A C T A I C H T H Y O L O G I C A E T P I S C A T O R I A
Vol. XXI, Fasc. 1 Szczecin 1991

Mohamed Hassan MOURAD

Fish physiology

EFFECTS OF WATER TEMPERATURE ON THE ECG; HEART RATE AND RESPIRATORY RATE OF THE EEL *ANGUILLA ANGUILLA* L.

WPŁYW TEMPERATURY WODY NA ZMIANY EKG, SKURCZE SERCA ORAZ ODDYCHANIE U WĘGORZA *ANGUILLA ANGUILLA* L.

Institute of Ichthyology, Department of Fish Physiology, Academy of Agriculture, Szczecin

Studies on the effects of water temperature upon the ECG, heart rate and respiratory rate of the eel were corried out. The results prove that the ambient temperature of the eel significantly affects the circulatory and respiratory performances of the eel.

INTRODUCTION

Water temperature is one of the most important factors in the environment of aquatic organisms and has received more attention from researches than any other factor (Carins et al. 1975). Differences in temperature can affect general activity, matabolsim and behaviour of aquatic organisms in ways which expose them to the pollutants present in the water. Temperature influences also the physical and chemical state of the pollutants, the extent to which they remain in solution or suspension, their persistance and the extent to which they are broken down or deactivated. In addition, the actual rate of uptake of a toxic chemical by aquatic by the aquatic organisms may be strongly influenced by the prevailing temperature conditions. The aim of this study is to assess the effect of water temperature on the ECG, heart rate and respiratory rate of the eel.

MATERIALS AND METHODS

Individuals of eel *Anguilla anguilla* L. weighing 213.4 ± 73.3 g and measuring 50.5 ± 7.6 cm obtained from Fish Center, Szczecin were brought to the laboratory and acclimated for at least one week under the appropriate experimental conditions.

One group of fish was acclimated at 10°C and the othes at and 18°C. Water temperature was decreased to 10°C by placing ice water in a plastic bag in the aquarium. Fish electrocardiogram were obtained with the method of Labat (1966), using a single channel CGK–301 electrocardiographic apparatus and a CMK–405 cardiomonitor. The heart beats per minute were calculated from the electrocardiogram obtained. The respiratory rate per minute was calculated by counting the mandibular movements during one minute. To evaluate the significance of changes caused by the water temperature, Student's t test was used.

RESULTS

The effects of water temperature on the ECG; heart rate and respiratory rate of the eel are shown in Table 1 and illustrated in Fig. 1. From these results it can be seen that the heart rate of the eel at 10°C was 34.00 beats per minute at the paper speed of 25 mm/second. This rate increased to 38.40 beats per minute in response to the rise in water temperature to 18°C. Also, an increase in water temperature to 18°C was associated with a decrease in the duration of the P–Q, S–T, T–P segments from 0.18, 0.54, 0.53 to 0.16, 048, 0.47 millisecond respectively as well as the P–Q, Q–T, R–R intervals from 0.28, 1.04, 1.82 to 0.26, 0.92, 1.67 millisecond. On the other hand, the amplitude of the R, P, T waves decreased from 0.72, 0.05, 0.10 mv. to 0.62, 0.03, 0.08 mv. respectively, in response to the rise in water temperature to 18°C. This means that an increase in water temperature appeared to cause a decrease in the force of heart contraction (negative inotropic).

The effects of water temperature on the respiratory rate was found to be similar to those in the circulatory system i.e. the respiratory rate of the eel at 10°C was 33.00 per minute and the rate increasing to 39.80 per minute in response to the rise in water temperature to 18°C. Also, it was observed that there was an interaction between circulatory and respiratory events in the eel under the same experimental conditions, i.e. at 10°C the heart rate of the eel was 34.00 beats per minute and the resppiratory rate was 33.00 per minute.

This synchrony was also found when water temperature increased to 18°C, which means that the circulatory and respiratory events in the eel are co-ordinated. Statistically, the ECG, heart rate and respiratory rate of the eel recorded at different water temperature showed significant differences.

DISCUSSION

The results obtained from studying effects of water temperature on the ECG, heart rate and respiratory rate of the eel demonstrated that the heart rate of the eel

Table 1

The ECG's heart rate and respiratory rate of the eels under control condition and different temperatures

	Segments [mm/sec.]			Intervals [mm/sec.]			Maves [mV]			Heart rate beats/min.	Respiratory rate per min.
	P–Q	S–T	T–P	P–Q	Q–T	R–R	R	P	T		
X_1	0.180	0.540	0.530	0.280	1.040	1.820	0.720	0.050	0.100	34.000	33.000
S.D.	0.040	0.110	0.260	0.400	0.160	0.390	0.310	0.040	0.060	7.130	5.930
X_2	0.160	0.480	0.470	0.260	0.920	1.670	0.620	0.030	0.080	38.400	39.800
S.D.	0.060	0.140	0.180	0.060	0.180	0.360	0.300	0.040	0.050	10.460	7.960
T	2.108	2.711	2.108	2.108	4.216	2.635	2.108	3.162	2.530	2.660	5.403

X_1: Average of 40 fish at 10°C
X_2: Average of 40 fish at 18°C
S.D.: Standard deviation
T: Computed "t"
Critical "t" at 5% level = 2.021

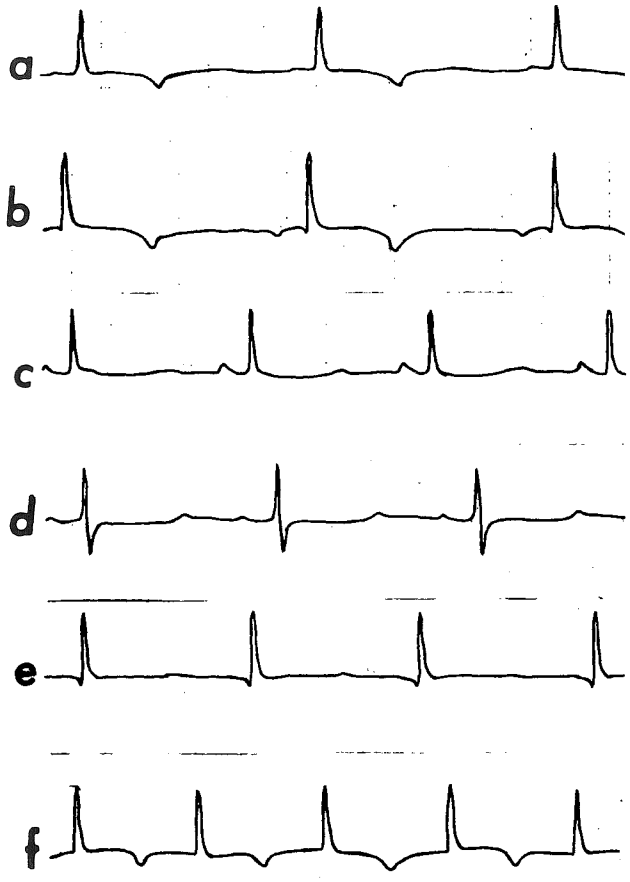

Fig. 1. Physiological ECG of eels under control conditions at different temperature "a, b, c at 10°C; d, e f at 18°C"

was temperature-dependent, that is a decline in water temperature was associated by a decrease in heart rate, an increase in temperature producing increased heart rate. This effect presumably results from an increased permeability of the cardiac muscle membrane to different ions, resulting in acceleration of the self-excitation process (Guyton, 1976). The results obtained are in accordances with Dohrn and Rein (1950), Wilber (1961), Sommerville (1975), Tuurala et al.(1982). Changes in the heart rate were found to be associated with an alteration in the duration of segments and intervals. That is, when the heart rate increases, the duration decrease and vice versa. This results is in agreement with Mroziński and Waśniowska (1956); Puth and Schneider (1972). In these experiments it was also observed that a decrease in water temperature appeared to have a positive inotropic effect on the eel heart.

This result is in agreement with Randall (1970). On the other hand, the respiratory rate of the eel was found also to be a function of water temperature, that is a rise

in water temperature is accompanied by an increase in respiratory rate and vice versa. This is normally due to changes in the oxygen requirements of the fish with temperature, therefore the fish must adapt its respiratory system to meet the increase in oxygen demand as water temperature rises. This result is in agreement with Davis (1968), Hughes (1972), Heath and Hughes (1973). The correlation between the frequency of the heart rate and respiratory rate in the eel under the same experimental conditions means that the beats originating near the time of mouth opening cause a rapid flow of blood through the gill surface at the time when water is expelled through the gills. This synchrony was suggested to maintain the diffusion gradient of oxygen across the gills epithelium. Lutz (1930), Satchell (1960), Hughes (1964), and Węgrzynowicz et al. (1975) showed the same tendency for the heart to be synchronized with a certain phase of the breathing cycle in the fish and elasmobranchs.

CONCLUSIONS

1. The ambient temperature significantly affects circulatory and respiratory performance of the eel.
2. The heart rate of the ell has been observed to be temperature-dependent.
3. The respiratory rate of the eel is a function of water temperature.
4. There is a strong correlation between the frequency of the heart beats and respiratory rate under the same experimental conditions.

REFERENCES

Cairns J., A. Heath and **B. Parker**, 1975: The effect of temperature upon the toxicity of chemicals to aquatic organisms. Hydrobiologia, **47**, 1: 135–171.

Davis J., 1968: The influence of temperature and activity on certain cardiovascular and respiratory parameters in adult sockeye salmon. M. Sc. Thesis, University of British Columbia.

Dohrn A. and **F. Rein**, 1950: Kreislaufphysilogische untersuchungen an Scyllium stellare. Pubbl. staz. zool. Napoli. **22**, 1–14.

Guyton A.C., 1976: Heart muscle; The heart as pump. In: Text book of medical physiology: 160–174.

Heath A.G. and **G.M. Hughes**, 1973: Cardiovascular and respiratory changes during heat stress in rainbow trout (Salmo gairdneri). J. Exp. Biol. **59**, 2: 323–338.

Hughes G.M., 1964: Fish respiratory homeostatis. Symp. Soc. Exp. Biol. 18: 81–107.

Hughes G.M., 1972: Morphometric of fish gill. Respirat. Physiol. 14: 1–25.

Labat R., 1966: Electrocardiologie chez les poisons teleosteen: Influence de quelques facteurs ecologiques. Toulouse Edouard Private, Libraire-Editeur: 255.

Lutz B.R., 1930: Respiratory rhythm in the Elasmobranch, Scyllium conicula. Bio. Bull. Woods Hole, **59**, 179–186.

Mroziński S. and **N. Waśniowska**, 1956: Electrocardiogram in experimental transient hypothermy. Acta Physiol. Pol. **7**: 393–404.

Puth E. and **H. Schneider**, 1972: Influence of body temperature on the heart frequency on some European Anurans. Pflugers Arch., 337, 1: 45–52.

Randall D.J., 1970: The circulation system. In: Fish Physiology. (Eds) W. Hoar and D. Randall, 4: 133–172.

Satchell G.H., 1960: The reflex co-ordination of the heart beat with respiration in the dogfish. J. Exp. Biol. 37, 719–731.

Sommerville B.A., 1975: Factor affecting the heart activity and blood pressure of the swan mussel Anodonta cygnea. J. Exp. Biol. 62, 2: 341–355.

Tuurala H.A., A. Solvic and **A. Nikinma**, 1982: The effect of adrenaline on heart rate and blood pressure in (Salmo gairdneri) at two temperature. Ann. Zool. Fenn., 19, 1: 47–51.

Węgrzynowicz R., B. Kłyszejko, R. Zbanyszek, K. Marczuk, K. Radziun and **J. Muzykiewicz**, 1975: Daily changes of the heart and respiratory rate of the bulltrout (Salmo trutta L.). Acta Ichth. et Pisc., 5, 1: 41–44.

Wilber C.G., 1961: Some physiological characteristics of the heart of the toadfish, Opsanustau. Chesapeak J. Sci., 2, 72–75.

Mohamed Hassan MOURAD

WPŁYW TEMPERATURY NA ZMIANY EKG, SKURCZE SERCA ORAZ ODDYCHANIE U WĘGORZA *ANGUILLA ANGUILLA* L.

STRESZCZENIE

Przeprowadzono badania wpływu temperatury wody na zmiany EKG, ilość skurczów serca oraz ilość oddechów u węgorza.

Wyniki wykazały, że temperatura wody zmienia w sposób istotny ww. parametry. Wraz ze wzrostem temperatury wzrasta ilość skurczów serca oraz ilość oddechów. W EKG stwierdzono skrócenie poszczególnych odcinków P–Q, S–T, T–P i zmniejszenie amplitudy R, P, T.

Author's address:

Dr. Mohamed Hassan Mourad
Institute of Oceanography and Fisheries
Alexandria, Egypt

Received: 1990.09.07