ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. IX Fasc. 2 Szczecin 1979

Remigiusz WĘGRZYNOWICZ, Regina ZBANYSZEK, Bernard KŁYSZEJKO, Grażyna GŁĘBOCKA

Physiology

EFFECT OF CRUDE OIL ON TISSUE RESPIRATION OF EEL, *Anguilla anguilla* (L.) KEPT IN WATER AT 18° AND 24°C

WPŁYW ROPY NAFTOWEJ NA ODDYCHANIE TKANKOWE WĘGORZA *Anguilla anguilla* (L.) W WODZIE O TEMPERATURZE 18°C i 24°C

Institute of Ichthyology,
Dept. of Physiology of Fishes

The paper describes studies on the effect of the Kamień Pomorski crude oil on tissue respiration of eel, *Anguilla anguilla* (L.). The crude oil concentration of 250 mg/l was tested at 18 and 24°C, the fishes being exposed for 5 hrs and 6 days. A very considerable reduction in eel tissue respiration was observed. Under the experimental circumstances, the oxygen uptake was at its minimum and maximum in gills and liver, respectively.

INTRODUCTION

In the recent years, marine life has been observed to be seriously endangered in off- and inshore waters polluted with crude oil and its derivatives. Self-purification of sea is a lengthy process; the polluted waters show a lower oxygen content. Crude oil, as a mixture of multiple fractions, affects the aquatic biota in many ways, thereby destroying the biological equilibrium in the sea.

Morrow and Gritz (1975) found, when studying toxicity of 16 compounds contained in non-purified crude oil, aromatic fractions to be particularly toxic. These authors

suggested that the toxicity of those compounds caused disorders in gill permeability, which results in a fast accumulation of univalent ions in blood and impairs the mechanisms of $CO_2 - HCO_3$ regulation, thus increasing the blood CO_2 load.

As shown by Tagatz (1961), juvenile herring were uncapable of avoiding oil-polluted waters as a result of blocking and destruction of their skin chemoreceptors. An average oil product concentration enabling the fishes to survive 48 hrs when exposed to it ranged, depending on the product, from 91 to 2417 mg/l, provided the oxygen content in the water exceeded 6 ppm; that range proved lethal at the oxygen content below 3 ppm.

According to Rustamova and Kasimov (1977), crude oil concentration of 20 mg/l brings about an increase in fish opercular rate. Fine droplets of crude oil derivatives, when introduced with water into a fish organism, cover membranes of digestive tract and gills, thus affecting the oxygen uptake. A decreased oxygen content in oilpolluted water as well as a harmful effect of oil products deepen respiratory disorders, which leads to death of a fish affected.

Eel, when migrating in marine and continental waters, is in particular danger of being exposed to the effects of oil pollution. For this reason the knowledge on how the physiological processes' dynamics reflects the fishes adaptive abilities will facilitate the determination of an extent to which a given oil-polluted habitat is unsuitable for the species in question.

Therefore studies on the effect of crude oil-contaminated water on tissue respiration of eel seem feasible.

MATERIAL AND METHODS

The tests were carried out on 57–68-cm long eel, *Anguilla anguilla* (L.) individuals weighing 640–750 g, caught in May-June 1977 in the Szczecin Firth. The experiments were run in aquaria, while the fishes to be tested were kept in basins filled with permanently aerated tap water. After a 3-day conditioning, the tests were run simultaneously in two groups: a control (K) and experimental (E) one. The control was made up of fishes kept in suitably aerated tap water, while the experimental group was exposed to a 250 mg/l concentration of the Kamień Pomorski crude oil in tap water.

The experimental fishes were exposed to the crude oil for 5 hrs and 6 days. Two temperature values, 18 and 24°C, were tested.

After the pre-set period of exposure, the fishes were killed and their tissues taken out and placed in ice. The amounts of oxygen taken up by tissues of liver, gills, and kidney were determined by a direct technique of Warburg as described by Kleinzeller (1965) and Umbreit et al. (1957). The tissues were cut to 5–10 μm pieces and incubated in Ringer fluid (according to Pequignot, 1964), 15% KOH being used as a CO_2 absorber. The water bath temperature was 30°C. The pre-incubation time was 15 min. Readings were taken at 20-min. intervals for an hour. The amount of O_2 absorbed (Q) was expressed in μl O_2/g wet weight/hr.

RESULTS

The results of studies on the effect of crude oil on tissue respiration in eel, *Anguilla anguilla* (L.) kept at 18 and 24°C are summarised in Tables 1 and 2, the data covering both the control and experimental groups.

Table 1

Oxygen uptake (QO_2) in μl O_2/g wet weight/hr in gills, liver, and kidney of control and experimental fishes kept at 18°C

No. of individ.	Group studied	Tissue			Water	
		Liver $\bar{x}$ σ	Kidney $\bar{x}$ σ	Gills $\bar{x}$ σ	Oxygen mg O_2/l	pH
10	Control	164±0.9	177±1.6	252±1.2	9.8	7.6
	Experimental					
10	−5 hrs^x	152±0.9	170±1.5	238±1.5	8.8	7.8
	−6 days^x	172±1.5	183±1.2	237±1.4	8.0	8.1

$\bar{x}$ = arithmetic mean
σ = standard deviation
x = exposure

Table 2

Oxygen uptake (QO_2) in μl O_2/g wet weight/hr in gills, liver, and kidney of control and experimental fishes kept at 24°C

No. of individ.	Group studied	Tissue			Water	
		Liver $\bar{x}$ σ	Kidney $\bar{x}$ σ	Gills $\bar{x}$ σ	Oxygen mg O_2/l	pH
10	Control	188±1.2	190±1.3	248±1.8	8.5	7.0
10	Experimental					
	−5 hrs^x	178±1.4	186±1.6	240±1.6	8.0	7.5
	−6 days^x	161±1.4	150±1.3	182±1.6	7.8	7.0

$\bar{x}$ = arithmetic mean
σ = standard devation
x = exposure

DISCUSSION

The studies presented indicate the eel tissue respiration to differ significantly in each organ tested. In both the control and experimental groups gills showed the most intensive respiration as opposed to liver with the least intensive process.

In the control, the tissue respiration intensity increased with water temperature. The oxygen uptake at 24°C increased by 15.8% (7.3% in kidney), while the respiration in gills remained at almost the same level as recorded in the control at 18°C.

Temperature of 18°C

The tissue respiration analysis for the experimental fishes kept for 5 hrs in crude oil-polluted water at 18°C showed a decrease, when compared to the control, in liver, gills, and kidney by 7.3, 5.5., and 3.8%, respectively

A prolongation of the exposure to 6 days proved to exert no effect on the tissue respiration in gills, while in liver and kideny increases by 4.3 and 3.3%, respectively, were observed compared to the control.

Temperature of 24°C

The tissue respiration intensity in the experimental fishes kept for 5 hrs at 24°C decreased by 5.3, 3.2, and 2.1% in liver, gills, and kideny, respectively, compared to the control.

After 6 days at 24°C, all the tissues tested showed a very marked drop in their oxygen uptake. The respective uptakes in liver, kidney, and gills were by 14.4, 20.7, and 26% lower than in the control.

When comparing tissue respiration intensities in the experimental fishes kept for 5 hrs at 18 and 24°C, liver and kidney showed a higher intensity at 24°C, while gills did not seem to be affected by temperature.

After 6 days of exposure at 24°C, tissue respiration intensity decreased markedly in every organ studied compared to 18°C.

Gills, owing to their direct contact with polluted water, are to the highest degree exposed to the harmful effects of crude oil. After the first 5 hours a considerable drop in tissue respiration takes place, while a prolonged period under the same thermal regime does not alter the oxygen uptake in gills.

An increase in the temperature of crude oil-polluted water up to 24°C results in a marked decline in tissue respiration. After 6 days gills and liver reduce their tissue respiration to one-fourth and one-fifth of the oxygen uptake recorded in the control.

A prolonged exposure to these conditions leads to death of a fish.

It is suggested that crude oil, as a toxic substance, at a certain water temperature may uncouple oxygen phosphorilation and transport during the respiration process; thus the amount of oxygen taken up is periodically increased, the released energy being los as heat rather than stored in ATP. After a prolonged action of the uncoupler, when – at elevated water temperature – all reactions are accelerated, the energetic resources indispensable for the normal functioning of physiologic processes may be exhausted, thus leading to death of an individual.

CONCLUSIONS

1. The tissue respiration as measured in gills, liver, and kidney of eel exposed for 5 hrs to crude oil in water of 18°C decreased by 3.8–7.6%.

2. After 6 days of exposure to crude oil in water of 18°C, the tissue respiration in gills remained unchanged, while it slightly increased in liver and kidney.
3. In water of 24°C, the tissue respiration of liver, kidney, and gills of fishes exposed for 5 hrs to crude oil in water decreased.
4. After 6 days at 24°C, a very marked reduction in the tissue respiration was recorded in every organ studied, i.e., the decline by 14.3, 21, and 26.6% in liver, kidney and gills, respectively.

REFERENCES

Kleinzeller A., 1965: Manometrische Methoden und ihre Anwendung in der Biologie und Biochemie. G. Fischer, Jena.

Morrow J.E., Gritz R., 1975: Effects of some components of crude oil on young coho salmon. – Copeia. 2: 326–331.

Pequignot J., 1964: La respiration tissulaire chez poissons. – Experientia **20**: 221–222.

Rustamova Sz.A., Kasimov R., 1977: Vlijane neftjanovo zagraznenija na važnejše fizjologičeske funkcii ryb. – Elmer Akad. heber. biol. Jelm. ser. Izv. AN. Az.SSR. ser. bioł. 3: 105–110.

Tagatz M.E., 1961: Reduced oxygen tolerance and toxicity of petroleum products to juvenile american. shad. – Chesapeake Sci. 2, 65

Umbreit W., Burris R.H., Stauffer J., 1957: Manometric techniques Minneapolis, Burgess Publ. Co.

Translated: mgr Teresa Radziejewska

WPŁYW ROPY NAFTOWEJ NA ODDYCHANIE TKANKOWE WĘGORZA *Anguilla anguilla* (L.) W WODZIE O TEMPERATURZE 18°C I 24°C

Streszczenie

Przeprowadzono badania wpływu ropy naftowej pochodzącej z rejonu Kamienia Pomorskiego na intensywność oddychania tkankowego węgorza *Anguilla anguilla* (L.). Badania prowadzono w okresie maj – czerwiec. Węgorz przetrzymywany był w wodzie o temperaturze 18°C jak i w temperaturze 24°C, skażonej ropą naftową w ilości 250 mg/l przez okres 5 godzin jak i 6 dni.

W wyniku badań stwierdzono wpływ podwyższonej temperatury wody z 18°C do 24°C na zwiększenie oddychania tkankowego wątroby i nerek, podczas gdy skrzela oddychały na jednakowym poziomie. Wpływ działania ropy naftowej spowodował zmniejszenie oddychania tkankowego. Szczególnie szkodliwe było podwyższenie temperatury wody do 24°C z równoczesnym przedłużeniem okresu działania ropy naftowej do 6 dni. Ilość pobieranego tlenu zmniejszyła się w skrzelach o 26,6%, w nerce o 21%, a w wątrobie o 14,3%.

Р. Венгжинович, Р. Збанышек, Б. Клышейко, Г. Глэбоцка

ВЛИЯНИЕ НЕФТИ НА ТКАНЕВОЕ ДЫХАНИЕ УГРЯ ANGUILLA ANGUILLA L. В ВОДЕ ПРИ ТЕМПЕРАТУРЕ 18°С И 24°С

Р е з ю м е

Проведены исследования влияния нефти, добытой в районе Каменя Поморского, на интенсивность тканевого дыхания угря Anguilla anguilla (L.). Исследования проводились в мае-июне. Угря содержали в воде, температура которой составляла 18°С и 24°С, загрязнённой нефтью в соотношении 250 мг на литр воды в течение 5 часов и 6 дней.

В результате исследований установлено, что повышение температуры воды с 18°С до 24°С влияет на увеличение интенсивности тканевого дыхания печени и почек, в то время как жабры дышали на одинаковом уровне. Действие нефти влияло на снижение интенсивности тканевого дыхания. Особенно вредным оказалось повышение температуры воды до 24°С при одновременном продлении времении действия нефти до 6-ти дней. Количество поглощаемого кислорода уменьшилось в жабрах на 26,6%, в почке - на 21%, а в печени - на 14,3%.

перевод: др. Юзеф Домагала

Address:

Prof. dr hab. Remigiusz Węgrzynowicz
Instytut Ichtiologii
71-550 Szczecin, ul. Kazimierza Królewicza 4
Polska—Poland

Received: 20 I 1979 r.