[ARTICLE 5.—EXTRACTED FROM THE BULLETIN OF THE U. S. FISH COMMISSION FOR 1895. Pages 311 to 324. Plate 55.]

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Fish-Cultural Methods at the Agricultural School at Freising.

The Course of Instruction of the Bavarian Fishery Association.

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5.—NOTES ON FISH-CULTURE IN GERMANY.

NOTES BY S. JAFFÉ ON INTENSIVE POND-CULTURE AT SANDFORT.[1]

In my pamphlet entitled "Trout-culture" (published by Rockhorst, Osnabrück), I have earnestly warned persons who carry on pond-culture on a small scale not to introduce into their ponds artificial food that can not be reproduced in the pond itself. They should till their ponds the same as their fields, and stock them only with fish which the water of the pond will feed without much aid. They should cultivate and increase the live pond-food by introducing snails, mussels, small crustaceans, and useful aquatic plants, but should avoid all dead food.

Wherever water, food, and energy are found, there is no reason why intensive pond-culture should not be carried on. I would, however, lay special stress on the fact that this pond-culture can become remunerative only where there is ample water, food, and time. The principles laid down in this treatise have been successfully followed at Sandfort and other establishments founded on the same plan.

The water of an establishment where trout are to be raised for market should come from ample and steady springs; the ponds should be near, but not too close to the springs, which near their origin contain very little oxygen. It is useful to introduce brook or river water into the pond, so as to occasionally render the water turbid; but river water alone is rather hurtful on account of the rising temperature. To make the water in the ponds occasionally turbid is useful, not only because the particles of soil which are precipitated act as a disinfectant on the remnants of food, but also because they furnish the trout, particularly in cemented and other entirely artificial basins, those particles of earth which they need for the mechanical process of digestion. After the water has been turbid for a short while, trout have invariably been observed to take to their food with particular readiness, and probably not merely because they had to fast while the water was turbid.

It is difficult to state the minimum quantity of water for a raising-pond; the temperature, the saturation of the water with oxygen by a strong fall, and other circumstances will render changes in the quantity of water necessary; but no fish-cultural establishment should be started without a steady total influx of 0.5 cubic meter (17.7 cubic feet) of water per minute.

If the ponds can get shade during the hot afternoon hours from rising ground in the neighborhood they will be all the cooler, but the condition which will exercise the greatest influence on the quantity of fry to be put in the ponds, and on their safety,

[1] Intensive Teichwirthschaft. Von S. Jaffé in Sandfort. From Allgemeine Fischerei-Zeitung, No. 24, 1894. H. Jacobson, translator.

is the depth, which should be as considerable as the nature of the ground and the absolute necessity of occasionally draining the ponds will allow. Even if there is a heavy flow of water into the raising-ponds, they should not have a depth of less than 1 meter (3.28 feet); and if it were not desirable to be able at all times to survey the bottom of the pond, through the water, throughout its entire extent, I would rather have the depth 3 than 2 meters (10 rather that 6½ feet).

The bottom of the pond should slope gently toward the aperture for letting the water off. The enormous pressure of the water, which is necessary in a pond of this depth, makes it desirable not to dam up the entire quantity of water, but to obtain at least half the depth by digging. It will be found advantageous to construct, if possible, several ponds (say four) at one and the same time, having a depth of 1.55 meters (4.92 feet) and a surface area of about 9 by 20 meters (29.5 by 65.6 feet).

It is necessary that every pond be arranged so that it can be absolutely drained; and it is an advantage if every pond has its inlet of fresh water independent of others. But with two pairs of ponds the lower ones should also receive the water of the upper ponds. The slopes on the banks and the bottom of the ponds should be well planed, and all hiding-places, sticks, stones, etc., should be removed, to provide for dragging nets through the ponds, which at a later period becomes necessary.

It is advisable to sow watercresses (the seed can be obtained from any seedsman) on the bottom and slopes of the pond immediately after it has been finished, and let in the water only about a week later, unless it is preferred to leave the second pair of ponds dry, to serve as reserve for emergencies. Wherever, in intensive feeding, it becomes necessary to deprive especially the shy brook trout of every hiding-place, the watercresses, which will soon grow luxuriantly, will later furnish shade for the fish and homes for the small aquatic animals which are as much needed for food in these ponds as in natural ponds. Long bean-poles (say, four to every pond) are laid in the surface of the water at regular intervals and bunches of watercresses are thrown among them; the cresses freely take root in the water and can easily be removed before the pond is dragged.

So far, I have only had reference to ponds dug out of the ground and have ignored the existence of raising-ponds constructed of boards or laid in with cement, such as are found in many places. These ponds, whose construction is very expensive, can be managed very easily, and the perpendicular sides afford good shade and a clear view of the entire pond. The growth of the fish, however, is very unsatisfactory in them, compared with ponds dug out of the ground (not to mention the smaller expense of the latter), and the excrements are not put to as good a use as in the earth-ponds, where the aquatic animalcula, which serve the purpose of removing refuse excrements, etc., thrive much better. I also think that trout make use of earth in digesting food.

Other fish than trout should of course not be kept in the ponds, and if possible only one kind of trout should be kept in each pond (char in the coolest ponds, brook trout in the warmer, and rainbow trout in the warmest). It is urgently recommended to introduce into the raising-ponds, at the very outset, swamp snails, small crustaceans, etc., to furnish the fish as much good natural food as possible and provide a means of clearing the ponds of the refuse of food and the excrements of the fish. Wherever fish are crowded together in a small space, and dead food is introduced, the natural equilibrium is disturbed, and this should be restored as far as possible by the introduction of live animalcula. At Sandfort there are, above and between the raising-ponds, special smaller basins dug out of the ground, which are thickly covered with

vegetation and which successfully answer the purpose of supplying the water with oxygen and live animalcula. For raising these animalcula I would not recommend ditches with standing water and liquid manure. It is true that these ditches develop a vast quantity of suitable live food, but they also produce water-beetles and other injurious animals.

The difficult question as to the proper quantity of fry to be placed in a pond can be satisfactorily answered to suit each individual case only. At Sandfort 4,000 young fish are placed in autumn in a raising-pond with an area of 180 square meters (1,937.5 square feet) and a depth of 1.5 meters (4.9 feet), and as the principal object is to produce as fast as possible a fish weighing not more than one-fourth pound (the favorite weight), all small and weakly as well as all fry of excessive size are eliminated, and the normal fish measuring 8 to 11 centimeters (3.1 to 4.3 inches) are used for raising. Where artificial food is used, artificially raised and fed fry are the best, as fry from natural ponds are as a general rule not so even in size and are not evenly fed. I am also of the opinion that they are more inclined to cannibalism than domesticated fish.

The great advantage which a fish-cultural establishment possesses over the culture of natural ponds, is in its ability to place its products on the market or retain them, just as it suits the proprietor. The natural pond puts its products on the market at the wrong time, either in autumn when the season for selling trout has not yet commenced in the great fish market, or in spring after Lent is over. No wonder that under these circumstances fish-dealers guard their interests by making only cheap offers. But fish-dealers also know where they can get fish at a season when ice covers the natural ponds, without running any risk from short weight, losses from death, and other causes. With some little care, a fish-cultural establishment can manage to have its fish ready for sale at the proper time and when they will fetch the highest price.

Even if the young fish in course of raising are most carefully sorted, some will be retarded in their growth, while others will grow more rapidly than the rest. Those whose growth has been retarded (probably 10 to 15 per cent) should be placed in a reserve pond and fed there; customers for them will be found in the spring. Most fish, however, will have their full weight from October to December, and the regular rotation of a raising-pond can be completed within one year. Those fish which have grown more rapidly than the rest will, in a well-regulated fish-cultural establishment, serve for selecting breeders for future campaigns; and if there are larger ponds it will pay (as far as rainbow trout are concerned) to keep these fish for two years longer.

In stock raising-ponds it is, above everything else, necessary to have normally developed and evenly sorted fish; and these are best obtained in autumn from the yearling ponds, immediately after the close of the fisheries. The fish are then in prime condition, and, owing to the cooler weather, transportation is cheaper than in spring. In the raising-ponds the fish will eat and grow all winter through, and a 10-centimeter (3.9 inches) fish obtained in autumn will naturally turn out better than such a fish obtained in spring.

As a general rule, it is very difficult to accustom the German brook trout to artificial food. It is a shy fish, and must be deprived of every hiding-place, and placed in pretty close confinement to induce it to eat artificial food. But its Scotch cousin, the "Loch Leven," through domestication continued for several generations,

has not only lost much of its shyness, but by adapting itself to our circumstances has become a fish very closely resembling the German brook trout, and is particularly well adapted to artificial culture.

Our fish-culture, however, would hardly have reached its present height, if we had not adopted the two Americans, the char or American brook trout (*Salmo fontinalis*) and the rainbow trout (*Salmo irideus*). They must be considered as of primary importance in fish-cultural establishments. They will never crowd out our brook trout but will maintain a place in the public favor. The char, wherever it is known, already fetches a higher price than the brook trout; and the rainbow trout, which, owing to its enormously rapid growth, easily becomes too fat, finds a ready sale as a three-year-old fish, weighing from 1 to 3 pounds.

At Sandfort and several neighboring establishments a ready market has rapidly been created for all the above mentioned kinds of trout. When sold at the ponds they fetch the following prices: Brook trout, rainbow trout, and char weighing one-fourth to one-third pound, 3 to 4½ marks per pound (71 cents to $1.07); large rainbow trout, 2½ marks (59 cents). The last-mentioned price pays better, as regards large fish weighing 3 to 5 pounds, which require but one young fish for raising, than 3 marks (71 cents) for fish weighing one-fourth pound, where four are required to make 1 pound. It is, of course, not possible to procure in every locality sufficient space for raising trout as large as that; in comparatively small ponds the fish will not reach such a weight in three or four years, even if there is an abundant supply of fresh water and very ample food.

Fish need, as they grow older, more space and greater depth of water. At Sandfort, therefore, the two-year-old rainbow trout which have outgrown the desired weight and weigh about half a pound are (to the number of 600 or 700) placed in a pond having an area of about 1⅔ acres and a depth of water of 6 feet, and there reach during one more year the weight of 3 to 4 pounds per fish. It is probable that the same result could be obtained in a smaller pond with a greater depth of water; at any rate, 1,400 fish averaging 4 pounds are, from one year to the other, kept in Scotland in a pond having an area of 30 by 70 meters (98.4 by 229.6 feet) and a depth of 4 meters (13.1 feet).

It will be useful to get a proper idea as to the quantity of food required per year in a trout-raising establishment of average size and to learn the cost of intensive artificial culture as compared with extensive natural culture. It should be remembered that trout are very settled in their way of feeding and that it is difficult to accustom them to a change in the color and consistency of the food. It will therefore be useful, from the very start, to select such food as can be obtained regularly and when mixed can be steadily given to the fish. It is true that it does not hurt the trout to fast for a few days, but regular feeding is nevertheless one of the conditions of success.

Trout-raising establishments should, with the view to facilitate the sale of the fish, not be removed too far from the great highways, and if this condition is fulfilled it will also be easier to obtain food.

Salt-water fish make excellent food for trout and can be obtained regularly and cheaply; and these, with the refuse from the slaughter-house, must be principally relied on.

The fish-auctioneers at Hamburg, Altona and Geestemünde will gladly indicate the sources from which salt-water fish can be obtained. It is best to take such as are sold with the blood and entrails, as the sea scorpion and cod; herring are generally too

fat. Of slaughter-house refuse, the liver and lungs are the most important, and both are excellent. It is urgently recommended that only such food should be bought as has passed the inspection of slaughter-house inspectors. Large pieces of animals which are not suitable for human food are also dangerous for fish, and only when they have been boiled (as is done in some slaughter-houses) so as to bind the albumen contained therein, is it advisable to use them.

Both salt-water fish and the refuse from the slaughter-houses are ground fine in a machine made for the purpose (for establishments of the average size I would recommend No. 91, by Scheffel & Schiel, Mühlheim-on-the-Rhine, which, worked by hand, grinds 100 pounds in an hour) and then mixed; an addition of shrimp flour or meat flour is useful and gives consistency to the food.

According to my experience, 5 to 6 pounds of such food will be required for 1 pound of fish, provided the water is kept at the proper temperature—char, 12° Réaumur (59° F.); brook trout, 14 to 16° Réaumur (63.5° to 68° F.); rainbow trout, 16° to 18° Réaumur (68° to 72.5° F.)—which temperatures can easily be maintained if the direction in which the sun strikes the ponds and the flow of water through the ponds are carefully calculated. The cost of raising 1 pound of fish, including cost of administration and culture will in an average-size establishment be, at the very highest, 90 pfennig (21 cents) per pound. For fish weighing from 1 to 5 pounds the cost of rearing will be still less.

It is also recommended to use snails, caterpillars, etc., for fish-food. They will form an excellent addition to the above-mentioned articles of food. Even if the expense of collecting is rather high, I would give my fish nearly all the food of this kind which could be obtained.

The trout is a very voracious fish. An average establishment which has, e. g., two ponds of 4,000 young fish and intends to produce with these 8,000 fish, with a total weight of 2,000 pounds, will during one campaign have to procure 10,000 to 12,000 pounds of food, or on an average 240 to 250 pounds of food per week (say 200 pounds of fish and 50 pounds of slaughter-house refuse). Even in summer fish-food can be kept sufficiently fresh for three days if placed in large earthen crocks, covered with a little salt, and washed by running water. Even average establishments will therefore be able to procure twice a week a 100-pound basket of salt-water fish by railroad.

It is quite evident that, food being so cheap, a profitable intensive culture is possible. The greatest danger to be feared is the possibility of epidemics; this danger can not be entirely eliminated, but I am justified in saying that (1) healthy food, (2) a sufficient supply of aquatic animalcula for destroying the refuse in the ponds, (3) ponds dug out from the ground which, after every campaign, are cleaned (both bottom and slopes), well supplied with watercresses, and laid dry periodically, will form efficient preventives of epidemics.

In summer the fish should be fed about sunset, otherwise shortly after noon, and they should never get more food than about 5 per cent of their average weight. They ought not to be fed in sultry weather nor when the temperature is considerably above 22° Réaumur (81.5° F.).

I strongly object to feeding-tables in these ponds. The food ought to be thrown to the fish with a ladle, and so little at a time that they catch it before it sinks to the bottom of the pond. In using feeding-tables there is danger that the attendant, from sheer laziness, will pour the entire quantity on the table at once, thereby causing the

loss of a good deal of the food by its becoming watered, etc., not to mention that a feeding-table becomes a receptacle for decaying matter and enemies of the fish which fear the light of day.

The duty of tending the fish should be in the hands of one person; and, if possible, the fish should not be disturbed by visitors.

Fish raised for the market should, as long as the pond is well stocked, be caught with a smooth drag net, and the water should be allowed to flow off thoroughly; if this is observed their flavor is just as fine as that of the wild fish, although their flesh has not the same degree of firmness. The older fish are not in any way inferior to the wild fish; and the rainbow trout in particular, when older, gains an excellent, salmon-like, pure flavor. On some estates, and especially in many factories (particularly paper mills) an establishment, as recommended above, will be possible and profitable and might, on account of the better supervision, be founded close to the house, in a simpler manner and within a small space. I have laid special stress on the advantage of such an intensive culture conducted on a small scale, but it is certain that it will also afford a good deal of pleasure to the cultivator.

If, as in many cases, there are, near factories, dams with spring water which can be let off and which are to be devoted to intensive culture, though the area exceeds that referred to above, it will be advisable to put in a smaller number of fish, as in such cases the brook trout will not very readily take the food provided for it. I would confine the culture to the American fish, particularly the rainbow trout, and from the start arrange for a two year's rotation and for raising large fish. The largest possible fry should be selected (even if the price should be somewhat high), and not more than 2,000 young fish should be set out per acre. The American fish will in such ponds take to the food at once; and as far as the rainbow trout are concerned, it does not matter if there is a temporary stagnation in the pond.

In conclusion, I would state, as the leading principles of intensive pond-culture, the following:

(1) Plenty of cool water and deep ponds.

(2) Use evenly sorted young fish which are accustomed to the food which is to be provided for them.

(3) Stock the pond pretty thickly, especially with the fry of the char and the rainbow trout.

(4) Never use inferior food.

(5) At proper times clear the ponds of all fish, dry the ponds thoroughly, and clean them well.

NOTES BY S. JAFFÉ ON THE REARING OF YEARLING TROUT AT SANDFORT.[1]

Repeated inquiries as to the manner in which yearling trout are raised at Sandfort have induced me to give a brief sketch of our local experiences and manipulations. The results regularly obtained here (and which can be obtained in other places by similar methods, perhaps slightly modified to suit local conditions) presupposes a large and regular business, with the fundamental conditions of a regular supply of suitable water and ample opportunities for obtaining fresh food. The establishment must, moreover, have one suitable person devote himself entirely to the propagation of the young fish. It is also important, according to the Sandfort method, to know from what trout eggs the young fry are hatched. Fry whose progenitors were accustomed to artificial food are more easily and safely raised and (I here refer to the different varieties of the *fario*) the result will be all the better the further back the pedigree of the tame generation goes. These experiences agree with those of English and American establishments, like the other experience, that the fish if possible shall leave the egg in the water in which it is to live during its helpless period, which extends into the summer.

The manipulations employed in raising *fario* and the American varieties of the trout are nearly the same in the Sandfort establishment. Eggs of both kinds are hatched in thin layers in wooden troughs about 4 meters (13.1 feet) long, which, on the inside, are charred to the depth of 1 centimeter (0.39 inch). The breadth in the clear is 22 centimeters (8.65 inches); height, the same; the depth of water is 6 to 8 centimeters (2.4 to 3.15 inches). The young fry, immediately after they have left the eggs, are placed in freshly cleaned hatching-troughs (about 15,000 in a box), which at the end have oblique sieves of perforated sheet-zinc (perforation No. 9). The fry are not counted (the eggs are counted immediately before hatching), as the least touch will affect the mucous skin of the young fish and lay the foundation for fungous development. Healthy young fish will, wherever unfiltered brook water is used, entirely clean the bottom of the box, and until the loss of the umbilical bag little remains to be done except an occasional cleaning of the sieves. During this period the young fish lie densely packed close to the inlet on a space extending hardly 0.25 meter (10 inches) in length; and toward the end of the umbilical period the current of water passing through the box—which hitherto has been about 20 liters (5.3 gallons) per minute and per box—is strengthened and the solid lids of the box are replaced by lids made of fine wirework. From the very beginning of the feeding period a strong light is good for the young fish.

As soon as the young fish begin to look around for food it should be given them. The food consists of fresh hog-liver (that over a day old is dangerous), which is put through a small meat-chopper and then, with a knife, forced through a finely perforated piece of sheet zinc (perforation No. 4, pin size) and afterwards mixed with a raw egg, in the proportion of two eggs to one hog's liver. During the first time, one hog's liver and the attention of one person are sufficient for daily serving four boxes, each containing about 15,000 young fish.

[1] Die Aufzucht von Jahrfingen in Sandfort. Von S. Jaffé. From Allgemeine Fischerei-Zeitung, No. 9, 1895. H. Jacobson, translator.

This food is given by the teaspoonful from a feeding spoon, which is covered with zinc (perforation No. 4 for char, No. 6 for other salmonoids) and from which the pulp gradually sinks under the water. The young fish take to this food very readily, but only when it is driven toward them by a strong current. Trout will not, till far into the summer, skirmish for food. The *fontinalis* and *fario* act very differently in taking their food. The *fario* kinds (and I include among these the Scotch Loch Leven) remain close to the bottom, and only a movement of the head indicates that they are taking food; the *fontinalis* are distributed throughout the entire depth of the water and almost rush at the food. In order to satisfactorily raise the young fish it requires extraordinary patience and great care not to let any food fall to the bottom unused. The young fish soon learn to gather at the head of the trough, and the sooner they do this the better are the prospects of success.

Fry which have been badly raised or hatched—and I include among these both fry from too young parent fish, apparently looking very nice in the eggs, and those which in a closely packed hatching-apparatus have not received a sufficient supply of oxygen in the egg during hatching—will perish at this stage; and I can not sufficiently urge the necessity of obtaining eggs (unless they have been laid and hatched in the establishment itself, which is of course preferable) only from thoroughly reliable establishments, whose eggs may be somewhat higher priced but whose careful management is a sufficient guaranty for a good article.

Failure to raise young fish is in many cases caused by mistakes made in remote stages of the development of the eggs or the parent fish. Whenever fry perish it is by no means right to seek the cause in recent occurrences, as the feeding of the parent fish and the hatching of the eggs may have had a great deal to do with it. The great care which is essential for producing high-grade eggs will naturally limit their production and will justify the higher price asked.

Healthy fry will, as soon as they commence to eat, give very little trouble. In addition to the utmost care in giving the food to the young fish it will be necessary to thoroughly clean the boxes at least once a week. A nail-brush with strong bristles will answer this purpose admirably, and, after the water has been let out of the hatching-trough until it is only an inch deep, the sides are thoroughly brushed, commencing at the head. The young fish skillfully evade the brush and are rarely injured. From the commencement of the feeding period the water in each trough is twice a day made thoroughly turbid by pouring in a bucketful of water and rich sod soil mixed. After this has been done the young fish will always take their food more readily. After they have been thoroughly accustomed to take the food the troughs are emptied by taking out the bung at the end and the young fish are swept into large buckets with the water. Prior to this the Sandfort "nurseries" (large raising-boxes) are laid at anchor in the open bed of the brook near the hatching-house by being fastened to boxes and poles.

These "nurseries" are strong boxes made of wood 1¼ inches thick with a well-finished and tightly fitting bottom of wood three-fourths inch thick. The sides are covered with plates of perforated zinc (perforation No. 9) and the boxes are furnished with closely fitting lids, which are covered with wirework and admit as much light as possible. The boxes should be placed in a strong current, and the stronger the pressure of water which the young fish have to resist the stronger and healthier they appear to be. The Sandfort brook is a mill stream with a very irregular current,

frequently rendered turbid by rainstorms, and with a depth of water varying from 0.5 to 1 meter (1.6 to 3.28 feet). After the water has become turbid the young fish appear to be in particularly fine condition. Each box now contains 10,000 to 20,000 young fish—the smaller number if brook trout, the larger if rainbow trout. It is customary in Sandfort to pour the tiny fish, immediately after they have been hatched, into these "nurseries" and to begin the feeding process, which with the rainbow trout is very easy, in these boxes. As the young fish grow the food is gradually changed to calf-liver without egg and then to beef-liver, which in June is fed to the fish just as it comes from the chopper. The feeding process has now become exceedingly easy and consists in simply throwing the food into the boxes with a common spoon. One person can easily serve six and later even ten boxes.

In June the young fish are transferred to earth-ponds and sorted closely according to their size. Henceforth the losses will be very few. The use of "nurseries," especially for young rainbow trout, has the advantage of great safety and cleanliness. The boxes are, after every campaign, covered with a coating of asphalt lac, and thus last for years. While the young fry are in the boxes, the earth-ponds can be thoroughly cleaned and dried; and as they are filled again late in the season (in June) a limit is thus set to the development of larva and vermin. The cost of such a box, according to its more or less careful finish, varies from 50 to 70 marks ($11.90 to $16.66), which can hardly be considered too much, in view of the comparatively high value of the yearlings produced.

Of fourteen boxes which in 1893 were used in the Sandfort establishment, those containing rainbow trout yielded the best results. One box, which had been stocked with young fry from 20,000 eggs, produced in June over 17,000 young fish. It is possible to keep the young fish in the boxes till November, in smaller numbers (up to 5,000); but, from June on, the growth in the earth-ponds is much more satisfactory than in the boxes, especially as in ponds filled late in the season young fish find an ample supply of natural food, such as *Cyclops* and other small crustaceans, and later the small pond-snails.

The only objection which could be raised against this system, which is apparently based entirely on artificial food, is that such fish would not be able to get their food in a brook or open pond. But apart from the fact that the instinct for seeking food and for self-preservation is exceedingly strong in all animals, the well-fed young fish from the fish-cultural establishment will surely carry with him a greater reserve of food than the hungry wild fish, and would be more apt to push the latter away from the food than perish. Fish can (and this is hardly sufficiently known) live a long time without any food whatever, and even lose 50 per cent of their weight without perishing or losing the faculty of seeking food. To see how fish which have just been fed will go gnat-hunting, it will be sufficient to watch yearling ponds, like those at Sandfort, some afternoon or evening. The eye can not quickly enough count the fish which leap out of water for gnats. If this is not sufficient proof all that will be necessary will be occasionally to dissect an artificially raised fish, and see what its little stomach contains, in addition to the artificial food, in the shape of snails, gnats, and small crustaceans.

FISH-CULTURAL METHODS AT THE AGRICULTURAL SCHOOL AT FREISING.[1]

Not far from Munich is the little town of Freising, one of the most ancient places in Bavaria. At this place the ancient Benedictine convent of Weihenstephan has been converted into a school of agriculture and a modern brewery. When I learned that instruction in fish-culture was given at this school I was glad to accept an invitation of Professor Steuert, who has charge of the instruction in fish-culture and the care of fish, to visit Weihenstephan, and on December 12 I went there to study the methods pursued. All the arrangements are exceedingly simple. As the buildings of the ancient convent lie very high above the stream which flows through the town, the supply of water for the entire institution has to be forced up by a steam pump. From the general reservoir a small pipe leads the water to the place where the fish-cultural section of the establishment is located.

This section, which is intended both for hatching and rearing trout, consists of a large box whose bottom is elevated a little above the ground. On this stand two Le Petit apparatus, which serve as filters, the hatching apparatus, and, when the fish have developed, an apparatus for raising larvæ. Fig. A shows the appearance of the box. The water flows into the apparatus through the pipe *r*, is filtered, flows through the box and out into a collector at the side of the apparatus. Thence it is led into the collecting pipe R, which pours the water over a wheel *m*, which is in the trough *t*, above the surface of the water, and is thereby kept in rotation. In the trough *t* the young fish are generally kept till they are seven to eight months old. At the time of my visit Professor Steuert had in this trough both rainbow trout, which had been hatched last spring, and brook trout which had been used in autumn for supplying roe. All of these fish had been fed during the last few months on cheese, which seemed to have made them grow healthy and strong.

Fig. B gives a profile view of the apparatus. To keep out the cold of winter, the inner walls of the box had been lined with straw *h*. We found the water warm enough to prevent all danger of freezing during ordinary winters. As both the Le Petit apparatus and the wheel *m* (fig. A)—the so-called "feeding wheel"—have been thoroughly tested and found to answer, a drawing and a short explanation of the apparatus may not be out of place.

Fig. 1 shows the apparatus, viewed from the side, and a section of part of it. At *a* the water enters the apparatus, which is filled for about two-thirds of its height with gravel *c*, serving as a filter. Above this layer of gravel there is a perforated vessel (sieve), on the bottom of which the fish eggs are spread. Through the pipe *d* the water flows out into the collector above referred to. The apparatus is closed by a lid which has a small glass window at the top. After the young fish have been hatched and placed in the trough, and have grown so large that they begin to snap after larger morsels of food, the apparatus is made to answer another purpose (fig. 2.) The gravel is emptied out, the perforated vessel is taken away, and a frame with a coarser grating *c* is laid in the apparatus. On this frame meat (refuse from butcher shops) is placed, the lid is put on, and a cover is placed over the little window. Through the opening *b* flies go to seek the meat and lay their eggs thereon.

[1] Letter from Bavaria, translated by H. Jacobson, from Fiskeritidskrift for Finland, No. 2, Helsingfors, February 17, 1895.

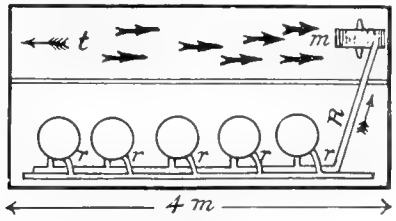


Fig. A.

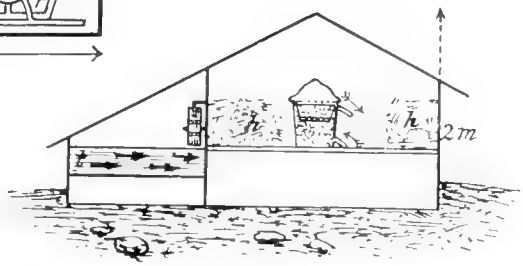
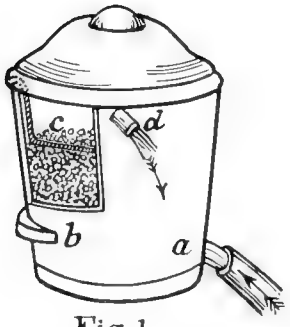


Fig. B.



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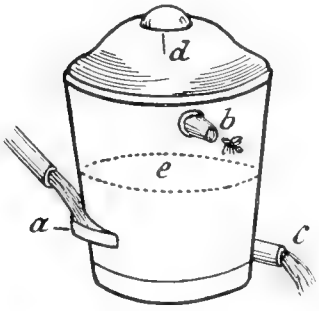

Fig. 2.

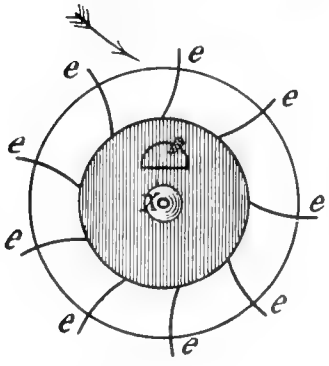

Fig. 3.

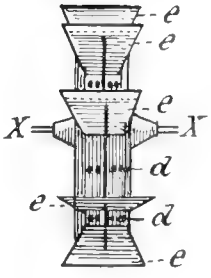

Fig. 4

HATCHING APPARATUS AT FREISING

When the larvæ have developed in the meat, the window is opened, so as to cause the larvæ, through the influence of the light, to go to the bottom. A stream of water is now let in through *a*, which drives the larvæ into the pipe *c* (fig. 2). Below this the trout gather in schools and watch for the food carried out with the water, with such eagerness that it is impossible for the larvæ to escape their voracity. On this fare the young trout thrive marvelously, and grow large and strong. The greatest advantage, however, of this arrangement is in the circumstance that there is no refuse to render the water impure or actually dangerous for the young fish; which is greatly to be feared when young fish are fed on liver or similar articles of food.

The so-called "feeding-wheel" consists of a cylindrical tin tray about 14 centimeters (5½ inches) in diameter, and 5 centimeters (nearly 2 inches) deep (fig. 3). The outer rim of the cylinder is perforated at *d d d* (fig. 4), and is provided with paddles *e e e e e*. The cylinder is moreover provided with an axletree. As this rests on two supports, and as a stream of water is forced against the paddles in the direction of the arrow (fig. 3), the cylinder is made to rotate, which motion causes the finely ground food inclosed therein to be gradually ejected through the apertures *d d d*. The young fish, which soon find this out, gather under the wheel—the waterfall—and catch the food. This arrangement has all the greater practical importance in feeding young trout, because, when the fish are fed by hand, they never get that portion of the food which falls to the bottom.

THE COURSE OF INSTRUCTION OF THE BAVARIAN FISHERY ASSOCIATION.[1]

I had the pleasure of receiving an invitation from Professor Steuert, who is a member of the Bavarian Fishery Association, to attend its course of instruction, where both theoretical and practical instruction in fish-culture are given. The meeting was held in the old building of the Royal Academy of Fine Arts, in Munich. The excellent work of the association was spoken of, and attention was called to the fact that the results were not solely due to practical work, but also to the aid which the association had at all times received from the scientists of the Munich University. Waters which were formerly fishless had been stocked with suitable kinds with such success as to give them a perfect wealth of fish.

A lecture by the well-known zoologist, Dr. Hofer, lasted from 10 a. m. to 7 p. m., with a recess of two hours. The lecture was in three parts: (1) Biological description of the kinds of fish which form the subject of the association's fish-cultural efforts; (2) the proper care and protection of the fishing waters; (3) fish-food.

Among the fish which the association had cultivated the speaker mentioned: Carp, tench, perch, bass (American), eel, trout (rainbow trout), German brook trout, American brook trout, and Alsace trout (a cross between the American brook trout and the European trout), grayling, gwiniad, etc., and finally the pike.

The speaker said that the carp was not indigenous to Germany, but was now found everywhere. He exhibited a number of select carp, which by cultivation had reached large and well-rounded dimensions, and which differed very much from the so-called peasant's carp, a small and insignificant-looking fish. There are two kinds

[1]Letter from Bavaria (concluded), translated by H. Jacobson, from Fiskeritidskrift for Finland, February 17 and March 16, 1895, Helsingfors, Finland.

of select carp in Germany, viz, Bohemian, which has a more elongated, and the Galician, which has a rounder shape.

It was formerly thought that carp lived on vegetable food, but it is now definitely settled that snails, crustaceans, and other small aquatic animals form its principal food. The carp gets albumen and soluble hydrates of carbon also from plants, and in many places it is therefore fed on boiled potatoes. For spawning the carp need water having a temperature of at least 14° to 15° Réaumur (63.5° to 65.75° F.); 18° Réaumur (72.5° F.) may be considered the best average temperature for the carp, and it can even stand 25° to 28° Réaumur (88.25° to 95° F.) without difficulty. With abundant food it can reach the weight of 4 pounds at the age of one year. Under ordinary circumstances it weighs 1 pound at two years, 2½ to 3 pounds at three years, and 3 to 5 pounds at four years. In many localities there is a demand for carp of a certain size, and owners of carp ponds must bear this in mind. An idea of the vast extent to which carp are raised in Germany may be gathered from the circumstance that Prince Schwarzenberg annually spends 250,000 florins ($100,000) for ground meat for feeding his carp. Mr. Burchardt, a prominent fish-culturist, received from Prince Hatzfeld 40,000 marks for bringing the prince's ponds up to a higher state of productiveness.

Perch are now quite common in Bavaria, but are not well suited for ponds. In their place American bass, both small and large mouth, have recently been introduced. The large-mouth, which can stand water of a high temperature, reaches the weight of 20 pounds. The small-mouth bass, on the other hand, requires colder water. The fish increase rapidly and with certainty, especially as the young are protected from enemies by their parents. For spawning they require a rocky bottom or one covered with coarse gravel. As perch grow slowly and generally do not reach a greater weight than 3 pounds, they should be supplanted by this more valuable fish. In Munich bass bring 2½ marks (59.5 cents) per pound.

The raising of eels is exceedingly profitable in Germany. One hundred young eels set out in a pond yielded 2,000 kilograms (4,410 pounds) of eels after three years.

The trout is very generally raised in Germany. It requires running water, but some kinds thrive in ponds. The common brook trout (*Salmo fario*) is not found in water of more than 18° Réaumur (72.5° F.). It is a predaceous fish.

The rainbow trout (*Salmo irideus*) which comes from the west coast of America, can stand both cold and warm water, the latter up to 25° Réaumur (88.25° F.). This alone makes it suitable for fish-culture. It spawns in spring, April and May. In cold water it reaches the length of 12 centimeters (4.7 inches) during the first year; 22 centimeters (8.7 inches) during the second year; 28 centimeters (11 inches) during the third year, and is then ready to spawn. The male fish are ready one year sooner. Under very favorable circumstances, and in water of high temperature, three-year-old rainbow trout have reached a weight of 5 pounds. It is much easier to raise this kind of trout than the common brook trout. It takes food much easier, is not predaceous, and is admirably adapted for pond-culture.

Of late years a brook trout (*Salvelinus fontinalis*) imported from America has been raised considerably in Germany. It has a dark-red belly and fins. It is found in very cold water, having a temperature of 7° to 8° Réaumur (47.75° to 50° F.), and grows faster in such water than other kinds of trout.

The speaker exhibited a cross between the German and the American brook trout, which has been called the *Alsace trout*. It is fatter and larger than the American and is best suited for small streams.

As regards the care of fish water, great stress was laid on the proper pains in establishing and maintaining the spawning-places. In Prussia certain spawning-places were protected all the year around in all larger sheets of water. The speaker did not consider it useful to place entire bays and coasts under protection, as these places then become favorite places of sojourn for predaceous fish. Arrangements should be made not to place in ponds too many kinds of fish living on the same kind of food, but rather such as live on different kinds of food. In this respect special regard should be had to shoal-water fish and to deep-water fish. Fish waters cared for in this manner have yielded good results in Bavaria.

As regards the *pike* the speaker stated that it was one of the most unsatisfactory fish for raising, on account of its voracity. Experiments had shown that it took 47 pounds of meat to raise 1 pound of pike. A beginning, however, had recently been made to raise pike in special ponds having a good supply of small fish. This had, for instance, been done in ponds having too large a stock of carp.

In regard to *artificial impregnation*, the speaker stated that, since the so-called "dry method" had been adopted, the percentage of impregnated eggs had increased from 50 to 80 or 90 per cent. Numerous investigations had shown that the spermatozoa of the male fish do not live in the water longer than 22 seconds, during which short time the eggs are not nearly all impregnated. Immediately after impregnation the eggs are very tender to the touch; and the fact had been positively ascertained that if a few days after impregnation the roe is disturbed on the frames in the apparatus, many eggs will perish. The germ in the egg is specifically lighter than the fluid contained in the shell, for which reason the germ always rises to the top. If the egg is turned, the germ again rises to the top, and this causes such a disturbance as to make the impregnated egg die. This does not apply, however, to gwiniad, perch, and some other kinds of fish, whose roe develops best if it is well stirred in apparatus specially constructed for the purpose.

The speaker finally showed, greatly magnified, the principal small aquatic animals which serve as food for fish. Experience had shown that Daphnia—very small crustaceans, most of them measuring no more than 1 to 2 millimeters in length (0.04 to 0.08 inch)—if properly treated, can be brought to a great degree of productiveness. The method is very simple. A ditch or small pond is filled with dry leaves, suitable aquatic plants, and manure (opinions differ as to the kind of manure to be used); a number of Daphnia are planted there and under the influence of the summer heat develop very rapidly. If the water in the ditch is allowed to flow through a pipe into the pond where the young trout are kept, the fish will thus be supplied with a sufficient quantity of natural food. When the fish are larger they are fed on larvæ of flies raised in Le Petit's apparatus. As the larvæ often grow too large for the fish, this difficulty is obviated by placing a fine grating before the opening of the apparatus so that only smaller kinds of flies can enter and lay their eggs; whereby, of course, smaller larvæ are obtained. As the air becomes cooler toward autumn the young fish are fed on the roe of salt-water fish (especially cod roe), which can be bought very cheap. Whenever the temperature is higher, the roe should be slightly salted and afterwards well soaked before it is fed to the fish by means of the feeding-wheel.

After the fish have grown they are distributed in small ponds measuring 15 to 20 square meters (161.5 to 215.3 square feet), which are always kept supplied with aquatic plants producing fish-food. The trout are now fed on a mixture of 30 per

cent blood and 70 per cent flour, dried and pressed through an apparatus which makes it come out in the shape of worms. Grown trout may also be fed on fresh refuse from butcher shops, but there should be an ample supply of fresh water in the ponds and suitable aquatic plants, in case the trout are fed on such refuse. Two-year-old trout are most in demand in the fish-markets.

The Starnberg Fish-Cultural Establishment, which belongs to the Bavarian Fishery Association, is near the little town of Starnberg and the large lake of the same name. This establishment, which is not very favorably located, was considerably enlarged and improved two years ago. The supply of water is furnished almost direct by the seven springs from which the little stream called Der Sieben Quellen Bach—the Seven Springs Brook—takes its origin. As the fall is but short and not very abrupt the water is led into the hatching-house through an iron pipe and forced to the height needed for the apparatus. On the higher bank of the stream a great many ponds have been dug, in which trout of different ages and of different kinds are raised. Mr. Le Petit has made several experiments in crossing different kinds of trout. He finds that it is of the greatest importance in what order the sex is employed.

The establishment yields a net revenue of 3,000 marks per annum ($714), and is expected to yield a great deal more after everything is put in proper working order. I was informed that some private establishments yield an annual revenue of 15,000 marks ($3,570).

The visitors witnessed the so-called "striking" of trout, i. e., the impregnation of trout eggs. In doing this, Mr. Le Petit, who was considered to possess great skill and experience in these matters, employed a method halfway between the so-called dry and wet methods. First the roe was squeezed into a tin vessel and then the milt from the male fish. Then water was poured in the vessel; the milt of one more male fish was squeezed into it; the whole was thereupon stirred with the hand, the water was poured off, and the roe was slightly rinsed with the remnant of the water. After the eggs, impregnated in this manner, had been allowed to stand about five minutes in clean water they were placed in the apparatus for further development. The result of the impregnation was stated to have been very favorable, as high as 90 per cent.[1]

As the water used in the establishment has a natural temperature of 6° Celsius (42.8° F.), the eggs develop very rapidly, so that the eye-spots become visible after 36 days. The quantity of water used is 2.38 gallons a minute for each apparatus.

In January I again visited the establishment to take further observations of some of its arrangements, and during the same trip I also visited the fish cultural establishment near Mühlthal belonging to Prince Ludwig of Bavaria. This was founded two years ago, and appears to be arranged in a very simple and practical manner. The supply of water is furnished by a large spring. Here I had an opportunity to see a very large number of rainbow trout, born April, 1894. These trout, which were of considerable size for their age, were crowded together in a dense mass below a "feeding-wheel" containing cod roe. In an area of about 400 square meters (4,305.6 square feet), 10 small ponds had been dug, in which fat trout of different ages were basking in the sunshine. The water is introduced into these ponds through iron pipes.

[1] Special stress is laid on the fact that it cost a good deal to gain the experience that only trout seven to eight months or, better still, one year old, guarantee the reproduction of trout in waters which are to be stocked with these fish.