XVI.—THE ARTIFICIAL PROPAGATION OF FISH.

By J. P. J. Koltz.

Chapter I.

§ 1.—*The artificial fecundation of fish-eggs.*

Whoever desires to engage in the artificial propagation of fish should endeavor to take nature for his guide in his manipulations. In the present work we shall do everything in our power to explain every principle by an example from nature, and shall refer to the results of experiments made in other places, without, however, entering into a useless and detailed examination of the different methods which so far have been recommended. We shall above everything else limit ourselves to indicating those methods which, after repeated experiments, promise certain success, directing attention at the same time to those points which are still somewhat dark and on which positive observations must throw further light.

When the spawning season has commenced one procures some males and females of that kind of fish which he desires to propagate artificially or to cross with other breeds. These fish are placed in tanks of sufficient size, keeping if possible each kind of fish separate, and taking care to give to all kinds those conditions of life which their nature demands. Thus trout, salmon, barbel, &c., which live in running or cold water, and propagate in it, should be placed in basins or tanks fed from springs, or by clear water

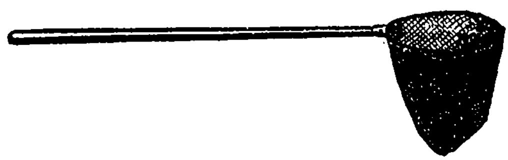

Fig. 1.

which is renewed from time to time; whilst the carp, tench, &c., which spawn in stagnant waters, should be placed in such water. These tanks have a double bottom, the upper one being of open wicker-work, whilst the lower one is a movable hair sieve. The young fish can then be taken out by means of a fine net, shaped like a dipper and furnished with a long handle (Fig. 1). If it is impossible to obtain tanks like those above described, the female fish are placed either in a fish-box (a kind of per-

* *Traité de la multiplication artificielle des poissons.* Brussels, 1858.—Translated from the French by Herman Jacobson.

forated box), placed in the water, or in a large cage furnished with floats* (Fig. 2), which is so placed as to insure all the conditions necessary for the health of the fish. One may also use the box depicted in Figure 17 after having taken out the hatching frames, which are no longer needed.

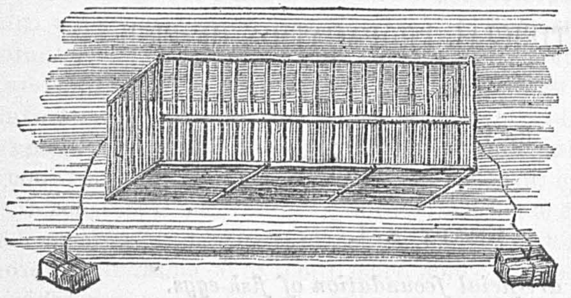

FIG. 2.

In case it should be impossible to procure live fish for the purposes of propagation, it will be necessary to operate with fish which have been dead for two or three hours or more. It is well known that the milt contained in the genital organs retains its fecundating property for a long time, and does not even lose it through frost; but we still lack positive and exact data as to the length of time in which eggs will retain the faculty of being impregnated by spermatozoa with regard to changes of temperature and to the different kinds of fish. Nothing but continued observations will lead to the solution of this problem.†

Towards the time when it may be assumed that the fish which are to be propagated are ready to lay their eggs, they must be watched so as to take them in the exact moment when the eggs are about to be laid. The following external signs indicate the near approach of this moment: The belly of the female is slightly distended, the anal opening is very moist and swollen and protrudes like a hemorrhoidal tubercle; the eggs, surrounded by an abundant ovarian secretion, are free from all connection and may by the slightest pressure be moved about in the cavity in which they have fallen. These eggs do not change color until they have come in contact with the water.

These symptoms are less pronounced in the male, but the slightest pressure on the abdominal walls provokes the emission of the milt and leaves no doubt as to the approach of the spawning period. One can now proceed with the fecundating process, which may take place in two different ways, according to the distinction made between fish laying *free* eggs, such as the trout, salmon, &c., and those whose eggs adhere to other bodies, such as the tench, carp, gudgeon, &c.‡

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* J. Lamy: *Éléments de pisciculture*, Paris, 1855.

† It has been stated that eggs extracted from dead female trout and salmon, although beginning to show a change, were still endowed with the faculty of being fecundated by the milt from a male fish in the same condition; and the Munich piscicultural establishment frequently works with eggs bought in hotels or from fishermen. The result, however, is never as complete as with eggs from live fish.

‡ COSTE: *Comptes-Rendus*, 1852, i, 985.

§ 2.—*Artificial fecundation of free eggs.*

For this purpose one may use any vessel of glazed clay, porcelain, stone, wood, &c.; the circumference of the upper edge should almost be equal to that of the bottom, which ought to be flat, so the eggs can spread over a certain surface and not be crowded. Water is poured into this vessel so as to cover the bottom to the depth of about 10 centimeters. This water, which should be clear, may be taken either from the stream or pond where the hatching apparatus is to be placed, and where the eggs ought to develop, or from those waters where the fish about to be propagated generally live. It is necessary to ascertain if the water has the temperature observed at the time of the natural spawning. When the water of those rivers is used in which a fish about to be manipulated propagates naturally, its primitive temperature should above everything else be preserved. For this purpose, and if one operates in the open air, as near a trout-brook, it will be preferable, in order to accelerate the manipulations, to operate only on small quantities and to use fresh water every time.

As soon as these preliminaries are finished, one takes up a female fish with the left hand and holds it perpendicularly by the fins of the head over and as close as possible to the vessel. When the fish is in this position the eggs which are near the anal orifice are emitted through their own weight. If this is not the case, the belly of the fish ought to be pressed very gently by moving the thumb and forefinger up and down. (Fig. 3.)

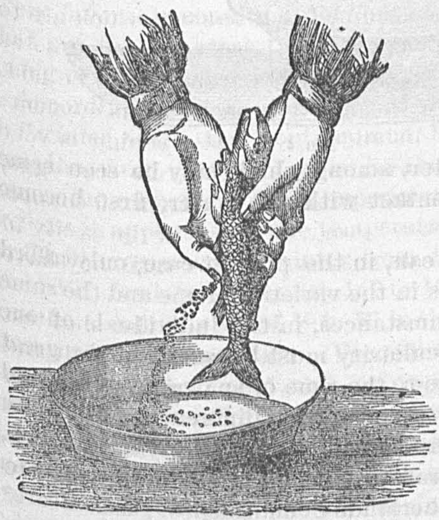

FIG. 3.

As soon as the eggs, which have been extracted in the above manner, form a thin layer at the bottom of the vessel, one takes a male fish, treating him in exactly the same manner as the female, until the water becomes slightly turbid, or assumes the appearance of milk which has been violently stirred. This mixture is thereupon stirred either with the tail of the male fish, held in the water during the operation, or with the hand, or with the beard of a brush or a feather. After letting it stand for 5 or 10 minutes fecundation is accomplished.

If the strength of the tail of the fish operated upon necessitates the employment of an assistant, the above manipulations are modified; the assistant holding the tail of the fish whose convulsive and irregular motions inconvenience the operator. The fish is then, necessarily, in an almost horizontal position, and the pressure on the belly is exercised in the manner indicated in Fig. 4.

The following are invariably the essential conditions of success in the above-described operation: Perfect maturity of the eggs, suitable temperature of the water, and rapid execution of all the manipulations.

We have above given the signs by which the near approach of the spawning season may be recognized. The degree of resistance met with in the operation of expelling the eggs furnishes the most certain indication in this respect. If a first attempt should be without result it will be necessary to return the fish to the water or to their basins and to renew the experiment one or several days later. The experiment will not succeed if one has waited too long in freeing the females from their burden. This may be recognized by the simultaneous emission of a purulent yellowish matter, among which may be seen some eggs, which, when brought in contact with the water, first become opaque and then turn white.

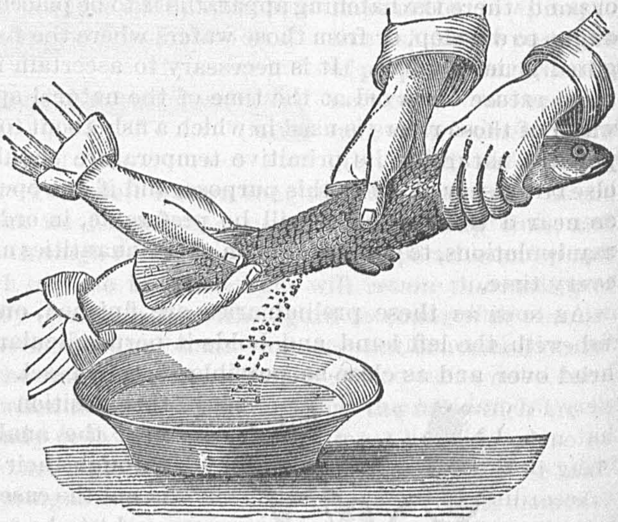

FIG. 4.

The habitual spawning period can, in the present case, only afford very little aid, as it not only differs in the varieties of one and the same family, but also, according to circumstances, in the individuals of one and the same variety. To this peculiarity must be ascribed the great difference between the data relative to the time of spawning of one and the same species of fish. As an instance of such differences in the data which we possess, we will mention the common trout (*Salmo fario*), which, according to the location and temperature of its different stations, spawns from September to March. The Netherlands Commission of Pisciculture* gives as the spawning season of this salmonoid the months of September and October, whilst M. Coste† gives the time from November to February. In the streams of the Vogelberg, in Germany, spawning commences about the end of September and seems to come to a close about the 1st November, as about that time no more trout containing eggs are caught. In the Grand Duchy of Luxemburg spawning generally com-

* *Handleiding tot de kunstmatige vermenigvulding van vischen*, p. 22.

† M. COSTE: *Comptes-Rendus*, 1852, p. 139.

mences about the end of November and is finished about Christmas. The spawning season for Southern Germany is during the months of November and December, and during these months the greater number of experiments in fecundation have been made by Mr. Detzem. J. Lamy* says that trout spawn from the 15th of December to the 30th of January, and Grand Forester Wagener of Detmold† reports that in 1853 he succeeded in the artificial fecundation of the fish in question as late as March.‡ These facts prove sufficiently how necessary it is to have strict regard to the above-mentioned indications for recognizing the maturity of the spawn, as it is not safe to be exclusively guided by the indications as to the time when spawning takes place.

The preservation of a suitable temperature during the process of artificial fecundation is just as important as the perfect maturity of the eggs. Although we still lack complete and positive data relative to the extremes of temperature between which the fecundation of the different kinds of fish can be more or less successfully accomplished, it may be considered as definitely settled that the success of the experiment depends essentially on the temperature of the water, and that, owing to differences of temperature, it is often retarded or accelerated, and even in certain cases does not take place at all. Every pisciculturist knows that fish never fail to spawn in certain waters presenting every favorable condition but that of the temperature of the water, but that not the slightest trace of young fry could be discovered, simply owing to the absence of a suitable temperature.

According to the average period when fish spawn they are divided in "*winter fish*,"—the trout, salmon, burbot, &c.; "*early spring fish*,"—the pike, &c.; "*late spring fish*,"—the perch, &c.; "*summer fish*,"—the tench, the carp, &c. From experiments made in France by M. *de Quatrefages* it appears that the temperature most favorable for fecundation is, for fish spawning in winter from 4° to 6°, for early spring fish from 8° to 10°, for late spring fish 14° to 16°, and for summer fish 20° to 25° Celsius. A difference of 4° to 5° in the above temperatures may thwart the success of fecundation. We will not attempt to disprove this assertion so far as the winter and early spring fish are concerned, although we have successfully fecundated trout eggs at a temperature of 4° to 8°. As regards the other two classes of fish, we take the liberty to entertain doubts, whilst maintaining that the determining of the extremes of temperature should be made the subject of continued and careful observations.

The necessity for executing the different manipulations of the process of fecundation as rapidly as possible is already explained by what we said above regarding the temperature of the water. But this rapid

* J. LAMY: *Éléments de pisciculture*, Paris, 1855.
† DR. FRAAS: *Ueber künstliche Fischerzeugung*, p. 59.
‡ The ordinance of 1669 fixes the spawning season of the trout from February 1st till the middle of May.

manipulation is also necessitated by the circumstance that the milt of most fish loses its fecundating property very soon when brought in contact with the water. The same applies to the eggs, which when first laid are united and surrounded by an almost invisible mucilaginous covering. When brought in contact with the water this covering becomes bloated in a few seconds; the fecundating spermatozoa can no longer reach the egg, and are thus, by the sheer force of circumstances, prevented from performing successfully the process of fecundation. It appears that the substance which unites and envelopes the eggs acts in the same manner as the spawn of frogs which, according to experiments made by Messrs. *Prévost* and *Dumas*, cannot be fecundated as soon as the glutinous matter which envelopes it has become bloated by water.

§ 3.—*Artificial fecundation of eggs which adhere to neighboring objects.*

In order to accomplish the fecundation of eggs of fish like the carp, gudgeon, barbel, &c., which, by means of a glutinous matter, attach their eggs to any objects near them, the above-described practice must be somewhat modified. One takes a small quantity (a few handfuls) of well-washed aquatic plants, such as the water ranunculus, vessels of the form and size above described, and a trough. Three persons must assist at this experiment; one takes the female fish and relieves it of its eggs in the manner described above, another takes the male fish and extracts the milt, whilst the third stirs the water with a small bunch of herbs and thus facilitates impregnation. The eggs, which are of a viscous nature, adhere to the plants, and when these are sufficiently charged with them, one lets them lie in the spermatized water for three or four minutes in order to give them time to absorb the fecundating molecules. In order that the eggs adhering to the bunches of plants may not dry, these bunches are gathered in a trough, where they are covered with pieces of wet cloth. This manipulation does not offer as many difficulties as the preceding one, but it nevertheless requires considerable attention. Thus it is essential to allow only a quantity of eggs proportioned to the surface which one desires to cover with eggs to fall in the vessel; otherwise they would become conglomerated on the plants, which would be very detrimental to their development.

If there is no other way, two persons may go through this operation. In that case one will extract the eggs whilst the other gathers them on the bunches of herbs. When the eggs have become attached to the plants they are placed in a vessel to be subjected to the influence of the milt of the male fish. The water is gently stirred with the plants in order to subject all the eggs to the influence of the fecundating liquid. After the bunches of plants with the eggs have remained in the water impregnated with milt for 5 or 6 minutes the operation is finished, and the eggs are put away for the purpose of being hatched, either in an apparatus especially prepared for this object or in a tank or basin having the desired conditions of safety and temperature.

Natural spawning places may suffice for everything which has been recommended in the above.

§ 4.—*Artificial spawning places.*

As has been indicated at the end of the last paragraph, the simplest means of multiplying those species of fish whose eggs adhere to foreign bodies is to make the fish deposit their eggs in a place provided for them in a pond or water-course, &c. This may be done by means of very simple and inexpensive apparatus which are generally composed of wooden frames (Fig. 5) of different shapes and sizes, covered with aquatic

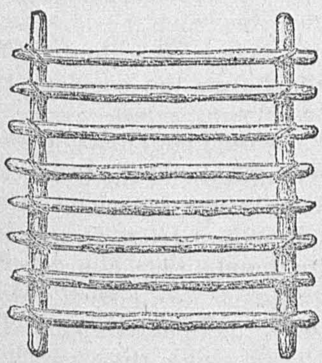

FIG. 5.

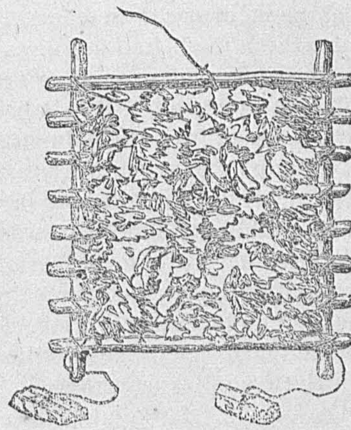

FIG. 6.

plants, brush-wood, &c., arranged in such a manner as to resemble a small roof for sheltering things (Fig. 6). Their size, which varies from 1 to 2 meters, their distribution and position, of course, depend on the different localities. It is always necessary that one end of the apparatus should be weighed down by a sufficiently heavy weight to have about three-fourths of the apparatus under the water (Fig. 7).

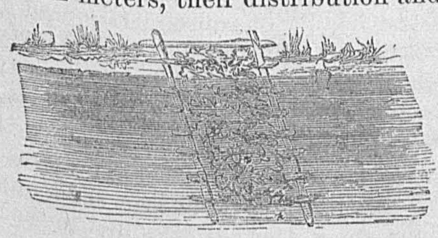

FIG. 7.

One or two months before the presumed time of spawning, these apparatus are placed on the banks of the water where the fish live, and are taken out again after spawning is over. The bunches of herbs are then carefully taken off, and are, in order to insure the hatching, placed under the same conditions as the products of artificial fecundation.

For those fish which deposit their eggs free on the gravel, or hide them in the spaces between the stones, as is the habit of the salmonoids, it will be best to select brooks with clear and not very deep water, and to cover the bed with a thick layer of stones, gravel, and sand, so as to induce the females to come and hide their eggs there.

These measures cannot in all cases replace artificial fecundation unless there is no danger of the spawn being destroyed in its free condition, and thus there is no ground for the objections raised against the natural restocking of our rivers.

§ 5.—*Crossing of different breeds.*

It rarely occurs in nature that different breeds of fish will cross, which is easily explained by the circumstance that the milt soon loses its fecundating property. Guided by their instinct the male fish deposit their milt in close proximity to the eggs laid by the females of their kind. The short duration of the fecundating faculty of the spermatozoa, when brought in contact with the water, does not allow the milt to attach itself to other eggs than those for which it is destined.

The possibility of producing cross-breeds is beyond a doubt. Thus at *Hüningen* a cross-breed has been obtained from the common trout and the salmon, from the salmon-trout and salmon, and *vice versa.* Attempts made in Bavaria to cross the trout and the pike have not proved successful, whilst the crossing of the common trout and the blay (therefore two different families) was successfully accomplished.† Cross-breeds have been produced from different species of trout among themselves, and specimens of these crosses are found in large numbers in the fish-ponds of the veterinary school at Munich. In crossing different breeds of fish, especially salmon, the object is to obtain fish able to live in those shallower waters in which those among them which live near the bottom of the lakes do not prosper.

We only mention these facts briefly, as our experience so far does not justify us in passing a final verdict as to their absolute reliability, and as to the profit which might be derived from crossing different kinds of fish. We have very good reasons for this; the majority of these cross-breeds are deprived of the faculty of reproduction, and if this is not the case they gradually return to their original types. The alleged fact of the sterility of certain cross-breeds is beyond a doubt; it is proven by the hybrid products of various kinds of salmonoids often met with. These cross-breeds, in which Dr. Fraas of Munich invariably found only a few sickly-looking eggs, can never spawn. But there are cross-breeds which can do it, as the cross between the carp and the crucian. Future experiments must show what are the species between which a cross can be effected and the conditions under which this can be done successfully. The objections raised against the production of cross-breeds is well founded, and in order to overcome it

* We occasionally meet with a cross-breed of the crucian and the common carp, and of the latter with the Chinese gold-fish. These cross-breeds may be recognized by having smaller scales and a shorter and thicker head.

† DR. FRAAS: *Die künstliche Fischerzeugung*, p. 57.

one ought to endeavor to confine the crossings to their reasonable limits, and to repeat them through several generations, always crossing the primitive kind with cross-breeds.

CHAPTER II.

HATCHING APPARATUS.

After the eggs have become fecundated they are placed in the hatching apparatus. For this purpose perforated boxes, resembling sieves, baskets of different shapes, boxes of wood, stone, earth, metal; sieves of every kind &c., have been proposed, and the only trouble is which to select among so many different kinds.

The long, open boxes described by Jacobi have for a long time been successfully employed in Germany, and have been replaced by the circular boxes of tinned iron, perforated like sieves, of Messrs. Gehin and Remy, which are still used in Germany, owing to the high praise bestowed upon them by Dr. Fraas, of Munich. He explains his preference for the apparatus of the two fishermen of *La Bresse* by stating the inconveniences presented by wire sieves, which easily rust and favor the generation of parasitical confervæ. The experience of all ages, however, has demonstrated that perforated boxes can only be successfully employed in very pure running water, as the holes easily become stopped up and are rendered useless by the oxidation of the tin of which they are made. The open wicker baskets recommend themselves by their cheapness, but they offer too little resistance to the enemies of the spawn; boxes made of coarse hair present the same inconveniences without even the advantage of being cheap.

These considerations have induced Mr. Coste* to find some method which would always enable him, whenever he deemed it useful, to manipulate the products inclosed in his apparatus and to pass them from the hatching-brooks to the fish-ponds. The incubating apparatus, consisting of artificial streams of continually-running water, were the result of Mr. Coste's researches. Their simplicity and their evident usefulness were immediately recognized, and facilitated the adoption of this system in a more or less modified form. We will first describe the apparatus in use in the piscicultural establishments in the Netherlands.

At the bottom of a common spring, with a capacity of 30 to 35 liters, beds are prepared of gravel, sand, and charcoal. The water, after having passed through the filter, flows through a faucet into a wooden tank, clothed on the inside with zinc or lead (a vessel of glazed clay is preferable); at the end of this tank there is an opening through which the water flows out into a small pond or tank.

The fecundated eggs are placed on hair frames and immersed in the

* COSTE: *Comptes-Rendus*, pp. 43 and 46.

water of the vessels to a depth of one or several centimeters, according to the different kinds of fish. These frames have raised edges which rest on the sides of the apparatus. Their dimensions are as follows: Length, 1 meter; breadth, 0.10 to 0.20 centimeters; depth, 0.05 to 0.10 centimeters.

Fig. 8 represents the incubating apparatus and Fig. 9 the hair frame.

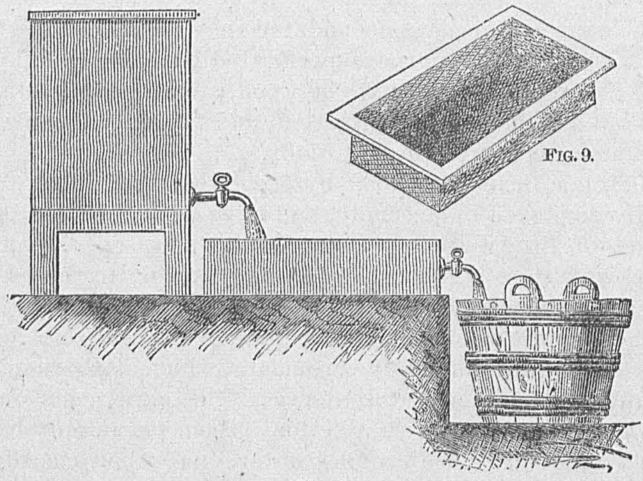

FIG. 9.

FIG. 8.

This apparatus may be considerably enlarged by adding more vessels, or by placing them one below the other in the shape of steps, as indicated in Fig. 10.

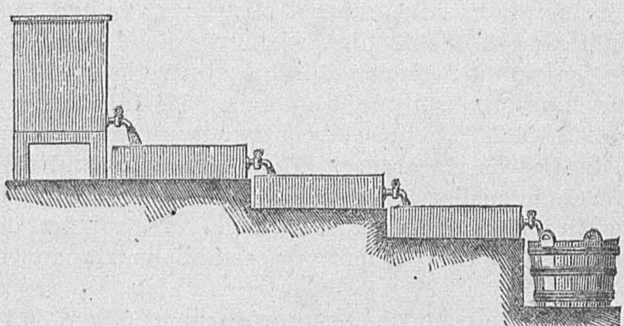

FIG. 10.

At one end or in the bottom there is an opening for a tube to let out the water, with a stop-cock, so that the water can be let out at any time.

For the incubation of trout eggs M. Coste uses an equally excellent apparatus, which is shown in Fig. 11, and therefore needs no further description. The outer portion, which is necessary to support the frames with glass-sticks (which here take the place of the hair-frames), is not seen in the drawing. The dimensions of the different troughs or vessels which compose this apparatus are as follows: Length, 0.52 meters; breadth, 0.15 meters; depth, 0.10 meters.

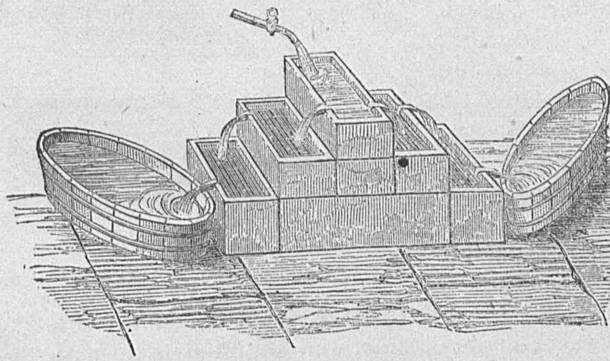

FIG. 11.

These troughs, which have been in use for a long time in Detmold, Germany, are placed in different ways according to the fancy of the operator. The hatching apparatus of the College of France, represented in Fig. 12, will show the utmost use to which this apparatus has been put.

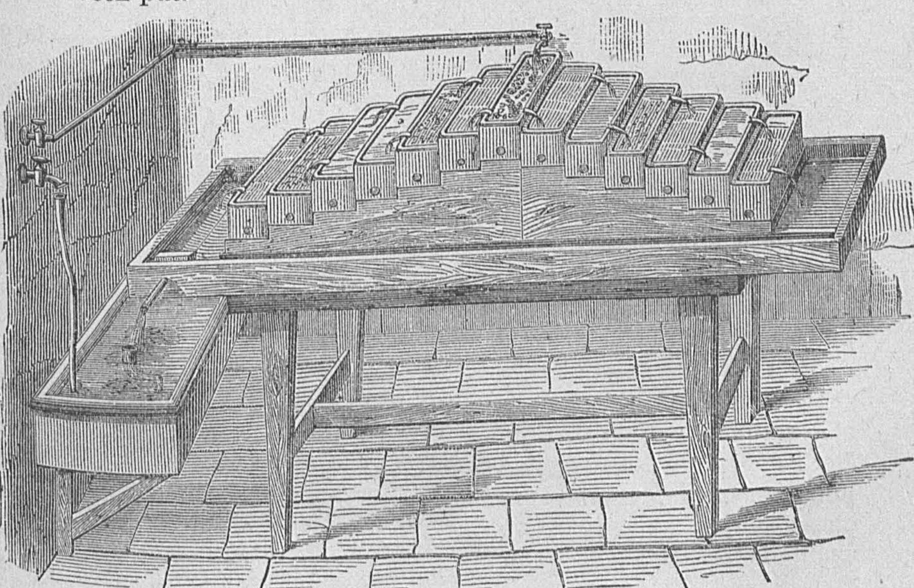

FIG. 12.

The incubating apparatus is placed under a shed, supplied on all sides with hatches opening outward. These openings are intended to let air pass through and to admit heat and light, all of which are necessary for the development of the eggs.

In case it should be impossible to construct any of the apparatus described above, and to carry on the incubating process in water-courses, one may, in pure running water which leaves no sediment, employ boxes like the one shown in Fig. 13, or the boxes of Messrs. Gehin and Remy. These last-mentioned boxes are used at *Scharnhouse.* In order to avoid the dangers threatening the spawn from the oxidation of the tin, Professor Rueff has had them made of zinc, and supplied them with floats. Vessels of glazed terra cotta are also employed, which have all the advantages of the Rueff boxes, and are less expensive (Fig. 14). Some pisciculturists prefer, in spite of the disadvantages mentioned above, flat wicker baskets, with or without floats (Figs. 15 and 16), according to the habits of the fish whose eggs are to be incubated.

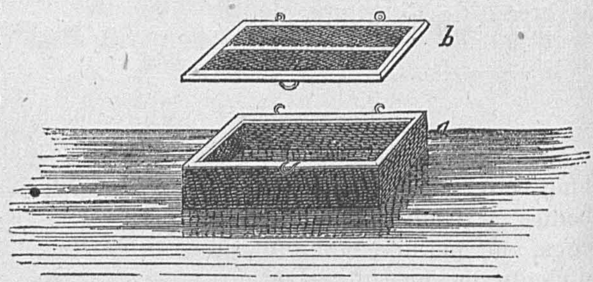

FIG. 13.

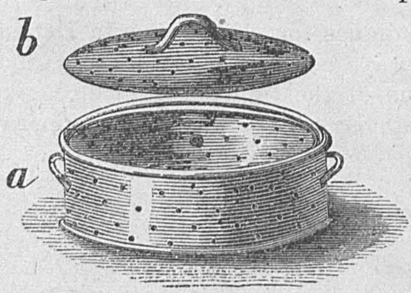

FIG. 14.

Coste* has also constructed an incubating-box which will remedy all the defects of the other boxes. This box (Fig. 17), which is an improvement on the Jacobi box, measures about 1 meter and one-half meter breadth and depth. Its sides and bottom are of solid wood. Its top is formed of a lid in two parts, in the center of which there is a grating of metal wire; and each end is closed by a door, whose opening is larger than that of the lids, and is also supplied with a grating. Both doors and lids move on hinges, open outward, and are closed simply by means of two small bolts fastened with strings, and, for greater safety's sake, supplied with padlocks. There are no subdivisions in the inside of this box, but there are running along the sides small ledges to support the frames. These frames are of wood

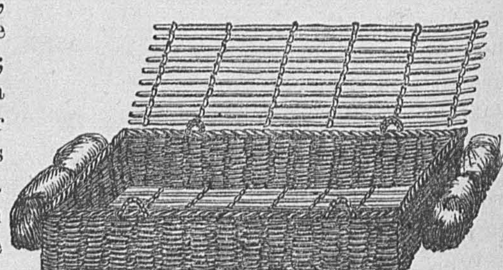

FIG. 15.

*COSTE: *Comptes-Rendus*, p. 55 et seq.

and glass sticks. But as these frames are intended to be put one over the other, the box must be somewhat higher than in the trough apparatus, and at the ends there must be large notches for the free passage of the water. To render the process easier, their surface must not (if the box has the length mentioned above) represent more than one-fourth of its capacity, so that four of them may be on the same floor.

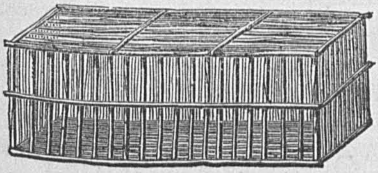

FIG. 16.

This box, which should be used in running water, can be used for free eggs and for eggs adhering to foreign bodies. In spite of its small size, it can hatch a very large quantity of eggs, and permits manipulations, which in the "sieve apparatus" are difficult or hurtful. For the purpose of observing what is going on inside, and to clean the gratings when they have become obstructed by sediments, the lids and doors can be opened as often as desired, without taking the apparatus out of the water and without disturbing the frames and the eggs. Whether attached to a floating frame by clamps or by strings attached to pegs driven in the ground, it must present to the current one of its extremities when the current is moderate and one of its angles when it is very rapid. A bed of pebbles and fine sand placed at the bottom receives the young fish, which either fall or descend on it as they are hatched, and offers them favorable conditions for their further development, till the time arrives when the gates can be opened and they can be set at liberty in some river or pond. Fish of small size will escape through the meshes of the wire grating and disperse through the water.

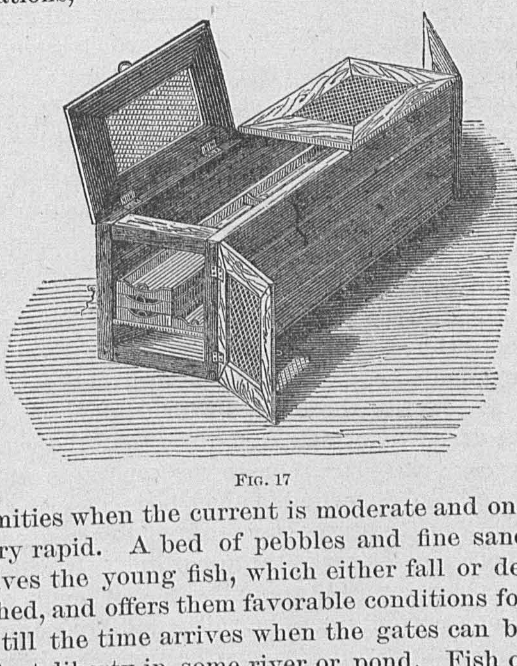

FIG. 17

When the hatching process is finished, all the frames are removed from the box, so that it can be cleaned, and better care can be bestowed on the young fish imprisoned in it.

Whenever it becomes necessary to place one or the other of the above-mentioned apparatus in stagnant water, the bottom should be covered with aquatic plants, to prevent this water, which of course is not renewed, from spoiling, and form an inexhaustible source of oxygen, which is so useful for the development of the embryo.

Wherever propagation is to be carried on on a large scale, it will be preferable to have hatching-canals, which should have solid walls, so as to exclude water-rats, as well as the *Disticus marginalis* and *Hydrophilus piceus* (both as larvæ and in their perfect state), and a good covering, and be provided with wire gratings, both to protect the fish from the voracity of other inhabitants of the water and to prevent their dispersion.

These coverings also prevent the appearance of the greenish mold which generally forms on the stones at the bottom, and which is composed of diatoms and other small algæ.

Chapter III.

§ 1.—*Hatching eggs in incubating apparatus.*

After the eggs have been fecundated either near or in water having the same temperature as that in which the hatching apparatus is placed, they are carefully put in this apparatus. By observing these conditions no disturbance need be feared from any sudden change in the temperature of the water. For incubating the free eggs of salmon and other winter fish, the specific weight of which is much greater than that of the water, and which consequently descend to the bottom of the apparatus, it will be necessary to furnish the apparatus with a layer of gravel several centimeters thick, and to see to it that this layer is uniformly covered with the eggs. Mr. Detzem and several other practical pisciculturists put a layer of fine sand on these eggs; others again avoid doing this, so as to be able to constantly watch the eggs, and to remove any spoiled eggs or causes of destruction.

As regards those eggs which adhere to foreign bodies, like those of the carp, &c., which are lighter than the water in which they float, it is necessary to place them in the apparatus with the plants on which they have been deposited, as has been described in Chapter I, § 3, of this treatise. It is necessary to avoid currents which would carry the eggs to one single part of the apparatus. It will, therefore, be best to select the stagnant and tranquil waters of ponds or canals where the effect of strong currents can be mitigated by using apparatus with very close wire gratings. In this case the apparatus must not be entirely submerged but should be placed in such a position that there is an empty space between the water and the lid. A few centimeters of water suffice for apparatus in which the water is easily and regularly renewed.

It should be mentioned that with Coste's apparatus and the one used in Holland, the eggs are deposited on glass or wire frames, and that no gravel is required; whilst the ingenious system of artificial brooks with constantly running water, invented by Coste,* regulates the distribution of the water in the most suitable manner.

It should also be observed that eggs which have been transported, or which come from a distance, should be gradually accustomed to the

* *Comptes-Rendus*, 1852, p. 301.

temperature of the water in which they are to be hatched, and that in that case it becomes necessary to place them for 24 hours with the boxes in water which has the same temperature as that which feeds the apparatus.

We must finally direct attention to the practice introduced by some German pisciculturists, to place the eggs, immediately after they have been fecundated, in those waters where they are to stay during the period that elapses between the two extremes of their life. The only precaution they take is to place the eggs in the most suitable location and to shelter them as much as possible from hurtful influences.*

§ 2.—*Rules to be observed during incubation; maladies and enemies of the eggs.*

During the entire period of their development the eggs require constant and watchful care. In the first place care should be taken, as has already been recommended above, that the eggs, no matter in what apparatus they are kept, are not piled up too high, but are evenly spread over the whole surface. If this is not observed, it would not only be impossible to constantly watch the eggs, but they would not develop evenly and their development may be indefinitely delayed. Piling up the eggs too high is also apt to produce those maladies which attack fecundated spawn. Confervæ and parasitical plants (Fig. 18) produced by the constant moisture in which the eggs are kept are particularly injurious to the spawn. They first attack the spoiled eggs, which may be recognized by their yellowish color, and by being opaque, and cover them with filaments of different colors.

FIG. 18.

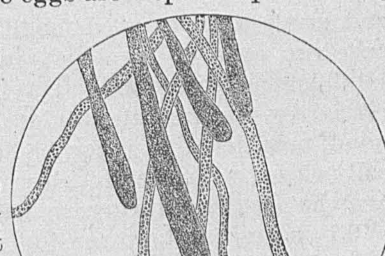

FIG. 19.

A small alga (*Leptomitus clavatus*, Fig. 19) is particularly active in carrying on this work of destruction. It is true it can only grow on spoiled or dead eggs; but it will envelop healthy eggs in a thick and fuzzy net, and will thus choke them. The only remedy against these parasites, the propagation of which would be diminished or hindered if the eggs had been evenly spread, or if the apparatus had been cleaned at the proper time, consists in immediately removing, by means of a pair of pincers, (Fig. 20) all the eggs which show the slightest trace of infection. It would not only be a useless trouble, but the evil would only be increased, if, instead of removing the infected eggs, one would endeavor to save them by attempts to destroy with the pincers the parasitical plants which

* VON SCHEWEN: *Zeitschrift des landwirthschaftlichen. Vereins für Rheinpreussen* 1857, No. 1.

cover them. Infected eggs are hopelessly lost, and in the attempt to clean them detached germs of these parasites might transfer the malady to eggs which so far have been spared.

Another very dangerous enemy of the spawn is found in the family of the *diatoms*, some of which attach themselves in enormous quantities to the stones and gravel at the bottom of the apparatus and cover it with a brownish or yellowish-green covering; they thereupon attack the eggs, exclude them from the air, and thus cause the death of the spawn, no matter to what degree of development it has attained.

FIG. 20.

The species most to be feared are (Fig. 21) *Meridion circulare* (*f*), *Synedra angustata* (*a*), *parvula* (*b*), *acicularis* (*c*), VAUCHERIÆ, *palea* (*d*), *mucida*, and the *diatoma pectinale*. We possess two very excellent remedies against these plagues of the pisciculturist. These are: rapidly running water and the exclusion of light; but whilst the first can only be applied to fish of the salmonoid species, the second will, under all circumstances, prove effective, is not at all hurtful to the spawn, and can be applied anywhere. The exclusion of light hinders the propagation of the diatoms and confervæ, whilst the eggs can be successfully hatched even in the densest darkness.* Several authors also recommend in such cases to transfer the eggs to other vessels. The crooked and straight pipes used for this purpose can only be employed in small establishments, and they may be replaced by the first glass tube near at hand, provided that it can be hermetically closed with the thumb when the eggs have entered its lower portion. It will be necessary, however, to have due regard to the state of development of the spawn, and only to employ this remedy when it is absolutely necessary, and even then only when the eyes of the embryo are visible.

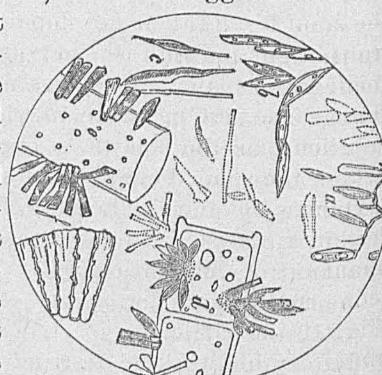

FIG. 21.

The intervention of man is also required when the eggs are attacked by the larvæ of insects, and particularly by those of *Disticus marginalis* and *Hydrophilus pisceus ;* nothing but constant watchfulness can prevent the ravages which they would cause. Another small insect, probably in its larva state (*Ascarides minor?*), and which probably comes from fish used in the operation, is very dangerous to the eggs at the time when the embryo has almost reached its full development. It pierces the outer shell of the egg and devours its contents. As the presence of this animalcula can only be recognized by the shells of the eggs floating near the surface, there is no time to think of its destruction.

* This observation is based on positive and repeated experiments. The hatching process takes place in a regular manner, but is somewhat delayed.

Water rats are also extremely dangerous to the embryo. They may be destroyed (though with considerable difficulty) by means of wire traps. In order to prevent as much as possible the approach of these unwelcome guests one should be careful not to destroy the damaged eggs near to the hatching apparatus, as thus the odor of putrefying animal matter which attracts the rats will be avoided.

We must once more direct attention to what has been said above regarding the temperature of the water. We believe that, if the water in the incubating apparatus is kept at the temperature which we have given above as being most suitable for fecundation, the first condition for a natural and rapid development is fulfilled. The person in charge of the apparatus should always watch the thermometer; by opening or closing the apparatus, or by adding cold or hot water, an even degree of temperature may be maintained.

§ 3.—*Transformation and development of the egg.*

There are various changes in the appearance of eggs which have been fecundated; one might almost say that their contents become turbid and that they become less transparent than when they left the opening near the anal fin; they again, and almost imperceptibly, assume their first transparent appearance, whilst in the inside there may be observed a small circular spot which was not seen there at first* (Fig. 22, 1). This change has erroneously been considered *a certain sign of fecundation;* it takes place both in fecundated and non-fecundated eggs, but it develops more slowly and irregularly in the latter (Fig. 22, 2).

During the first moments and even during the first days it is (with certain kinds of fish) impossible to distinguish with the naked eye fecundated from non-fecundated eggs, but when examined under the microscope there can no longer be any doubt.

After a certain time an arched line makes its appearance in the fecundated eggs (Fig. 22; 3, 4, 5). This time differs not only according to the different species of fish to which the eggs belong, but also according to the temperature of the water in which they are placed. Farther down we shall point out the causes of this (Fig. 22).

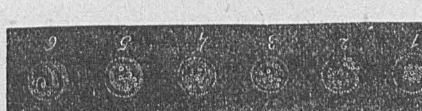

FIG. 22.

This line increases in size with the gradual development of the eggs; whilst one of its ends is prolonged in the shape of a tail, the other assumes the form of a spoon. This latter part is the future head of the young fish; the eyes, which now appear like two brown points† (Fig. 22, 6), prove this sufficiently.

The motions, particularly of the tail, of the young fish become more

* This fact has already been observed by ARISTOTLE. *Hist. anim.*, lib. 6, cap. 14.
† Also noticed by Aristotle.

and more noticeable according to the degree of its development. These motions, which cause the bursting of the shell which incloses the embryo, increase in violence till the moment when the young fish leaves the egg.

Finally, there is formed in the shell of the egg a small opening which allows the young fish to slip out of his place of imprisonment.

Either the tail or the head generally appear first; sometimes the umbilical bladder makes its appearance before either of the above-mentioned members. But whatever part of the body emerges from the shell first, the young fish is not yet master of all its motions. It remains partly inclosed in its shell, and only gradually and by repeated efforts does it succeed in enlarging the opening of its prison; after a few hours it is entirely free (Fig. 23), and can divest itself of a membrane which was only intended to protect it during the early stages of its development, and which was of no use whatever in forming any of the organs of the body.

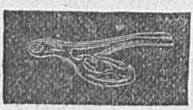

FIG. 23.

The space of time which elapses from the moment of fecundation till the fish is freed from its protecting cover is different with the different kinds of fish. With the pike, it is eight, ten, or fifteen days; with others, like the salmon, it is one or two months.

The development of the fish progresses slower or quicker according to the temperature in which incubation takes place. Pike eggs placed in water exposed to the rays of the sun, and which has not been renewed, are hatched after nine days, whilst other eggs which have remained in the shade in water which has been constantly renewed would require eighteen to twenty days for their entire development.

CHAPTER IV.

RAISING YOUNG FISH, AND THE CARE WHICH SHOULD BE BESTOWED ON THEM.

§ 1.—*Dissemination.*

During the first period after the fish has torn its protecting membrane, it is useless to give it any food, as the umbilical sack, which in certain fish, like the carp, is found in the abdominal cavity (whilst in others, like the trout and salmon, is outside this cavity and can be plainly seen) furnishes it with food until it is entirely absorbed. The time required for this differs in the different species of fish; thus the carp goes without food for two or three weeks. Salmon remain one or two months after being hatched in the incubating apparatus without taking any other food but that furnished by the umbilical sack, or perhaps by microscopic animalculæ found in the water.

The necessity for other food asserts itself with the disappearance of this sack; and the further preservation and raising of young fish will have to follow one of the two methods described below, until further experience has shown which of the two is positively to be preferred.

(1.) Some pisciculturists begin to disseminate the fish in the water which is to be stocked with them as soon as the umbilical sack has been absorbed; they maintain that the young fish, which at that time is particularly lively and active, can escape dangers better than when it has grown larger.

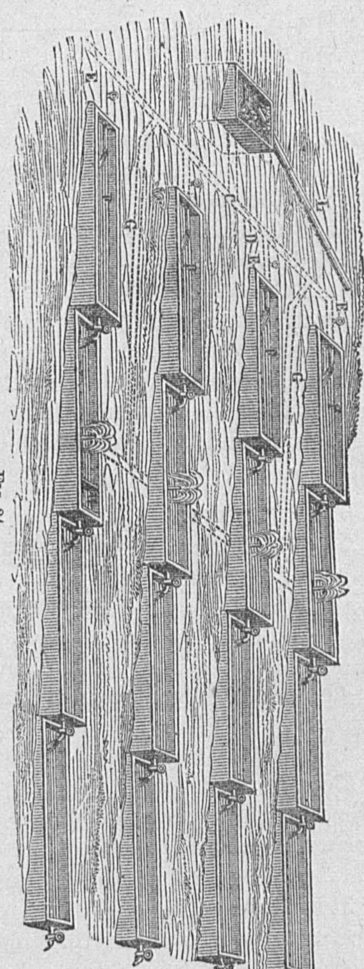

FIG. 24.

The fish, moreover, becomes accustomed to the water in which it is to grow, and will not have to undergo a change of water and food, nor be subject to transportation, the expenses and difficulties of which increase as the fish grows older.

(2.) Other pisciculturists feed the fish for some time, and place them in special basins of different size, among which we would choose those of the piscicultural establishment of *Enghien-les-Baines*, as modified by the Netherlands Fish Commission (Fig. 24), which combines all the advantages of salubrity and easy management.

We give only those explanations which are absolutely necessary for understanding our sketch. The wooden sluice or the lead pipe A leads the water into the square basin B, which serves to filter the water; it is filled with stones and has a lid.

On the opposite side of this basin there is the lead pipe C, which opens into the transverse pipe D, of the same metal; the four tubes E lead the water from the tube D to the upper basin F, whence, by means of faucets, it can be conducted into four lower basins, and even further, in such a manner as to allow it to flow with ease.

Between the tubes F there are joined to the transverse tubes D the longer tubes G, which empty into discharging tubes; on these latter there are placed perpendicularly other tubes destined to form little fountains. These fountains may be provided with stop-cocks. The fish are placed in these basins, the water of which is continually renewed, until they have reached a certain size.

In order to prevent the little fish from getting into the faucets by which the different basins communicate—which, of course, would very seriously interfere with such communication—small wooden boxes are used, which are partly filled with stones, and which are placed in the basins at some little distance from the faucets (Fig 25).

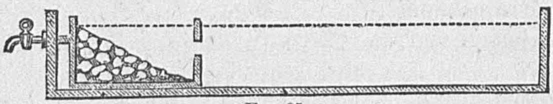

FIG. 25.

The faucets are placed in the walls of the large basins, which are put in communication with the small basins by means of a discharge pipe; one or several holes opposite to that of the discharge pipe serve to prevent the water from flowing out too freely.

In Fig. 24, H indicates the place where one of these small boxes is located, whilst Fig. 25 gives the profile of the two basins placed one within the other. The little fish would have to pass through the entire mass of stones before they could reach the stop-cocks.

In case the rising of the water should fill the basins too much, it will become necessary to draw off the surplus water by means of tube L, and lead it to some convenient place.

Figs. 26 and 27 give the elevation and ground plan of these basins rising one above the other like steps. The scale is 1 to 600.

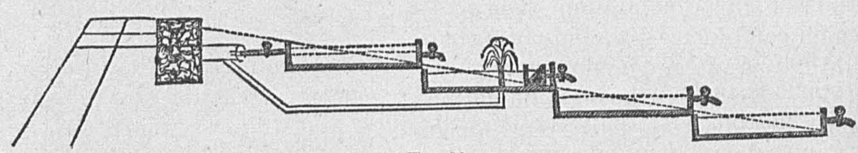

FIG. 26.

The dotted line indicates that part of the apparatus which is under ground.

In case the level of the water is not high enough above the ground on which the basins are to be constructed, it will become necessary to lead the water, by means of pumps or other contrivances, into a common reservoir destined to feed the entire establishment. The basin B can very well be replaced by a filter placed in the common reservoir.

It is probably not necessary to demonstrate that the young fish should be fed as nearly as possible in the same way as they would feed if they were entirely free. We therefore think it advisable to plant some aquatic plants in the basins where those fish are which feed on plants and insects; they ought also to have all the worms and larvæ that can be procured, as well as insects of the species *Cyclops*, *Cypris*, and *Cythera*, which in spring are plentiful in fresh water; boiled peas, hemp cakes, bread, &c., may also be given to them.

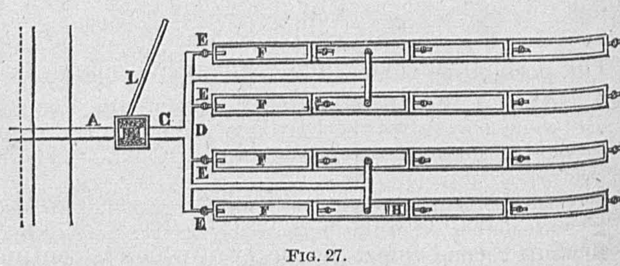

FIG. 27.

Those fish which live on their congeners may be fed with the spawn and young fish which they have produced. If it is not possible to do this, the following articles may be used to advantage: whiting, reduced to a paste; frog meat, cut, dried, and made into a very fine powder; veal or beef cooked and chopped up fine, or blood dried and pulverized. If this kind of food is used, the basins should be well cleaned from time to time, so as to prevent any accumulation of decaying animal matter.

As soon as the fish are large and strong enough to encourage the hope that they will not fall a prey to their worst enemies, they are let loose in the water which is to be stocked with them, or they are forwarded to those places where that particular kind of fish is desired, in kegs filled with water.

We are not in favor of any prolonged stay in the piscicultural establishments, except where foreign breeds of fish are to be acclimatized, where rare species are to be multiplied, or where continued stocking of waters necessitates the constant production of young fish; and even in this case it will be necessary to consider whether it is not preferable to place the young fish in basins specially set aside for that purpose.

§ 2. *Sickness of young fish.*

When fish-ponds are established in much frequented localities, it often happens that dead fish are found at the bottom. They generally sink to the bottom with their mouths wide open, and when examined the entire buccal cavity is found to be filled with blackish flakes. These are produced by small atoms floating in the air, which fall into the water and gather into small flakes, which the movements of the fish scatter throughout the whole pond. This detritus, which is too light to be swallowed, enters the respiratory organs, obstructs them, and finally causes asphyxia.

This evil may be remedied by supplying the apparatus with a double bottom, either by means of a wicker frame, or some tissue with large meshes, which is placed between the bottom of the basin and the space reserved for the fish.

§ 3. *Acclimatization.*

The possibility of acclimatizing fish was demonstrated a long time ago. Among the ancients, the Chinese* and the Romans hatched the

* Several authors tell us that the Chinese have from time immemorial pursued a method which only now begins to be known in Europe. Inquiries relative to this subject show that their whole merit consists in having transplanted eggs from one water to the other. For this purpose they gather spawn which has been fecundated in a natural manner on mats, which answer the same purpose as our artificial spawning-boxes, and which are sold by measure. No one will seriously consider the method recommended by their authors, to put spawn in egg shells, to seal these up hermetically, and have them hatched by a bird!!

spawn of salt-water fish in fresh water, and succeeded in acclimatizing them. In the sixteenth century Marshall imported carp into England.

A hundred years later the gold carp (*Cyprinus auratus*) was introduced into Europe from China, and at the present time is a frequent ornament of our ponds and of glass globes in our parlors. Towards the end of the last century the celebrated Dr. Franklin† gathered fecundated spawn of the Norfolk herring on marine plants, and successfully transplanted these fish to the inland waters of America, &c., &c. *M. de Lacépède*, in his *Traité des effets de l'art de l'homme sur la nature des poissons*;‡ and Backwell in his *Travels in Tarentaise* and in the *Edinburgh Review* of 1822, demonstrated the usefulnesss and possibility of such acclimatizing experiments, and directed special attention to the salmon family, which also at the present day forms the principal subject of our experiments. It was reserved for our modern pisciculturists to make this question the order of the day, and to hasten its solution by the facility and certainty which the artificial methods have brought to the propagation of fish. This facility of multiplying rare or foreign species of fish opens out a wide field of profitable speculation. No one will deny the great benefit which agriculture has derived from the introduction and the crossing of foreign breeds of domestic animals, and which horticulture has derived from the acclimatization, cultivation, and hybridization of rare and exotic fruits and plants. These facts show what we may justly expect from pisciculture; and the experiments which have been made of late years prove that these expectations have not been disappointed. The large quantities of fecundated eggs which have been transported in France and in foreign countries by Coste, Fraas, and by the *Hüningen* establishment, and the satisfactory results of all these experiments, are as many guarantees for the practicability of this method.

CHAPTER V.

MEANS USED FOR TRANSPORTING EGGS AND FISH.

Our knowledge of the methods of preserving and transporting fecundated eggs of fish is based on observations made in France in connection with the practical experiments in artificial propagation. Although it has been known for some time that aquatic birds, and particularly ducks, often become the propagators of fish, the fecundated spawn of which had become attached to their feet, no conclusion had been drawn from this circumstance relative to the subject of this chapter, nor to the solution of the question how long eggs can remain out of the water without endangering their ulterior development.

* LACÉPÈDE: *Œuvres.* Paris, Duménil, 1836, ii, 255.

† VON EHRENKREUTZ: *Das Ganze der Angelfischerei.* Quedlinburg, 1856, 6th ed.

‡ LACÉPÈDE: *Œuvres*, ii, 253.

The means which have been recommended for transporting fish-eggs are very numerous. The one which recommends itself on account of its simplicity, and which is invariably successful, is to use flat boxes, measuring 10 to 12 centimeters in height, which have been previously furnished with a piece of moist linen or muslin, to spread the *free* eggs on them, and to cover them well. These pieces of cloth are moistened from time to time. Of late years cloth has been replaced by aquatic mosses (*Sphagnum*), between which the eggs are placed in layers. This way of transporting eggs will invariably prove successful if the eggs do not touch each other, and if the pressure of the upper or the lower layers of moss is not too great.

As regards *glutinous eggs*, like those of the perch, it is recommended to place them with some bunches of aquatic plants in glass globes about three-fourths full of water. *Eggs adhering to foreign bodies*, like those of the carp, should be wrapped with the bodies to which they adhere in moist cloths and be placed in a box or basket, on a layer of moist plants, in such a manner as not to bring any great pressure to bear on them.

The forwarding of spawn in glass globes filled with water, which has lately been recommended by some, is fraught with great danger to the life of the embryo, and this method should, therefore, only be employed in the cases indicated above. The shell of the egg is easily broken by the motion of the water in the globe, and the germ is thereby destroyed.

In all cases, and whatever means of transportation are employed, it is essential not to pack the eggs immediately after their fecundation. Experience has shown that the most favorable time for transporting spawn is *the period when the embryo is far enough developed to show the eyes like two black spots on the membrane of the shell.**

The forwarding of fish is regulated by the age of the fish which are to be transported. *The younger the fish, the easier it is to transport them a great distance.*† Fish which have been recently hatched are inclosed in vessels filled with water, in which a few aquatic plants are placed. When still in the state of young fry they are placed in large buckets three-fourths filled with water, the motion of which is deadened by means of a board or a wreath of straw placed in the water. Spring or autumn are the seasons most favorable for transporting fish.

In summer the heat and thunder-storms may kill the fish. If they have to be transported during this season, they should be forwarded by night, and fewer fish should be put in the vessels. Care should be taken to keep the water constantly in motion, even when the vehicle conveying the fish stops.

During long journeys it is necessary to renew the water from time to time, in such a manner as not to produce too great a difference of temperature between the old and new water. It is also necessary that air should enter the tubs at all times.

*M. COSTE: *Comptes-Rendus*, p. 109.

†M. COSTE: *Comptes-Rendus*, p. 110.

CHAPTER VI.

EXPENSES OF THE ESTABLISHMENT AND OF RUNNING IT.

The cost of the first establishment of piscicultural apparatus, and of their maintenance, will depend on the object for which they were established and on the extent to which the work is to be carried on. If the operator wants to have recourse to artificial means of propagation only for stocking small sheets of water, for which he would only need 30,000 to 40,000 eggs, the expenses will be very small.

An intelligent workman can, even during a very severe winter, take care of an enormous quantity of successfully hatched eggs, whilst his work will be greatly simplified in spring and during summer, because the fish belonging to these seasons are very prolific. These expenses may, on the other hand, amount to a considerable sum, according to the greater or less extent of the operations and the degree of development to which the fish are to be brought.

The expenses will, in all cases, comprise the ground, sheds, canals, water-courses, and will be regulated according to the location.

The establishment should comprise the following: (1) Fecundating vessels; (2) hatching apparatus; (3) pincers; (4) thermometer; (5) nets, &c.; (6) different vessels.

The principal and regular expenses of the establishment comprise: (1) Wages of the persons in charge of the propagation and the surveillance of the spawn; (2) cost of spawn and its transportation, fish, &c. These expenses are, comparatively speaking, very small, so that for 4,000 to 5,000 francs a year one would have an establishment which would be able to supply on the most liberal scale all the fish needed for stocking the waters of a country like Belgium. With this sum several millions of eggs of the finest kinds of fish could be produced every year.

The operation becomes expensive only when one wishes to raise young fish of a certain age, instead of placing them as soon as possible in those waters where they are to live. In that case a sufficient quantity of the proper food should be procured, their development should be watched, they should be regularly fed, and protected against the attacks of their enemies. All this would in the end amount to more than the value of the fish in its *wild state;* for it should be remembered that pisciculture will only yield a certain profit, proportionate to the capital invested, if the means employed are simple and follow nature. It would therefore be profitable to scatter the young fish throughout the open waters immediately after the umbilical sack has been absorbed, and to consign propositions for the permanent and prolonged maintenance of fish to the domain of laboratory experiment.

CONCLUSION.

All the above regulations are based on the principle that small piscicultural establishments, founded in those localities where the need of restocking the rivers makes itself felt, are preferable to establishments on as large a scale as the one founded by the French Government at *Hüningen.* In order to justify this assertion, it will suffice to state that one is very apt to make a miscalculation in concentrating all the means for stocking water-courses at his command on a single point. Fish are subject to many contagious diseases. Parasitical confervæ, which attack both the eggs and the young fish, and even at times tolerably large fish, may at a single stroke destroy all that which has been prepared at great expense.

Small establishments will also occasion smaller losses, and can easier be removed to some new locality; one can, moreover, hatch the eggs in water which suits the species, and the expenses incidental to the transportation of fish are saved.

The art of propagating fish artificially is of too recent date to expect that the rules and hints given above are not to be modified or changed in many respects, and that they may not possibly be entirely replaced by other rules based on more recent experiments.

We have indicated those methods which, in our opinion, are the best, and which agree most with those principles which practice and nature have, so far, pointed out to us. The possibility, or rather the certainty, of changes and improvements which may considerably modify these principles, is still another reason in favor of cheap establishments.

In conclusion, we must make the following remarks: A somewhat lively imagination may see in the artificial propagation of fish an unlimited source of production, which may render applicable to our rivers and lakes what is said of the river Theiss in Hungary, that it contains one-third water and two-thirds fish. We consider artificial propagation of fish simply as the means of bringing the finny population of our rivers and water-courses back to that degree of prosperity which they enjoyed before steam navigation, various industries, and other causes of destruction threatened our fisheries with slow but gradual ruin. We look upon the artificial propagation of fish simply as a means of stocking our rivers with fish quicker than nature can do it; but this object can only be attained if sufficient care is bestowed upon the preservation of the young fish, thus artificially produced, after they have been placed in the water. It should not be forgotten that it would be useless to stock our waters with choice kinds of fish if these were left to the mercy of the ignorant and indolent inhabitants of the river banks.

The artificial propagation of fish, is not, and cannot be, a substitute for a well-regulated management of the water courses and their fisheries, but should only be considered as a powerful aid to pisciculture; it cannot, therefore, render unnecessary legislative provisions protecting and restricting the fisheries. Establishments for propagating fish artificially are to pisciculture what nurseries are to forest culture; and as forest culture would be useless if the irregular and destructive management of forests continues, thus the artificial propagation of fish would not aid in restocking the water-course if the young fish are not protected by every means within reach of the law. It will, therefore, not only be necessary to see to it that the existing fishery laws are carefully observed, but that the production, catching, transportation, and sale of fish should be properly regulated.

It will hardly be necessary to observe, in conclusion, that the species of fish which are to be propagated artificially should be carefully selected. This is very important, for if, as an example, one should stock waters with pike, all the other fish would soon disappear.