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*Fish Culture*

# STUDIES ON PREVENTING DISEASES OF CAGE–REARED RAINBOW TROUT (*SALMO GAIRDNERI* RICH.) IN LAKES

# BADANIA NAD ZAPOBIEGANIEM SCHORZENIOM PSTRĄGA TĘCZOWEGO (*SALMO GAIRDNERI* RICH.) W JEZIOROWYM CHOWIE SADZOWYM

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Juvenile rainbow trout, *Salmo gairdneri* Rich., kept in cages in lakes showed better health and survival after some preventing procedures had been applied in order to improve living conditions of fishes and counteract the spread of mass diseases. With this purpose in mind, the cages were fed with lacustrine deep waters and various medicated baths were applied.

## INTRODUCTION

A commercial cage-rearing of rainbow trout, *Salmo gairdneri* Rich., in lakes suffers frequently great losses resulting, to a considerable degree, from fish diseases. This method of culturing tends to promote mass infections and invasive diseases. The lacustrine habitat, typical of rainbow trout, enhances the spread of diseases as well.

In order to reduce losses in cage-reared juvenile stock, an attempt was made to work out disease-preventing procedures. The available literature indicates no such sufficiently developed procedures (Knäsche, 1974; Steffens, 1975). Our own field studies involved treatments aimed at the improvement of culture conditions and the prevention of development of diseases.

## MATERIAL AND METHODS

The material to be studied consisted of 9600 feeding juveniles of rainbow trout, *Salmo gairdneri* Rich., of mean length (l.c.) and weight of 2.6 cm and 0.17 g, respectively.

The 1.5×1.5×2.5 m cages used in the experiments contained 2.25 $m^3$ of water. They were constructed of an anti-algae paintimpregnated 1.8 mm mesh netting and mounted to a floating platform (Wojno et al., 1975) equipped in devices to well up the water from the lake's deeper part (Wojno and Tucholski, 1975). The experiment was performed in 8 cages, each stocked with 1.200 fish individuals.

The preventing action involved using two basic kinds of treatment: cage water cooling achieved by flushing them with water from the lake's deeper parts and medicated baths applied to the stock. The treatments applied to each cage are summarised in Table 1. The Series I (cages 1 and 2) were the controls.

**Table 1**

Experimental design

| Series | No of cage | Treatment | | |
|---|---|---|---|---|
| | | Water cooling | Baths | Type of bath and time |
| I | 1 | - | | |
| | 2 | + | - | - |
| II | 3 | | + | |
| | 4 | + | + | Malachite green (1 g/$m^3$ water) up to 1 h |
| III | 5 | - | + | |
| | 6 | + | + | Copper sulphate (5 g/$m^3$ water) up to 30 min. |
| IV | 7 | | + | 36–40% formol (150 ml/$m^3$ water) up to 40 min. |
| | 8 | + | % | copper sulphate as in Series III<br>common salt (2500 g) + malachite green (125 mg/$m^3$ water) up to 30 min. |

The water in cages was cooled by pumping cooler water from deep layers into the cages using an electric compressor. This treatment was applied periodically whenever the surface water temperature increased above 21°C.

Medicated baths were applied at one week intervals throughout the experimental period. In the Series IV, a medicinal additive was altered each week using subsequently: formol, copper sulphate, and common salt-malachite green blend. Bathing was performed in elastic containers pulled over the cages.

The health state of the fishes was continuously monitored throughout the experimental period, dissection and parasitologic examinations being performed. The fishes

were examined each week during the first two months and every other week later on. Whenever a possibility of a disease occurring was detected, both the controls and experimental fishes were subject to the medical treatment. When needed, the cages were mechanically cleaned to remove precipitates and algae. The oxygen content and water pH were determined every day using the Winkler method and colorimetrically with the Yamada indicator, respectively; the water temperature was measured at 6.00, 12.00, and 18.00 hrs.

Having completed the experiments, the health state of the fishes studied was assessed, due attention being paid to the parasiticides used, on twenty individuals selected at random from each experimental series. The assessment consisted of: 1) determination of selected haematologic indices, i.e., erythrocytes and leukocytes numbers per 1 $mm^3$ of blood, haemoglobin content as determined by the cyanmethaemoglobin method, erythrocyte resistance as determined from acidic erythrogrammes (Telitčenko and Govorova, 1962; Terskov and Gitelzon, 1957), percentage composition of leukocytes; 2) anatomopathological examination on dissection; 3) histopathologic examination of selected organs (gills, liver, intenstine, kidneys); tissue fragnents were fixed in one of the following fixatives; Bouin, Susa, Carnoy, 10% formol; paraffin mounts were stained with the Mayer haematoxylin with yellow eosine; 4) histochemical examination of liver using the Sudan III stain.

## RESULTS AND DISCUSSION

### Field experiments

The experimental cages were placed in the Głębokie Lake near Mikołajki. The lake's surface area, mean and maximum depths are ca 47 hectares, 12 and 34 m, respectively. The lake has a narrow littoral zone, poor emerged and submerged vegetation. The trophy is low scoring 2.3 at the 5-grade Patalas scale. The thermo-oxygen regime has been described as favourable for salmonids (7.9–9.0 mg $O_2/dm^3$, 22°C); from time to time oxygen deficit was being found at the 10--15 m depth. In summer, the water transparency ranged within 1.4–1.9 m. The lake is inhabited by a multi-species zooplankton characteristic of ablen-type lakes (Anon., 1966).

The experiments were commenced in the first decade of June, the cages being stocked with feeding rainbow trout juveniles pre-adapted (ever 10 days) to the lacustrine conditions. At that time the water temperature and oxygen content ranged within 16.9 - 18.5°C and 9.5–11.0 mg $O_2/dm^3$, respectively (Table 2).

In the second decade of June a considerable rise in the water temperature was recorded; this situation continued until late summer (second decade of August). At that time the water temperature approached the critical value for rainbow trout, ranging from 19.3 25.0°C, while the oxygen content and saturation ranges were 9.6 -10.7 mg$O_2/dm^3$ and 108--130%, respectively. When the water temperature was remaining at 21°C, the water from deeper layers of the lake was begun to be pumped to cages 2,4,6 and 8 according

**Table 2**

Selected physical and chemical parameters of water over the experimental period

| Month | Parameter studied | Water origin | | |
|---|---|---|---|---|
| | | surface (0.5 m) | pumped from deeper layers | water flowing through cages* |
| June | temperature (°C) | 19.9<br>16.9 22.7 | | |
| | oxygen content (mg $O_2/dm^3$) | 9.28<br>8.32 10.24 | | |
| | pH | 8.4 | | |
| July | temperature (°C) | 22.5<br>19.3 25.0 | 11.3<br>11.2 12.0 | 14.6<br>12.5 15.7 |
| | oxygen content (mg $O_2/dm^3$) | 10.08<br>9.1 10.7 | 4.1<br>2.5 4.8 | 5.8<br>4.7 - 6.3 |
| | pH | 8.6 | 7.4 | 8.0<br>7.0–8.1 |
| August | temperature (°C) | 21.8<br>20.3 24.8 | 15.0<br>14.8 15.2 | 17.0<br>16.6 17.4 |
| | oxygen content (mg $O_2/dm^3$) | 9.6<br>9.4 10.7 | 2.5 | 3.8<br>3.5 4.2 |
| | pH | 8.4 | 7.6 | 7.9 |
| September | temperature (°C) | 19.0<br>17.5 21.3 | | |
| | oxygen content (mg $O_2/dm^3$) | 9.4<br>8.5 10.4 | | |
| | pH | 8.2<br>8.0 8.4 | | |

* Water flowing through cages was a mixture of deep and surface water

to the experimental lay-out. The pumping time was 2 23 hours per day depending on the temperature. The mixing of surface waters, warm and oxygen-rich, with the water from deeper layers, cooler and less oxygenated, caused a change in the thermo-oxygen regime and resulted in the water flux in the cages. The thermo-oxygen situation and pH of the water is presented in Table 2.

The water pumped from deeper layers mixed with the surface water along a 0.3 m long stretch, thereafter flowing into the cage where a further mixing took place. The fishes were usually confined to the flushed part of a cage because of more favourable thermal and oxygen conditions prevailing there. Simultaneously to the pumping action, the fishes were periodicaly bathed (cages 3 8) as in the design; algae-killing copper sulphate baths were used during intensive algal blooms (4 5 day treatment).

The preventing action did not manage to rule out juvenile mortality, intensive from time to time. However, a higher mortality was being observed in cages beyond the reach of up-welled water. The health check-ups were invariably revealing the presence of various algae (*Ceratium hirundinella* Berg., *Draparnaldia sp.*, *Cladophora sp.*, *Ulothrix sp.*, *Asterionella sp.*, *Tabellaria sp.*) on skin, and on gills in particular, the algae being most frequently mixed with mucus and detritus. At the same time, lesions and losses of epithelial tissues were found in places covered with algae. To counteract myxobacterial re-infections (Amend, 1970; Anderson and Conroy, 1969; Ghittino, 1969), antibiotics were added to food (detreomycin in daily doses of 50 mg/kg fish weight over 4 5 days). Periodically, ectoparasitic invasions caused mainly by ciliates *Ichthyophtirius multifiliis* and *Trichodina sp.*, and by flagellates *Ichthyobodo necatrix* were noted. Stronger invasions were cured by applying medicated baths, the most effective being the common salt – malachite green blend. An improvement of culture conditions (temperature fall below

**Table 3**

Effects of rainbow trout culture

| Series | No of cage | Survival | | Total weight of stock (g) |
|---|---|---|---|---|
| | | individuals | % | |
| I | 1 | 289 | 26.1 | 6 300 |
| | 2 | 541 | 47.5 | 10 400 |
| II | 3 | 431 | 37.8 | 8 400 |
| | 4 | 602 | 52.8 | 13 600 |
| III | 5 | 512 | 44.9 | 10 400 |
| | 6 | 657 | 57.6 | 13 000 |
| IV | 7 | 439 | 38.5 | 8 000 |
| | | 418 | 36.7 | 8 400 |

* Escape of some fishes from the cage No. 8 excluded the series IV samples from the survival assessment.

20°C, no blooms) in the second decade of August acted in favour of fish health, the mortality having been diminished to almost zero.

Having completed the experiment, its results were assessed (Table 3).

The number of fishes caught and the total stock weight were higher in cages remaining within the reach of up-welled water. The values were still higher in those cages to which medicated baths were applied along with water cooling.

## Haematologic examinations

Erythrocyte numbers in rainbow trout from different series and in control fishes are similar, the values being consistent with the range accepted for juvenile raibow trout (1.07–1.47 million/mm$^3$ blood) but usually closer to the lower limit of the interval (5). The haemoglobin content remained also within the range accepted as appropriate for the species (5.2–12.0 g% Hb) but below the mean (McCarthy et al., 1973). The lowest haemoglobin content was found in fishes treated with copper sulphate baths; the value was lower by 23% from that in the control.

**Table 4**

Erythrocyte number, haemoglobin and erythrocyte resistance index in control and experimental rainbow trout (mean values)

| Series | No of erythrocytes (million/mm$^3$ blood) | Haemoglobin (g%) | Resistance index |
|---|---|---|---|
| I | 1.25 | 7.4 | 1.00 |
| II | 1.06 | 7.2 | 1.15 |
| III | 1.09 | 5.7 | 0.75 |
| IV | 1.15 | 7.2 | 1.01 |

The erythrocyte resistance index describing the blood cells resistance to haemolytic agents is presented in Fig. 1. The index was higher in fishes bathed in malachite green, which indicates a numerical predominance of juvenile erythrocytes in blood; this can be due to a damaging agent's effective action against less resistant, older erythrocytes, the regeneration potential of the system being, however, intact. A decreased erythrocyte resistance index in fishes treated with copper sulphate evidences a numerical predominance of older erythrocytes, which can either be associated with an action of a haemolytic agent or indicate a hampered haemopoiesis.

Numbers of leukocytes found do not differ from the standards for rainbow trout (6.7–24.1 thou./mm$^3$ blood); they are usually higher than the mean, only in those fishes bathed in malachite green are they close to the lower limit of the range (Bernhart, 1969; McCarthy et al., 1973). Moreover, the analysis of the leukocyte percentage composition in those fishes showed some irregularities, i.e., a relative lymphopoenia caused by the absolute granulocytosis, which points out to an intensified defending activity of a fish organism.

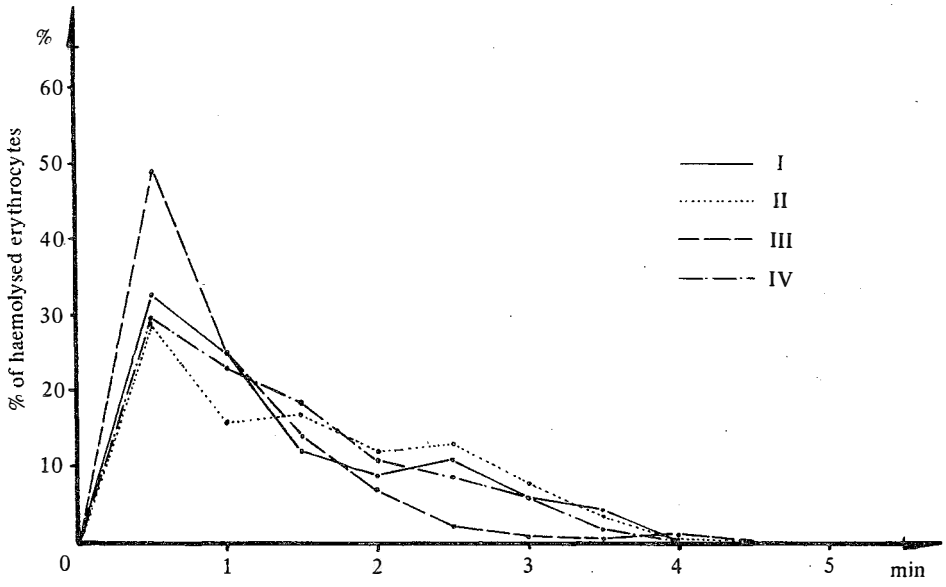


Fig. 1. Acidic erythrogramme of erythrocyte resistance in control and experimental rainbow trout

**Table 5**

Numbers and percentage composition of leukocytes in control and experimental rainbow trout (mean values)

| Series | No of leukocytes (thou./mm$^3$ blood) | Percentage composition of leukocytes | | | | | |
|---|---|---|---|---|---|---|---|
| | | myelocytes | granulocytes with segmented nuclei | granulocytes with rod-like nuclei | lymphoblasts | lymphocytes | monocytes |
| I | 15.30 | 0.2 | 4.2 | 7.5 | 0.1 | 87.8 | 0.2 |
| II | 7.66 | 1.4 | 8.2 | 8.6 | 0.9 | 78.0 | 2.9 |
| III | 21.20 | 0.8 | 2.1 | 4.3 | 0.1 | 92.0 | 0.7 |
| IV | 19.80 | 0.5 | 3.3 | 3.2 | 0.2 | 92.4 | 0.4 |

**Anatomico- and histopathological studies**

Both the control and experimental rainbow trout showed damages, visible as losses, in fins, the dorsal and caudal fins being the most affected ones, which in many cases resulted in a considerable shortage of a fin. Damaged fins were in the process of healing or were

healed completely, showing thickened and uneven margins. In less numerous instances, patchy losses of thoracic skin were found. They were usually shallower and occurred over limited areas. In gills, central congestions, mostly poorly developed, were revealed in 1/3 of the cases. The organ's surface was covered with an increased amount of mucus mixed with detritus and algae. In the respiratory epithelium, the cells were swollen, in some places showing stronger damages to the extent of necrosis and disintegration. Gills of fishes kept in cages cooled with the up-welled water, on the other hand, were close to a normal state. They showed uniform blood supply, small amount of mucus and algae on the surface, and a low intensity of regressive changes and lesions in the respiratory epithelium. Furthermore, the respiratory epithelium of both the control ad experimental fishes showed symptoms of renewal, in many cases leading to an excessivex growth. This excessive production of tissue resulted in an irregular structure of the organ observed as deformations and adhesions of gill filaments and lobes into a more or less solid tissue. At the same time, capillary vessel lacunae along with blood stasis occurred in the changed parts of gills.

Pictures of viscera of the control and experimental rainbow trout showed no discernible differences. In the body cavity, conspicuous was the abundance of adipose tissue. Most fishes' liver was homogenously stained pink- or yellowish, in some congestion centres occurred. When observed under microscope, the organ showed changes in hepacytes cytoplasm resulting from usually significant fatty infiltrations. The intenstine showed symptoms of enteritis, an excessive amount of dense or semi-liquid mucus being present. Kidneys of some fishes (ca 1/4 of cases) were excessively supplied with blood and slightly swollen. Congestion of glomerules and their slight swelling was observed. No discernible aberrations were noted in the remaining organs.

## CONCLUSIONS

1. Cage-kept young rainbow trout, particularly the juvenile stages, were found to be very sensitive to unfavourable environmental conditions, especially with respect to a too high water temperature, algal blooms, and parasitic invasions resulting in diseases and excessive mortality of stock.

2. Juvenile rainbow trout showed a better health state and higher survival when preventive measures were taken to improve thermal conditions of the water and counteract the results of blooms and parasitic invasion: the preventive action comprised:

a) filling the cages periodically with water pumped from deeper layers to cool the warm surface water and produce a water stream restricting the settlement of algae and impurities on fish gills and skin

b) weekly baths in various medicinal compounds. The best results (haematologic examinations) were obtained when the compound was changed in subsequent baths, which could have led to soothing of the harmful effects of one compound had it been applied throughout the entire culture period

c) systematic monitoring of the fish health state in order to pinpoint the threat of a disease at its onset, which enables an effective counteraction to be taken.

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## BADANIA NAD ZAPOBIEGANIEM SCHORZENIOM PSTRĄGA TĘCZOWEGO (SALMO GAIRDNERI RICH.) W JEZIOROWYM CHOWIE SADZOWYM


### Streszczenie

U narybku pstrąga tęczowego (*Salmo gairdneri* Rich.) w jeziorowym chowie sadzowym podjęto próbę opracowania postępowania przeciwdziałającego nadmiernej śmiertelności obsad. W tym celu zastosowano zabiegi wpływające na poprawę warunków termicznych wody oraz przeciwdziałające

skutkom zakwitów i inwazji pasożytniczych. Podstawowymi zabiegami były: zasilanie sadzów w wodę z głębszych warstw jeziora wpływające na ochłodzenie przegrzanych wód powierzchniowych oraz wytworzenie strumienia wody ograniczającego osadzanie się glonów i zanieczyszczeń na skrzelach i skórze ryb, kąpiele profilaktyczne w preparatach pasożytobójczych, systematyczne badania kontrolne zdrowotności ryb. Po zakończeniu doświadczeń przeprowadzono ponadto badania hematologiczne i histopatologiczne pozwalające na ocenę skutków oddziaływania preparatów pasożytobójczych na ryby.

W wyniku całościowych badań stwierdzono iż narybek pstrąga tęczowego w jeziorowym chowie sadzowym poddawany zabiegom profilaktycznym odznaczał się lepszym stanem zdrowotnym i wyższą przeżywalnością niż ryby, u których zabiegi nie były stosowane.

Д. Валюга

## ИССЛЕДОВАНИЕ ПО ПРЕДУПРЕЖДЕНИЮ ЗАБОЛЕВАНИЯ РАДУЖНОЙ ФОРЕЛИ (SALMO GAIRDNERI RICH.) ПРИ ОЗЁРНОМ ВЫРАЩИВАНИИ В САДКАХ


### Р е з ю м е

При озёрном выращивании в садках молоди радужной форели (Salmo gairdneri Rich.) была предпринята попытка разработать методы предупреждения повышенной смертности посадочного материала. С этой целью были рассмотрены и использованы приёмы, влияющие на улучшение температурного режима воды и противодействующие её зацветанию и инвазии паразитов. Основными такими приёмами явились: снабжение садков водой из более глубоких слоёв озера для охлаждения перегретых поверхностных вод и образование струи воды, ограничивающей осадку водорослей и загрязнений на жабрах и коже рыб; профилактические ванны в бактерицидных препаратах; систематические контрольные исследования состояния здоровья рыб.

По окончании опытов были проведены гематологические и гистопатологические исследования, дающие возможность произвести оценку результатов воздействия на рыб бактерицидных препаратов.

В результате проведенных опытов установлено, что молодь радужной форели при озёрном выращивании в садках после профилактической обработки характеризовалась лучшим состоянием здоровья и более высокой выживаемостью, чем рыба, которая не была подвергнута такой обработке.


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