (Hamilton). Aquaculture. 20: 261-274.

Kwain, W. (1975): Effect of temperature on development and survival of rainbow trout, Salmo gairdreri, in acid waters. J. Fish Res. Bd. Can., 32: 493-497.

Larsen, H.N. and Snieszko, S.F. (1961): Modification of the microhematocrit technique with trout blood. Trans. Am. Fish. Soc., 90: 139-142.

Lowe, C.H. and Heath, W.G. (1969): Behavioral and physiological responses to temperature in the desert pupfish. Physiol. Zool., 42: 53-59.

Menasaveta, P. (1981): Lethal temperature of marine fishes of the Gulf of Thailand. J. Fish Biol., 18: 603-607.

Neill, W.H. and Magnuson, J.J. (1974): distributional ecology and behavioral thermo-regulation of fish in relation to heated effluent from a power plant at lake Monona, Wisconsin. Trans. Am. Fish Soc., 103: 663-710.

Pipe, R.K. and Walker, P. (1987): The effect of temperature on development and hatching of scad, trachurus trachurus L., eggs. J. Fish Biol., 31: 675-682.

Scott, A.L. and Rogers, W.A. (1981): Haematological effects of prolonged sublethal hypoxia on channel catfish Ictalurus punctatus (Rafinesque). J. Fish. Biol., 18: 591-601.

Sylvester, J.R. (1973): A note on the upper lethal temperature of juvenile Haemulon flavolineatum from Virgin Island. J. Fish Biol., 5: 305-307.

Weinberg, S.R.; Siegel, C.D.; Nigrelli, R.F. and Gordon, A.S. (1972): The hematological parameters and blood cell morphology of the brown bullhead catfish. Zoologica 71-78.

United states Department of Interior Fish and Wildlife Service (1964): Procedure for evaluation of acute toxicity of pesticides to fish and wildlife.

Table (1)

Avoidance temperature (AT), cirtical thermal maximum (CTM) and upper incipient lethal temerature (UILT) at different acclimation temperatures.

Species	Acclimation temperature	AT (°C)	Range of CTM (°C)	Mean CTM (°C)	Mean UILT (°C)
Tilapia nilotica	24	35	38.0-42.0	39.9	34.0
	28	35	37.5-42.0	40.3	35.0
	30	37	39.0-42.5	40.5	36.0
Labeo nilotica	24	34	36.0-37.5	36.6	34.0
	28	36	37.5-38.0	37.6	34.0
	30	37	38.5-39.5	38.7	34.0
Gambosia affinis	24	34	37.5-39.0	38.2	34.0
	28	35	37.5-39.5	38.8	34.0
	30	36.5	39.0-41.0	39.7	35.0

Table (2)
Blood picture of (mean ± S.E.) Tilapia nilotica fish subjected to temperature level of 32°C for one week.

	Time Post-exposure (day)							Control
	1	2	3	4	5	6	7	
Hb	16.88** ± 0.639	15.9** ± 0.535	10.2 ± 0.737	8.7* ± 0.816	11.26 ± 0.557	13.52 ± 0.639	15.58** ± 0.364	11.18 ± 0.392
RBCs	2.34** ± 0.141	2.56** ± 0.115	1.93** ± 0.152	1.29** ± 0.237	1.95** ± 0.120	2.07** ± 0.241	2.95** ± 0.024	4.09 ± 0.088
PCV	24.4 ± 0.02	22.8 ± 0.49	17.4 ± 1.57	21.8 ± 3.6	23.2 ± 10.2	18.8 ± 1.02	23.6 ± 0.76	24.8 ± 2.94
MCV	104.7** ± 3.8	89.32* ± 2.39	89.64* ± 3.52	162.25** ± 20.07	126.81** ± 9.276	64.55 ± 7.21	79.80 ± 2.16	61.24 ± 8.54
MCH	72.34** ± 2.54	62.31** ± 2.37	52.79** ± 1.10	77.88** ± 16.8	57.88** ± 1.24	45.66** ± 3.46	52.68** ± 0.972	27.30 ± 0.772
MCHC	69.33* ± 2.77	69.8* ± 2.38	59.11 ± 1.56	43.32 ± 8.93	48.88 ± 3.27	72.71* ± 4.94	66.08* ± 0.605	47.9 ± 6.18

** Significant at P/ 0.01   * Significant at P/ 0.05