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THE TRANSPORTATION OF FROZEN LIVE FISHES
(Le transport du poissons congelés)

(By Eugene Mir and Dr. J. Audigé in Tome 25, pp. 7-14, Bulletin de la Société Centrale d'Argiculture et de Peche. Paris, 1913)

Cold is used to advantage both in the fisheries and in fish culture. The refrigerating establishments which possess numerous fishing boats, the placing in circulation on the railroads of cars suitably arranged, and finally the easy use of, and the low cost of ice, permit the transportation, sometimes very distant, of fish, an article of food of the first order, but exceedingly perishable. Not only does refrigeration permit the long conservation of dead fish, but it facilitates the shipment of live fish. It is the current practice in fish culture to refrigerate the water in the receptacles serving for the transportation of these animals. In this way numerous fishes can be collected in a limited space and their transportation in a living state assured, to the great profit of fish-culturists. Everyone knows that the sale value of living fish surpasses that of dead fish.

In a very able work Mr. E. Poher has described the process used in Germany to facilitate the transportation of living fishes. Cars furnished with reservoirs in which refrigerated water continually circulates are placed at the disposition of fishermen and fish-culturists.

The United States, and particularly the State of California, has employed for some time this means of transportation. It must be recognized, however, that in spite of the perfection to which these cars have been brought, the number of fishes shipped is small, out of proportion, it would seem, to the considerable value of the apparatus employed.

In an interesting discussion of this question, Mr. R. Merle estimates that about 4 to 5 litres of water are necessary to assure the transportation in good condition of one kilogram of carp 2 to 3 years of age; carp of one year require 10 litres of water per kilogram; it takes 10 to 20 litres to keep for a few hours 1 kilogram of trout. Under these conditions a car, the capacity of which is 10,000 kilograms, is hardly able to carry 500 to 1,000 kilograms of living trout.

We have endeavored to discover whether it is not possible to obtain better results by another method, suggested by data furnished at the same time by nature and by experimentation.

It is known, in fact, that fishes behave in low or in variable temperatures like other cold-blooded animals, their own temperature falling in proportion to the chilling of the medium in which they live. The resulting lethargy can go even to the suspension of life. To take an example from nature, the great rivers of Siberia, the Lena, the Yenisei and the Obi, freeze solid during the winter months. The fishes thus imprisoned in the ice hibernate, but do not die. In the spring the ice melts, and the fishes set free revive. Without this property of hibernation the streams of Siberia would have no fishes, when, in fact, they have an abundance of them.

The first experiments attempted on the freezing of fish are already old. Franklin, Hubbard, and others otbained the revival of fishes stiffened by cold. In 1863 Milne-Edwards gave to these experiments the consideration of his high intelligence. More recently Mr. G. Weiss in his "Precis de physique biologique," describes the same phenomenon. "One is able," he says, "to freeze fishes and batrachians, to transport them even, at 15°, and to see them revive if precaution is taken to thaw them out gradually." Finally in a recent article Mr. R. Peetet, the eminent Genevois physician, describes his personal researches upon the same subject. "The most convincing results," says Mr. Peetet, "have been furnished by the fresh-water fishes. They can be frozen and thawed out without their dying. One day at the University of Geneva I placed in a deep glass bowl 28 fishes. By taking the precaution to leave these fishes nearly 24 hours in water at 0° we have been able, by slowly freezing this water, to form a block composed of water and the fishes inclosed therein. The block was frozen gradually, from nearly 20° to below 0° * * *. Three weeks to two months later, by allowing the ice and the fishes inclosed to melt slowly, the latter swam about as before without any sign of discomfort."

In repeating the experiments of these numerous savants, one of us has been able to confirm this excellent result. It is upon these data that the process of transportation indicated below is based. The technique of the operation comprises three principal phases:

1. The preparatory chilling, the concentration or assembling of the fishes in a small quantity of water, and the freezing.

2. The transportation.

3. The thawing out of the fishes.

CHILLING, CONCENTRATION, AND FREEZING OF THE FISH

The apparatus which we have used consists of a simple wrought-iron basin in the form of a truncated (inverted) cone. Around the outer edge of the opening (which corresponds to the base (top) of the vessel), is soldered a flat collar upon which is fixed, by screws which can be tightened, a sheet-iron cover. A rubber gasket, interposed between the cover

and the collar, insures the tightness of the joint. The cover itself is pierced with three holes furnished with short tube holders in which can be fixed perforated corks. In one of these is placed the beak of a large funnel; the second is fitted with an elbow tube-holder, and the third with a thermometer which permits the progress of refrigeration to be followed. To the beak of the funnel and to the end of the elbow tube-holder, which descend into the basin, are fitted two rubber tubes in such a way that their free ends are at a distance of a few centimeters from the bottom of the vessel when the cover is in place. The receptacle being filled with water, the fishes to be frozen are introduced, the cover is put in place, care being taken that the joining is air-tight. The slow and progressive refrigeration of the water then proceeds.

Water is first poured into the funnel, and after having run through the receptacle it comes out through the elbow tube-holder which serves for an overflow outlet. The funnel is then filled with cracked ice. The melting of this ice chills the water gradually and the temperature of the basin drops progressively. In varying the discharge of the water and the quantity of ice a refrigeration as gradual as may be desired can be obtained.

When the fishes have passed several hours above 0° the flow of water is checked, and by means of the elbow tube-holder oxygen under pressure is injected. This gas, penetrating to the interior of the receptacle, forces back the water into the funnel, and in this manner the basin is emptied of half of its contents. The funnel is then refilled with cracked ice and communication between the elbow tube-holder and the oxygen reservoir is momentarily interrupted in order to permit the discharge (evacuation) of the liquid. The melted ice water runs into the receptacle which is refrigerates, and which it keeps in the neighborhood of 0°. The operation must remain in this state for 15 to 19 hours.

In the course of some experiments which were conducted on the respiration of fishes we were convinced of the possibility of keeping fishes alive in a very small quantity of water in a closed atmosphere of pure oxygen. We have kept trout living for 18 days in a glass bowl full of oxygen which contained just enough water to permit the fish to maintain their normal position. The apparatus which we propose to employ permits, without the least damage to them, the assembling of the fishes in a small quantity of liquid and their gradual refrigeration.

When the duration of the chilling process is sufficient the new injection of a certain quantity of oxygen reduces by a few centimeters the height of the water in the basin. The freezing is then easily accomplished by plunging the basin into a refrigerating mixture.

TRANSPORTATION

Congealing having been produced, there remains in the bottom of the vessel only a cake of ice, inclosing the frozen fish. The cover is removed from the mould with care, the operation being facilitated by the form of the basin. The cake is then wrapped in linen and inclosed in an insulated adiathermic envelope designed to hinder the melting of the ice during the journey. If it is desired to ship several cakes, they are piled one upon the other in a cylinder so that they will occupy the minimum space. The

cylinder should be inclosed in an insulated medium, a box, or a cask, for example, which is then filled with powdered cork, sawdust, or chaff. It would be easy to replace this insulation, if desired, with cracked ice, and also to transport the discs in refrigerator cars in which the temperature should not be above 0°.

THE THAWING OUT

As with the refrigeration, the thawing also must be slow and progressive. It does not require, however, the same apparatus and the same conditions as the refrigerating process. Good results may be obtained by employing the following method:

At their destination, the cakes (of ice and fish) are plunged into troughs filled with water, the temperature of which is maintained at 0° by blocks of ice. Little by little the cakes melt and the fishes fall to the bottom of the troughs. If their revival is desired, it is imperative that the temperature in the troughs be maintained for several hours in the neighborhood of 0°. The thawing should occupy at least 10 hours.*

CONCLUSIONS

The method which we propose unites the following advantages:

1. The omission, in the transportation of living fishes, of a heavy and cumbersome liquid.

2. The absence in transit of complicated and troublesome apparatus.

3. The moderate price of the machinery which, considering the needs of a great industry, appears to cost but little.

4. The simplicity of operation.

5. The possibilities of shipping living fishes for long distances.

6. The possibility of using the fishes in cases where the operation, through mishap, does not permit the revival of all the fishes.

Although susceptible of improvement, this process appears to be of a nature to render service to the fisheries and to fish culture.

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The following paragraph is taken from: Refrigeration of Fish, by Harden F. Taylor, p. 631, of Bureau of Fisheries, Document 1016 (Appendix 8 to the Report of the U. S. Commissioner of Fisheries for 1926 (1927). Washington, D. C.

HOLDING LIFE FISH BY REFRIGERATION

It is known that many species of fish hibernate in winter; that is, they become inactive under the influence of low temperature, consume no food, and lie dormant for a long time. Carp have been known to be inclosed in solid ice and survive. (The freezing point of fish is lower than that of water, so that it is possible for fish to be inclosed in ice without themselves freezing). Mir and Audigé devised a method of taking advantage of these facts by inducing hibernation artifically. The fish are held in tanks of aerated water, chilled to the freezing point. The fish become torpid. The water is then slowly frozen around them, care being taken not to lower the temperature below 32° F. The fish remain alive, dormant, and surrounded by solid ice, and if released by careful defrosting will still live. Oxygen must be present and available in small quantity, else the fish will suffocate, for they require a slight amount of oxygen to sustain life processes. This does not appear to be a practicable commercial procedure, though it might be useful in certain instances.

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*/ This article was translated from the French by Jessie E. Drayton, November, 1916. Supersedes Memorandum S - 291 issued by former Bureau of Fisheries.