copy to: M. P. Adams

INSTITUTE FOR FISHERIES RESEARCH
UNIVERSITY MUSEUMS
UNIVERSITY OF MICHIGAN
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PROGRESS REPORT

ON

EXPERIMENTS WITH DISSOLVED OXYGEN ON FISH

Whenever time permits and specimens are available experiments on the minimum oxygen requirements for fish have been in progress. A report (No. 53) has been sent to the Department of Conservation which summarizes to some extent the available information on this subject. This paper has been prepared as a progress report since pollution experts working in the Stream Control Commission are very anxious to obtain all available information on minimum oxygen requirements for fish.

In these experiments aquaria with a 46-liter capacity have been used. The number of fish in the aquarium has never been excessive and in experiments where the oxygen content of the water was very low the number of fish used will be given. The running water supplied to the experimental aquaria was passed through an iron filter and the water was practically constant for temperature. All aquaria were fitted with a coarse meshed galvanized screen top which was from 1/2 to 1 inch below the surface of the water thus preventing the fish from gasping at the surface. A metal tube with a flaring top perforated the screen and extended to within three inches of the bottom

at the center of the aquarium. The water supply to the aquarium entered this tube which insured circulation of the water as indicated by dyes which were placed in the metal tube. The water was supplied to the aquarium by a siphon since mechanical devices could not be relied upon to give a constant flow.

The city water used in the experiments was devoid of oxygen and was aerated to the amount desired by dropping it from various heights into the metal tube. The water was tested for oxygen content from day to day and from different parts of the aquarium and was found to be uniform in the aquarium and quite constant from day to day. No experiment was begun until the water in the aquarium showed that the oxygen supply was constant for at least 24 hours.

Fish, as a rule, cannot be changed suddenly from water with a high oxygen content to water with a low oxygen content. It was necessary, therefore, to set up a series of tanks having respectively the oxygen content as follows: 8.0 p.p.m., 6.0 p.p.m., 4.0 p.p.m. and the fish were transferred from one to the other down the series and left in each for 12 to 24 hours.

Landlocked salmon kept for six weeks in water containing 9.0 p.p.m. and 6.0 p.p.m. of oxygen, respectively, showed no differences. In this experiment the rate of flow of water was 930 cc. per minute and the temperature was 12.5°C. The fish ranged from 55 to 133 mm. in length.

Eighteen landlocked salmon, length 61 to 112 mm., average 82.5 mm. were used in the following experiment. The fish were put in the aquarium on the morning of May 4, 1931, in water with 9.7 p.p.m. of oxygen and by manipulating the siphon supplying the water the oxygen content was reduced gradually during the day and in the evening the water contained 6.0 p.p.m. On May 5, 1931, by the same method as already stated, the oxygen content was reduced from 6.0 p.p.m. to 4.5 p.p.m. In the following list are given the subsequent dates on which the oxygen content was determined and the amount of oxygen present is given; 5-6-31, 5.9, 4.9, 4.2 p.p.m.; 5-8-31, 4.5 p.p.m.;

5-13-31, 2.7 and 4.3 p.p.m.; 5-14-31, 4.0 p.p.m.; 5-15-31, 4.0 p.p.m.; 5-16-31, 4.0 p.p.m.; 5-18-31, 4.0 p.p.m.; 5-19-31, 4.1 p.p.m.; 5-20-31, 4.4 p.p.m.; 5-21-31, 5.4 p.p.m.; 5-25-31, 4.0 p.p.m. The experiment was continued uninterruptedly until June 8, 1931. No detrimental effects of the low oxygen were noted in the fish although they did not act the same as fish living in water with a greater oxygen content. The fish in this experiment seemed more restless than ordinary moving around until exhaustion compelled them to settle to the bottom for a rest. In this experiment water was added to the aquarium at the rate of 950 cc. per minute. The temperature was 12.5°C.

A single rainbow trout, length 230 mm., was used in the following experiment. The oxygen supply was decreased by regulating the distance of the siphon from the aquarium. The experiment was begun May 13, 1931, and at this time the water had an oxygen content of 7.7 p.p.m. In the following list are given the subsequent dates on which the oxygen content was determined and the amount of oxygen present is given; 5-14-31, 5.0 p.p.m.; 5-15-31, 3.9 p.p.m.; 5-16-31, 3.9 p.p.m.; 5-18-31, 3.6 p.p.m.; 5-20-31, 3.9 p.p.m.; 5-21-31, 4.2 p.p.m.; 5-25-31, 3.6 p.p.m.; 7-27-31, 3.2 p.p.m., on which date the experiment was terminated. Lack of appetite was the only abnormal condition noted in the fish during the experiment. Rate of flow of water during the experiment was 940 cc. per minute. The temperature of the water was 12.5°C.

Miscellaneous fish (22) were used in the following experiment. After the fish had been placed for at least 12 hours in each of the aquaria in a series containing 8.0 p.p.m., 6.0 p.p.m., and 4.0 p.p.m., respectively, they were transferred to the experimental aquarium. At the time the experiment was started, May 18, 1931, the oxygen content of the water was 1.9 p.p.m., and for subsequent dates as follows: 5-19-31, 1.9 p.p.m.; 5-20-31, 2.2 p.p.m.; 5-21-31, 2.0 p.p.m.; 5-22-31, 2.0 p.p.m.; 5-25-31, 2.2 p.p.m., when it was terminated. The rate of flow of water was 775 c.c. per minute. The temperature of water was 12.5°C. The different kinds of fish used with their measurements are as

follows, Campostoma anomalum (Stone-roller minnow) 50 mm.; Semotilus atromaculatus atromaculatus (Creek chub) 52 mm. and 57 mm.; Rhinichthys atronasus meleagris (Black-nosed dace) 38 mm., 41 mm., 52 mm., 57 (3) mm., 68 mm.; Esox vermiculatus (Mud pickerel) 164 mm.; Eupomotis gibbosus (Pumpkinseed) 82 mm., 96 mm.; Cottus bairdii (Miller's thumb - Muddler) 45 mm., 47 mm., 66 mm., 72 mm.; Poecilichthys coeruleus coeruleus (Rainbow darter) 31 mm., 38 mm., 42 mm., 50 (2) mm.

A number of miscellaneous fish were used in the following experiment in which the water contained only a small amount of oxygen. The fish were transferred periodically to aquaria containing less oxygen and when held for 24 hours in water containing 2.0 p.p.m. oxygen no fish died. On May 12, 1931, they were transferred to water containing 1.0 p.p.m. The following fish died in the water containing 1.0 p.p.m. of oxygen; Campostoma anomalum (Stone-roller minnow - breeding male) 127 mm.; Poecilichthys coeruleus coeruleus (Rainbow darter) males, 57 mm., 50 mm., females, 50 mm., 45 mm.; Chrosomus erythrogaster (Red-bellied dace) 65 mm.; Rhinichthys atronasus meleagris (Black-nosed dace) 51 mm. The following fish lived for the duration of the experiment and seemed to be in good condition when removed; Aplites salmoides (Large-mouth bass) 105 mm.; Semotilus atromaculatus atromaculatus (Creek chub) 54 mm.; Esox vermiculatus (Mud pickerel) 178 mm., 120 mm.; Ambloplites rupestris (Rock bass) 92 mm.; Perca flavescens 71 mm.; Cyprinus carpio (Carp) 64 mm.; Catostomus commersonnii (Common sucker) 230 mm.; Eupomotis gibbosus (Pumpkinseed) 79 mm.; Cottus bairdii (Miller's thumb - Muddler) 58 mm., 46 mm.; Umbra limi (Mud minnow) 66 mm.; Poecilichthys coeruleus coeruleus (Rainbow darter) 54 mm.

In this experiment all fish except one remained down near the bottom of the aquarium and seemed somewhat sluggish. The rock bass stayed near the surface of the water but was never seen trying to gasp near the surface. Repeated trials with numerous rainbow darters to acclimate them to the water with one part per million of oxygen were

futile, why the single specimen lived I am at a loss to explain.

In the following list is given the amounts of oxygen in the water on consecutive days until the experiment was terminated May 21, 1931; 5-12-31, (10 A.M. and 3 P.M.) 1.0 p.p.m.; 5-13-31, 1.0 p.p.m.; 5-14-31, 1.0 p.p.m.; 5-15-31, 1.0 p.p.m.; 5-16-31, 0.95 p.p.m.; 5-17-31, 0.95 p.p.m.; 5-18-31, 0.9 p.p.m.; 5-19-31, 0.9 p.p.m.; 5-20-31, 1.3 p.p.m.; 5-21-31, 1.0 p.p.m. The rate of flow of water into the aquarium was 820 c.c. per minute. Temperature of water was 12°C.

All species, which are given in the last two series except Esox lucius, were killed when transferred directly from water containing 8.0 p.p.m. of oxygen to water with 1.0 p.p.m. The pike, however, did not seem to be at all inconvenienced.

Several other direct transfer experiments were completed. In the first the fish (10) were transferred directly from water containing 10.0 p.p.m. of oxygen to water with a very low oxygen content. At 8 A.M., May 22, 1931, when the fish were transferred to the experimental aquarium the oxygen content was 1.2 p.p.m., at 10:30 A.M. it was 0.9 p.p.m., and at 8 A.M., May 23, 1931, 0.8 p.p.m. The experiment was terminated in 26 hours and at the end of that time some fish were dead, others were living and appeared normal. Cottus bairdii (Muddler) 70 mm., 45 mm.; Aplites salmoides (Large-mouth bass) 74 mm.; Perca flavescens 60 mm.; Notropis heterodon (Black-nose shiner) 50 mm.; Rhinichthys atronasus meleagris (Black-nosed dace) 46 mm., were dead. Esox vermiculatus (Mud pickerel) 108 mm., Catostomus commersonnii (Common sucker) 102 mm., Eupomotis gibbosus (Pumpkinseed) 70 mm., Erimyzon sucetta kennerlii (Chub sucker) 57 mm., were living and appeared to be normal. The temperature of the water was 12.5°C. and rate of flow 960 c.c. per minute.

Twenty miscellaneous fish were used in the following experiment and transferred directly from water containing 10.0 p.p.m. to water with a small amount of dissolved oxygen. The experiment was begun 3 P.M., May 21, 1931 and concluded at 11 A.M. May 23, 1931. The following fish lived; Catostomus commersonnii (Common sucker) 111 mm.; Ambloplites rupestris (Rock bass) 70 mm., 77 mm.; Esox vermiculatus (mud pickerel) 86 mm.;

Aplites salmoides (Large-mouthed bass) 65 mm.; Perca flavescens (Perch) 70 mm.; Cottus bairdii (Muddler) 54 mm.; Eupomotis gibbosus (Pumpkinseed) 94 mm.; Poecilichthys coeruleus coeruleus (Rainbow darter) 52 (2) mm., 44 (2) mm., Rhinichthys atronasus meleagris (Black-nosed dace) 60 (2) mm., 53 mm.; Semotilus atromaculatus atromaculatus 65 mm.; Nocomis sp. 57 mm. The following fish died; Aplites salmoides (Large-mouthed bass) 72 mm.; Cottus bairdii (Muddler) 82 mm. Oxygen content of water previous to and during the experiment was as follows;5-19-31, 1.3 p.p.m.; 5-20-31, 1.7 p.p.m.; 5-21-31, 3 P.M., 1.8 p.p.m.; 5-22-31, 8 A.M., 1.7 p.p.m., 10:30 A.M., 1.6 p.p.m.; 5-23-31, 8 A.M. 1.7 p.p.m. Temperature of the water was 12.5°C. but the rate of flow wasnot recorded. All the fish except the rock bass, pumpkinseed, and pike were noticeably distressed by lack of oxygen shortly after transfer.

Since these experiments have not been completed, no conclusions will be drawn at this time. We feel that the temperature is an exceedingly important factor in determining the tolerance of fish to water containing a small amount of dissolved oxygen and regret the fact that we do not have facilities for carrying out similar experiments at higher temperatures.

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Wendell H. Krull
Fish Pathologist