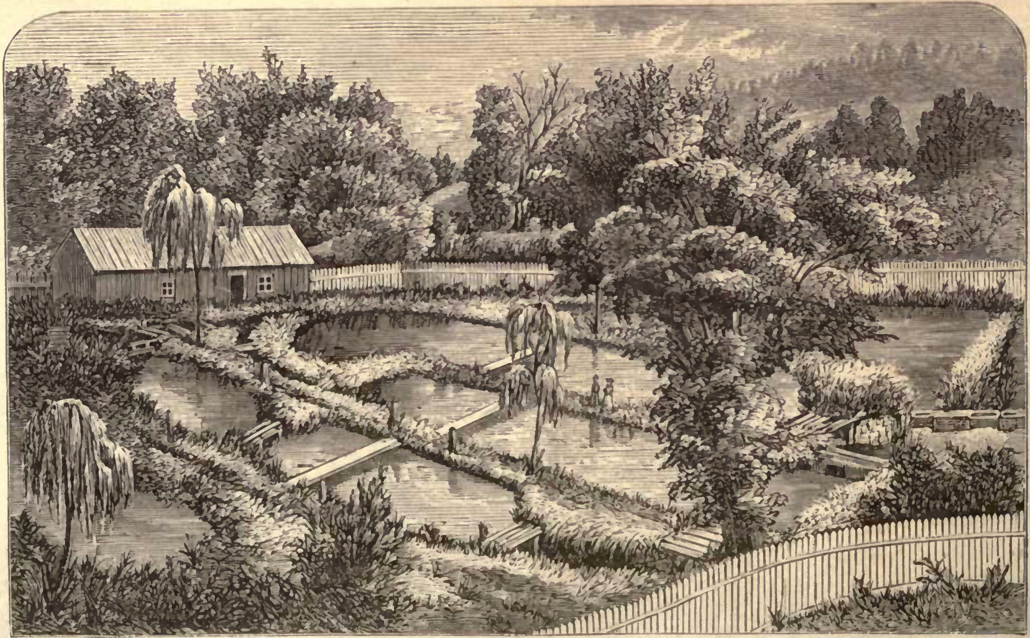

TROUTDALE PONDS, FROM THE SOUTH-EAST.

PRACTICAL

TROUT CULTURE.

BY

J. H. SLACK, M.D.,

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"We speak that we do know, and testify that we have seen."

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INTRODUCTION.

"THEREFORE, honorable and worthy countrymen, let not the meanness of the word fish distaste you, for it will afford as good gold as the mines of Guiana or Potosi, with less hazard and charge, and more certainty and facility."—*Smith's Hist. of Virginia. London*, 1624; *page* 248.

THESE words of the original John Smith, written some two hundred years since, were prophetic. Spite of the sneers and scorn of the ignorant, to which few have been more exposed than ourselves, and spite of the wails of would-be pisciculturists, who, dazzled by the imaginary balance-sheets of hypothetical trout farms, have rushed ignorantly into fish-farming and become disgusted that the mines of Guiana or Potosi were not at once opened to them, fish culture, in the hands of able and persevering individuals, has proven to be a thorough and complete success. That many have failed, there is no doubt; but compared to the number of those whose fortunes have been wrecked, if not upon the mines of Guiana and Potosi, upon other equally unprofitable investments, the number is few indeed. Fish culture, like farming, is a branch of industry which, strange to say, is generally though erroneously supposed to require little or no study. We have known numbers of cases in which large sums of money have been invested in fish culture by tyros, whose only knowledge had been gained from a few articles in the columns of a newspaper, or from the only original American work then written upon the subject. The result of book-farming is proverbial; that of book fish-farming is equally disastrous. Yet far be it from us, especially at the commencement of a treatise upon the subject, to ignore the value of technical works; they are *much*, but not *all;* and the preparation of the reader for their full comprehension is only to be obtained at the pond side and in the hatching-house, where, and where alone, the thousand minutiæ of the work of the fish-farmer can be observed and thoroughly learned.

In the following pages we hope to present to our readers, as far as can be presented in a volume, the theory and practice of fish culture—the theory as we understand it, and the practice as we have performed it at our fish farm near Bloomsbury, N. J. This farm was purchased by us in August, 1867, of Mr. Thaddeus Norris, a gentleman well-known both as an author and angler. The place was in an unfinished condition, but one pond had been erected and stocked with a few hundred sickly fishes. At first, our undertaking was anything but prosperous. Our stock fishes died by dozens; our spawn, from want of proper knowledge of the theory of impregnation, and the sickly condition of our parent fishes, perished by thousands. Musk rats bored their way through our improperly-constructed banks; a flood carried away thousands from our badly-located hatching house, and, finally, during our absence from home, some kind individuals relieved us of a large number of our finest fishes.

Far, however, from being discouraged at this multiplicity of misfortunes, we at once set ourselves to work after each new disaster to ascertain its cause and prevent its recurrence, and we are happy to state that we have met with no repetition of any of these evils. Our undertaking has for two years past been in every respect a perfect success; and we have now on hand at least thirty thousand trout, from three to eighteen inches in length, all raised from spawn impregnated by ourselves. In every case our misfortunes could be traced to our own ignorance or neglect. For the latter we can offer no excuse; for the former we can only plead the great want of facilities for instruction which then existed. Thus far, but two original works* on fish culture have appeared in America, and both were issued subsequent to our entering upon the business. These works, written as they are by two of our most renowned fish culturists, should have a place in the library of every lover or practitioner of the art. Yet, as a practical man, we feel that many points of the greatest importance are in them but casually mentioned; and since their publication many new facts have appeared and new theories been advanced, beside the invention of labor-saving apparatus, which we think will render a new work upon the subject not unwelcome to the fish-breeding fraternity.

Though every care has been taken in the preparation of this work, we can not flatter ourselves that it is perfect. New theories will often be accepted, rendering the old baseless or even ridiculous. New inventions may be made by which the manual labor required will be still more simplified, though the Collins' spawning race, by which spawn may be taken without wetting the hands of the operator, seems to us the *ne plus ultra* of labor and health saving apparatus. Much has already been done, but the science is still in its infancy; doubtless much remains to be discovered and invented, as "let well enough alone" is a maxim not to be obeyed by the fish-breeder. All science is progressive, and fish culture must not be expected to be an exception to the rule.

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* Norris' "American Fish Culture," Philadelphia, 1868; Green's "Trout Culture," Rochester, 1870.

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PRACTICAL TROUT CULTURE.

CHAPTER I.

HISTORY OF FISH CULTURE.

It is a fact well known that fish-hatching has been carried on by the Chinese from the earliest periods of the world's history, their oldest writers mentioning the fact, and it is stated by savans that in the works of Fo-hi, who flourished, according to the computation of the best authorities, 2,100 B.C., mention is made of laws regulating the time at which fish spawn should be taken. The earliest European notice of Chinese pisciculture we have met with, is that of Father Duhalde, a Jesuit missionary, who, in 1735, published at Paris a history of the Chinese Empire, in which he states that, "At a certain season of the year an immense number of merchants resort to the banks of the Yang-tse-kiang for the purpose of purchasing fish spawn. In the month of May the country people place across the current of the river, mats and hurdles extending for a distance of nine or ten leagues, leaving only an opening sufficiently wide for the passage of vessels. The fish-spawn, in its passage down the river, is caught upon these hurdles; it is removed, placed in vessels of water, and sold at once to the merchants who transport it to various parts of the Empire." This statement is corroborated by the testimony of modern travelers, who speak of impregnated spawn as a regular article of commerce. The eggs thus obtained are in precisely the same condition as those taken by the Ainsworth or Collins spawning race, being naturally impregnated; and, strange to say, this naturally-impregnated trout spawn is now sold at prices much higher than that taken by hand, though in our experience the proportion of properly impregnated eggs is much greater by the latter process. The enormous piscines of the Romans, both under the Republic and the Empire, as well as the accounts which have been transmitted to us of the enormous prices paid for their contents (in one case, that of Lucullus, four million sesterces, $160,000, having been obtained), show that fish culture, if not fish breeding, had at that period attained gigantic proportions. We have full and accurate accounts of the huge piscines, and their voracious inhabitants, to whom even the flesh of a well-fattened slave came not amiss; and it is more than probable that had artificial means been resorted to for the impregnation and hatching of the ova, some account of it would have been transmitted to us.

The numerous fasts imposed upon the monks during the middle ages by the Roman Catholic Church, rendered an ample supply of fish food an article of paramount importance to the monastic fraternity; and to them we would naturally look for any improvement in the art of fish culture. While hunting among the musty archives of the Abbey of Réome, Baron Mongaudry accidentally discovered that a monk of that religious establishment, yclept Dom Pinchon, during the fourteenth century, practiced a method of hatching, at least similar to that still pursued in some of our largest trout farms. How the reverend father obtained his spawn is unfortunately not recorded; but obtain them he did, and no doubt received the blessing of his confreres for the welcome additions to their larder. To Dom Pinchon must be ascribed the honor of the invention of the first hatching-box.

In 1761, C. F. Lund, of Linkoeping, Sweden, having noticed the spawning of fishes in Lake Koken, prepared a large, wide, shallow box, in which, the bottom being covered with brush, he placed male and female carp during the spawning season. As soon as the spawn was deposited, the parents were removed and the eggs protected from the attacks of enemies. This process is still practiced with success in various portions of the Continent. In 1752, Spallanzani, the eminent Italian naturalist, performed for the first time the operation of artificial impregnation, not with fishes, but with the frog; yet the fact was established, and it was not long ere practical benefit was derived from it. To Lieut. (afterward Major) G. L. Jacobi, of Hollenhausen, must be given the credit of first introducing, if not discovering, the process of artificial impregnation of the eggs of fishes.

The results of his experiments, which were preeminently successful, were published in 1763 in the *Hanover Magazine*, a local periodical with but a small circulation, and for a few years excited no attention; but by its translation into Latin by Goldstein, and French by Duhamel du Monceau, in 1773 it was brought to the notice of the scientific world. Jacobi's account of his method forcibly recalls to mind the pictures of a poor, tortured salmon being held up by a hand to which no body is attached, her eggs falling in a graceful curve into a pan of water beneath, which were wont to ornament the covers of the numerous French pamphlets on pisciculture. Jacobi says: "Place in a clean vessel about a pint of pure water; seize the salmon by the head, and hold her over it; if the eggs have arrived at maturity they will fall out of her of their own accord; if not, press lightly on the belly with the palm of the hand, the eggs will then detach themselves and fall easily into the water. Perform the same operation on a male salmon, and when there is enough milt upon the eggs to whiten the surface of the water, the fecundation of the eggs will be accomplished." His hatching-trough was similar, strange to say, to that of Dom Pinchon. Full directions are given for the removal of dead spawn, and the care required by the living. His is the first work upon pisciculture as a science. Under the care of Lieut. Jacobi, fish farms were established at Nortelem, Hanover, and Hohenhausen, and the fish produced became an important article of commerce; it is stated that the Queen of England bestowed a handsome pecuniary reward upon their founder.

The next aspirant for piscicultural honors is an American school-boy. The late Rev. John Bachman, D.D., of Charleston, S. C., claimed, in a paper read before the State Agricultural Society, in 1855, that in 1804, at the age of fourteen years, he had impregnated and hatched the eggs of trout and other fishes. This has been denied and ridiculed, but the character of Dr. Bachman as a Christian gentleman is too well known and recognized for us for a moment to doubt his veracity. Though his opinions upon religion, politics, and natural history may have met with many opponents, his truthfulness, save in this one* case, has never been impeached.

That Dr. Bachman, at the age of sixty-five, should willfully and maliciously prepare and publish a series of falsehoods, is an opinion not for one moment to be entertained. The length of time which elapsed between the experiments and the publication of the paper in which they are described, has been urged as an argument against the possibility of their having been performed. This is readily answered by the fact that Dr. Bachman makes no claim to the invention of the process. A full account of Jacobi's experiments and their result was published in 1773 in Duhamel du Monceau's "Traite general des Péches," a work to which young Bachman had, most probably, access. And we therefore see in this school-boy experiment the early dawning of that love for scientific research which in riper years rendered him famous.

Between the years 1804 and 1844, experimental pisciculture was frequently practiced both by

* Garlick's "Fish Culture," 1858, p. 135.

amateurs and savans, and numbers of facts ascertained which upon the revival of the science proved of the greatest value and importance. In 1820, Messrs. Hivert and Pilachon, after much trouble, succeeded in hatching a sufficient number of trout to stock a small stream in the south of France. The eggs used in the microscopical examination of the development of the embryo, by Messrs. Vogt and Agassiz, were also obtained in this manner. But claim to the re-establishment of pisciculture as a science must be awarded to Joseph Rémy of France. Rémy was a fisherman who gained his livelihood by the capture of trout in the streams of the Vosges Mountains, dividing Alsatia and Lorraine, those two countries which, from time to time, alternately appear on and disappear from the maps of France and Germany. He had noticed with regret the rapid disappearance of his favorite fishes, and being, though uneducated and ignorant, active, energetic, and persevering, devoted himself for several years to the study of their habits, especially during the spawning season. The excessive drought during the summer and autumn of 1842 favored his investigations. It was, of course, impossible for one man to keep a constant eye upon a school of fishes; nature would demand rest; Rémy therefore associated with him a tavern-keeper (aubergiste) named Gehin, who alternated with him in his observations. So earnestly were these pursued, that in one instance, during the full of the moon, a school of trout were kept constantly in view during four consecutive days and nights. The result was the rediscovery of the process of Jacobi, which they at once put into successful practice; for four years it was kept secret, as even if desirous of so doing, neither of the operators were able to prepare an account of their work for the public use; but in 1848 Dr. Haxo, of Epinal, visited their establishment, and at once recognized the value of their labors. Reports were immediately prepared by him and forwarded to the Government and French Academy; by both were they received with favor. A commission of savans, headed by Mr. Coste, Professor of Embryology in the College of France, visited the fish farm of the Vosges, and reported upon it favorably. Rémy became at once a celebrity; he was invited to Paris, and the fisherman, but a few months previous utterly unknown, was an honored guest at the table of the President of the then Republic. Work after work was written; report upon report issued. A violent war of words arose between Dr. Haxo and Prof. Coste in regard to the question of Rémy *versus* Jacobi, the whole resulting finally in the establishment of the French Governmental fish farm at Huningue, in 1851.

In 1853, Dr. F. Garlick and Prof. H. A. Ackley succeeded, after great labor and expense, in establishing a small fish farm near Cleveland, O. The primary result of this was the hatching of a few trout; the secondary, the appearance of a work entitled "A Treatise on the Artificial Propagation of Fish," a work at the present day far more curious than valuable. In 1859, Mr. Stephen H. Ainsworth, of West Bloomfield, N. Y., commenced his experiments; from the paucity of his supply of water, it was impossible for him to enter upon fish culture as a business; but as an experimenter, he has perhaps done as much if not more for the advancement of American trout culture than any other person. He has made numerous inventions, among which his SPAWNING RACE stands pre-eminent. The following letter, received some time since, will explain his character as a man and a pisciculturist better than pages of eulogy:

WEST BLOOMFIELD, N. Y., *Oct.* 26.

DEAR SIR—The spawning race you refer to is not patented, nor will be with my knowledge and consent. I have done all I well could for eleven years to improve the cultivation of trout for the benefit of mankind, not for my own profit. Should this race prove to be the best method of impregnating and saving the spawn to produce healthy trout, without mortality soon after they commence to feed, it will be the great object sought for, and make trout-breeding certain. But time and experience will test this.

Respectfully, yours,

STEPHEN H. AINSWORTH.

Among the frequent visitors to Mr. Ainsworth's fish farm was Seth Green, whose name is now known and honored by every angler and epicure throughout our land. For years he had been studying the problem of fish culture, and had, like Rémy, spent days and nights in observing the habits of fishes. In 1864 the well-known Mumford establishment was originated by Mr. Green, and hundreds of thousands of impregnated spawn annually shipped to all parts of the United States. The great problem was solved, and for the first time in America fish culture was made a pecuniary success. Trout were hatched by thousands, but as a representative American, Seth was not satisfied: the production of millions alone would content him. Our shad were rapidly diminishing in numbers and decreasing in size; his desire was to restore them to our depleted streams. This was the task to which he bent all his energies. The difficulties he encountered are too well known to be repeated; but at length his hour of triumph came: the shad hatching-box, beautiful in its simplicity, was invented. The Connecticut River was replenished with shad, thousands were captured at one sweep of the seine where hundreds had been taken but the previous year, and fish culture had become a matter of national importance.

Such is a slight sketch, which we hope may not prove uninteresting, of the rise and progress of our art; step by step has it advanced from 2,100 B.C. to 1872, but who can prophesy its future? In 1864 there was but one fish farm in the United States; in less than eight years they are counted by hundreds. Success is within the reach of all—may all achieve it!

CHAPTER II.

CHOOSING A LOCATION.

THAT the choice of a location for a fish farm is a matter of vital importance to the pisciculturist, is self-evident. The statement that any farmer who has a spring upon his place can at once enter upon the business at little cost of time and money is, as experiment has too often proved, scarcely correct. We have examined hundreds of streams and springs in various parts of our own and adjacent States, and though a few have been found to combine all the necessary requirements, many, from causes hereafter to be mentioned, were totally unfitted for the purpose. The requisites for a perfect trout farm are:

1. An ample and constant supply of pure, cold water.
2. Sufficient fall for the construction of ponds and race-ways.
3. Protection from surface water.
4. Proper material for the construction of banks.

That an ample and constant supply of pure, cold water is absolutely necessary, must be apparent to all. For judging this, the only proper time is during midsummer, when the supply is at its minimum and the temperature at its maximum. Try the water with a good thermometer (not one of those twenty-five cent abominations with which the energy of peddlers have stocked the country), and if the temperature is above 65°, though in the air it may be among the nineties, it is unfit for fish culture. It is true that trout will thrive even at a temperature some five degrees higher, but it must be remembered that the water, in passing through the ponds during the summer season, has a most unpleasant habit of becoming hotter and hotter, and while spring head is at 60° lowest pond may be some ten degrees higher. Again, we have found from careful research that the lower the temperature of the water to which the spawn are subjected during incubation, the more healthy the little fishes are likely to be; we say temperature of the water, for below 32° of course ice is formed, which is in most cases fatal to the vitality of the egg. The springs by which the hatching-houses of our most successful establishments are supplied, range from 47° to 55°. It is true that by a low temperature the time of incubation is lengthened, but this is a matter of little importance; again, with increased temperature comes increased danger: the fungoid growths which, in spite of all our care, will sometimes appear in our hatching-trays or rearing-boxes, are too often evidence of a too elevated temperature. Attempts made to keep down the temperature by passing the water through a refrigerator filled with ice have thus far failed, even when the experiment has been performed upon a very small scale. Other fish may be hatched at a much higher temperature; shad eggs not coming to maturity below 70°, and gold fish have been bred even when the thermometer stood over a hundred; but trout are a peculiar fish, and 55° is the highest at which their spawn will produce vigorous and healthy young. The question is often asked: given the capacity and temperature of the water supply, what amount of trout will it support? To answer this we sought diligently the pages of all authorities upon fish culture, but in none of them was the subject even mentioned. Inquiry was made of those who were supposed to be thoroughly posted in every branch of the art, but no information could be obtained. We at once entered upon a course of experiments, resulting in proving that for each gallon of water per minute at the temperature of 50° degrees, ten pounds of trout can be sustained; thus the Troutdale spring delivers a volume of water which at the dryest season has been proved by repeated experiments to measure twelve hundred and fifty gallons per minute; as each gallon will support ten pounds of trout, twelve thousand five hundred pounds weight can be sustained by the water of our spring. When sufficient fall can be obtained, by proper aeration the capacity of the water may be still greater increased.

Many rules, most of them involving abstruse mathematical calculations, have been given for ascertaining the number of gallons delivered by a stream per minute. The following, however, we have found to be the most simple and sufficiently correct for all practical purposes. Measure the width and depth of the stream where for a short distance the banks are nearly parallel and the depth nearly uniform; between these parallel banks throw a chip or cork into the water, and note the distance it drifts during a quarter of a minute; multiply the product of the depth and width of the stream by the distance traversed by the chip or cork, and the product, when diminished by one-fifth, will give the number of cubic feet delivered in a quarter of a minute. The one-fifth must be deducted, as the rapidity of the flow on the surface is greater than at the bottom of the stream. Thus, suppose the depth of the stream to be two feet and its width four, and that the chip has traveled ten feet in one quarter of a minute. Twice four are eight; this multiplied by ten, the distance traversed, will give eighty, from which deduct one-fifth (16), and we have sixty-four cubic feet as the amount delivered in a quarter of a minute, or two hundred and fifty-six per minute. Now, as a cubic foot of water contains about six and a quarter gallons, we multiply the number of cubic feet (256) by six and a quarter, and the result (1,599) will be the number of gallons furnished per minute by the stream. The accuracy of the result of this method of measurement will depend, of course, upon the parallelism of the banks and the uniformity of the depth of the portion of the stream over which the chip has floated. When the water passes through a rectangular trough, the result will be found to be almost absolutely correct.

The necessity of a sufficient fall for the proper arrangement of ponds, race-ways, and buildings is absolute; in fact, the maintenance of the proper temperature depends greatly on the rapidity with which the water flows through the ponds,—a slow, sluggish stream becoming rapidly heated, while a rapid current may pass over a comparatively long distance without the water becoming perceptibly warmer. The rapid-running mountain brook is the home of the trout; and this should be imitated as closely as possible. Four feet is the least fall which will render the ground suitable for the construction of trout ponds.

From the influx of surface-water more loss has probably been sustained by pisciculturists than from any other cause. "My banks have been again carried away by a freshet," is the cry of too many sufferers, and no accident is more difficult to prevent than this. All streams are liable to freshets; and for this reason, as well as others to be mentioned in a succeeding chapter, a spring supply is greatly to be preferred. A properly-constructed trout pond should not become muddy during the heaviest rain storm. By a proper system of ditching, or the construction of guard banks, in many locations the surface water can be kept out; but too frequently the lay of the ground renders it impossible to construct them without great expense, and sites which possess all other advantages are unavailable for trout ponds. The best material for the construction of pond banks is, beyond all doubt, clay; but this is not always to be met with. Much labor and expense, however, is saved if it is found upon the spot, though good banks can and have been made with other material. Yet in case several locations, otherwise similar, being offered to the seeker for a pond site, it would be well to investigate the nature of the surrounding soil, and choose that upon which earth is found most suitable for bank construction. Sandy loam or gravel will, with proper care and expenditure, form good banks, but clay is far preferable. It may here be suggested that the immediate vicinity of a large town is to be avoided, as the roughs, that class of population to be found in every city, have a fondness for trout; and a nocturnal visit from individuals of this stamp is generally attended by results far from pleasant. In fact, the stealing of trout from a private pond is too frequently regarded by even the so-called better classes as a venial offense. In many of our States it is considered in law only as a trespass; and many have been deterred from engaging in fish-farming from want of proper protection for their crop; but unfortunately no distinction is made between fishes reared with much labor and expense and the wild denizens of the mountain brook, all, wherever found, being regarded as *feræ*, and their captors being liable only to a small fine and the market value of the fishes taken; in fact, Mr. Ward, of Mumford, N. Y., was obliged to suffer an imprisonment in the county jail, a few years since, for peppering with shot the carcass of a scoundrel whom he detected in the act of stealing his fishes. Can it, therefore, be considered strange that a large percentage of the trout sold in the New York market bear upon them, in the marks of the gill nets in which they were taken, silent proofs of the necessity of more stringent legislation? It is advisable that the ponds should be so located as to be in full view of the residence of the proprietor, and a good dog, or, better still, a pair, will generally give notice of the approach of a nocturnal visitor. We have no doubt but that the voices of our faithful bloodhounds Nero and Flora have frequently prevented the visits of poachers to our ponds.

Such are the points to be examined in selecting a location for a future fish farm; and should a situation be found combining all these necessary qualifications, nature has done her part, and now the work of human hands must commence.

CHAPTER III.

PLANNING AND CONSTRUCTION OF PONDS.

THE site being procured, the next step is the planning of the ponds, a matter of no small trouble and care. One wrong step at the commencement may entail constant perplexity and even disaster. It is easy for an expert to plan and construct, but for a tyro it is a matter of no small difficulty, and the few dollars paid at the outset to a competent piscicultural engineer may save in the end thousands. The plan must, of course, vary with the nature of the ground; in fact it would scarcely be possible to construct two in different locations precisely alike, but the following directions are applicable to all cases.

Three ponds at least are always required connected by race-ways never less than fifteen feet in length. In these race-ways the spawning races are to be placed; or if the spawn is to be taken by hand they must be prepared so as to entice the fishes into them when ready to give up their eggs. Unless the water supply is very scant, the full current must not be allowed to pass through the pond in which the youngest fishes are to be placed. Each pond should, if possible, be so arranged that it may be drawn entirely off without affecting the remaining ponds. The shape of the ponds is a matter of importance. For ornamental pleasure grounds the circle or elipse may suit, but for working ponds the form should be always oblong, and the width no greater than twenty-five feet. This will allow the ready removal of dead fish or any filth which may accumulate upon the bottom, which it would be impossible to reach were the pond of a circular or even oblong form. Should the formation of the ground permit, the ponds should be placed parallel to each other, and not, as is too frequently the case, strung along like beads upon a string. It must be remembered that the hardest work of the fish-farmer occurs in the coldest season of the year, and the whole works should be arranged as compactly as possible, that every unnecessary step may be avoided. A full suite of ponds need not occupy a space of over two hundred and fifty by one hundred feet.

As an example of a complete system of ponds, we present on the following page a diagram showing the arrangement of our works at Troutdale, near Bloomsbury, N. J., the compactness and convenience of which we think can scarce be excelled. The original plan, which, however, we have greatly modified, was devised by Mr. Thaddeus Norris, of whom we purchased the place in 1867. At the time of purchase, pond No. 1 only was completed, though work upon the banks of the other ponds had been commenced. Four years have we been engaged in perfecting them, and it is only within the past season that our improvements have been entirely completed.

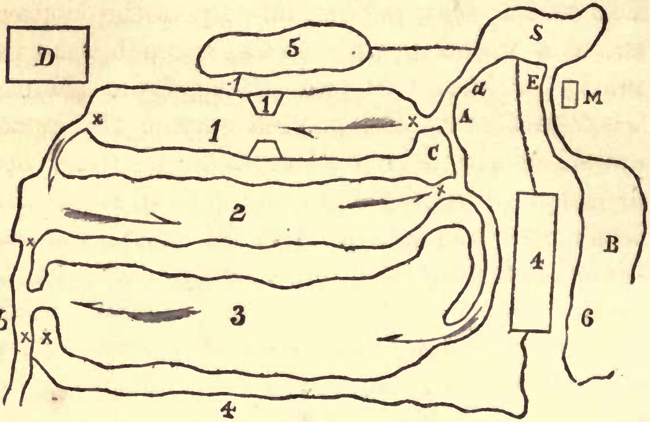

FIG. 1.

The spring (marked S on the plan) from which all the water is obtained is of a capacity of about twelve hundred gallons per minute, constant in quantity, throughout the entire year. The temperature of the water is 50°; never varying more than one degree in the heat of summer or depth of winter. Analysis shows it to contain carbonate of lime, alumina, and iron in small quantities, with a small amount of free carbonic-acid. Passing down a race-way (*a*) fifty-five feet long, four wide, and six inches deep, the water enters pond No. 1; and, following the course of the arrows, passes successively through 1, 2, and 3, and is discharged at the point *b* into No. 4. This pond is not used for fishes, but for the culture of water-cress, an article which finds a ready sale in the New York market. At the points marked *x* are sluice-gates, at which are placed screens of wire gauze. These screens are arranged in pairs, and each performs a separate duty—the upper arresting all leaves, sticks, or other floating trash which may find its way into the ponds, and the lower preventing the mixture of fishes of different ages.

When the young fishes are first placed in No. 1, were the whole current of the stream allowed to pass through they would be washed against the lower screen and perish; but by means of the cross race (*c*) the amount of water supply can be regulated to a nicety. The hatching-house (H) formerly occupied the site of the gold-fish pond (5), and was supplied with water from the spring by pipes, but some two years since was removed to its present and more convenient location. At C a small branch from the spring supplies the water by which the machinery in the meat-house (M), used for preparing the fish food, is put in motion; the waste water then passes to the bass pond (6), in which experiments upon the breeding of the black bass are to be prosecuted during the coming summer. At D is the house of the superintendent, while the residence of the proprietor overlooks the whole. The dimensions of the principal ponds are:

No. 1, 150 by 15 feet.
No. 2, 150 by 18 feet.
No. 3, 185 long, and varying from 20 to 35 feet in width.

Depth: No. 1, one to two feet; No. 2, two to four feet; No. 3, three to five feet.

In cases where ponds are constructed in the direct course of a stream, the pond for the small fry should be placed on one side and connected with the main channel by a race with a sluice-gate at its opening, by which the supply of water may be regulated. Fig. 2 represents a series of

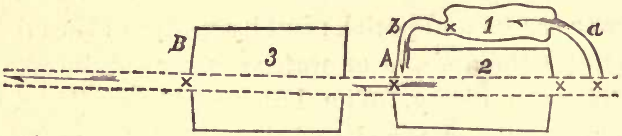

FIG. 2.

ponds planned by us in 1869, and now in successful operation. The dotted lines indicate the original course of the stream. At the points A and B dams were erected and the earth removed, forming ponds Nos. 2 and 3. Pond No. 1 is excavated upon the right bank and connected with the main stream by the race *a; b* serves both as an outlet for No. 1 and a spawning race for No. 2. Sluice-gates (marked *x*), with screens, are placed at proper points. We might go on adding plan to plan, *ad infinitum*, having in our portfolios dozens which we have either designed, or drawn from other sources; but we hope that the two presented will afford our readers a general idea, which is all that can be expected in a work of the present size.

The plan of the ponds having been decided upon, the proportionate size of the banks required to retain the water will next occupy the attention of the projector.

This is a matter of more importance than is generally considered. Moving earth is an expensive process, and every cubic yard unnecessarily transported is money lost to the projector; while if not built of the requisite strength, severe loss is sure to follow. The proportions suggested by the French engineers, and which we have found in every case to be perfectly satisfactory, are as follows: the width at base must be three times the the height, and the width at top equal to the height. Thus, if the height of the embankment is ten feet, the width at base must be thirty feet, and the width of the top ten. These are the proportions with ordinary earth; if stiff clay be used the thickness need not be so great, and if sandy loam or gravel only can be obtained the width, base, and top, must be increased. The water line should never be nearer the top of the bank than one foot. Great damage is frequently done by the muskrat. He has been accused of killing the trout. This we think to be a mistake; but his burrowing propensities we know by sad experience. In localities where these pests abound it is well to build a wall of brick, and fill in each side with earth to the proper slope. The driving of sheet piles through the banks has been recommended, but the creatures seem rather to enjoy gnawing their way through them. A wall of brick or stone, be it only but a few inches in thickness, will, however, effectually keep them out. For the same reason, the race-ways should be lined with brick. As soon as the banks have settled they should be sodded. Besides adding to their beauty this will prevent them from being washed and guttered by the rains. If trees are wanted they should be planted at once. The best tree for pond banks is the weeping-willow—of rapid growth, sending out roots in every direction, which firmly bind the banks together, the first green tree in spring, and the last to shed its leaves in autumn, it is peculiarly adapted for the shading of fish ponds. The building and proper setting of the sluice-ways require much care. We are sorry to see that several new, and otherwise well-appointed establishments have adopted a species of concealed gate, a large portion of which is totally inaccessible unless the water be entirely drawn off from the pond. An open gate, to every part of which free access can be had at all times, is the only one which should find a place at the ponds of a practical fish-farmer. The best wood for their construction is well-seasoned chestnut. The frame should be of 2×2 lumber, mortised and tenoned. Every nail should be dipped in oil before being driven, and two thick coats of paint applied to the whole woodwork and allowed to become thoroughly dry before the sluice-gate is placed in position. It is well if the boards are plowed and grooved, but this is not absolutely necessary. In setting in position, level the ground accurately, place the gate perfectly level, and behind, place across the bed of the stream a frame of scantling upon which nail boards, forming a sheeting, reaching from the gate about three feet up stream. On this build the wings, extending at an angle of about 45° to the end of the sheeting. At the *front* edge of the gate lay up a rough wall and fill in with mud—not dry earth, nor even dampened earth, but liquid mud. Allow this to remain until dry, and you will have that rare article upon trout farms, a perfectly tight sluice-gate. The frames of the screens should be strongly made and mortised. Of these frames it is well to have an extra supply on hand, that in case of injury to one it may be at once removed and another substituted. For leaf screens, galvanized iron wires, No. 9, should be used, placed parallel, about three-quarters of an inch apart, with a transverse wire every four inches to prevent bending and falling out. The fish screens (Fig. 3) should be made of wire gauze from one-eighth to

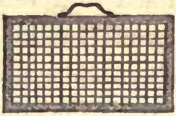

FIG. 3

five-eighths of an inch mesh; the smaller sizes (say to three-eighths) of copper or brass; the larger may be of iron, painted or galvanized. If kept well painted they will last a long time, even under water. The wooden frames should be thoroughly painted, and a japanned iron handle attached to the top will be found very convenient.

Shade, which is absolutely necessary for trout, is best furnished by trees which, as previously stated, should be planted as soon after the completion of the banks as possible; but while they are growing, a few boards nailed together, forming a float, should be anchored in each pond. A few rustic bridges will also afford hiding-places to the fish, as well as adding to the beauty of the grounds.

The bottom of the first pond, or that intended for the fishes during the first year of their existence, may be covered with gravel, but none should be allowed in the other ponds. During the spawning season the adult fishes will seek gravel for the purpose of depositing their ova, and should it be found by them in the ponds, they will not resort to the race-ways, and the eggs will be lost. The growth of aquatic plants should be encouraged, especially in the first pond, as they perform a triple service: first, they assist in oxygenating the water; secondly, they give ample shade to the little fishes; and thirdly, they afford refuge for myriads of minute insects, the natural food of the young trout. There is but one objection to plants: they are the favorite food of the muskrat; and, during the winter, when green vegetable food is not everywhere to be met with, these pests of the fish-farmer will be attracted by it, and, as they cut off much more than they eat or carry away, serious difficulty may occur from the clogging of the screens.

To obviate this, we have for some years past drawn down the water of our ponds about the first of October, and cut off all plants with a sharp scythe. This removes temptation from the muskrats, and favors the spreading of the water plants. The best for this purpose are the hornwort (*ceratophyllum*) and water starwort (*callitriche*).

A number of large, irregular stones should be placed in the second and third ponds, that the fishes, by rubbing against them, may free themselves from the parasites with which they are sometimes infested. And if fears are entertained of visits from midnight marauders, a number of stakes deeply driven into the bottoms of the ponds and sawed off even with the top of the water will effectually prevent the dragging of a seine, or the proper (or improper) manipulation of a scoop-net.

A strong and high picket-fence should inclose all. The best pickets are made of hemlock, and should be at least eight feet long, four inches wide, and one and a quarter inches in thickness. These must be strongly nailed to the string-pieces, which should not be less than 4×4 inches. A light fence, from its liability to be broken, is a source of constant trouble, besides affording but little protection. A good coat of whitewash every two or three years will be all the care required.

CHAPTER IV.

HATCHING-HOUSES AND APPARATUS.

THE hatching-house is a modern invention. A simple trough by the side of the stream, guarded by wire screens at each end, having the bottom covered with sand or gravel, and a cover with lock and key over the whole, was the only apparatus used by Pinchon and Jacobi; Rémy inclosed his spawn in perforated tin boxes; and a champagne basket anchored in the stream was frequently used as a means of hatching ova by the early French pisciculturists. The trough of Pinchon and Jacobi is still retained in some of our largest American establishments, and was used at Troutdale until 1870. In our latitude, out-door hatching-troughs, except on a very small scale, are entirely out of the question. Trout-spawning takes place during the coldest and most inclement season of the year, and a covering is positively required—even a stove in the hatching-house being a luxury by no means to be despised. Three styles of hatching apparatus are now in use: the trough, the Coste (or, more properly, Caron) arrangement, and a combination of the two. The cut on the opposite page, representing the Troutdale hatching-house, in 1868, will show the trough arrangement.

In the floor are set two double rows of wooden troughs, thirty feet long by eighteen inches wide and four inches deep; these are each subdivided by cross-pieces of wood into twenty compartments, 18×18 inches, the bottoms of these divisions being covered to the depth of about an inch with fine white gravel, and a gentle current of water allowed to flow through them, the water being carefully filtered. In fact, no unfiltered water should be allowed to enter any hatching-house; not only so-called dirt (which has been properly defined as misplaced matter) will enter, but also the larvæ of insects, many species of which destroy the spawn with tremendous rapidity. At Stormonfield, Scotland, over seventy thousand salmon eggs were lost in one season from this cause.

When, from the location, it is possible, it is well to have the troughs raised breast-high, that in examining the spawn and removing the dead a back-breaking position may be avoided. This, in our old hatching-house, was unfortunately impossible —the fall from the spring to the level of the floor being but a few inches. Short troughs have been much lauded by writers, but after careful experi-

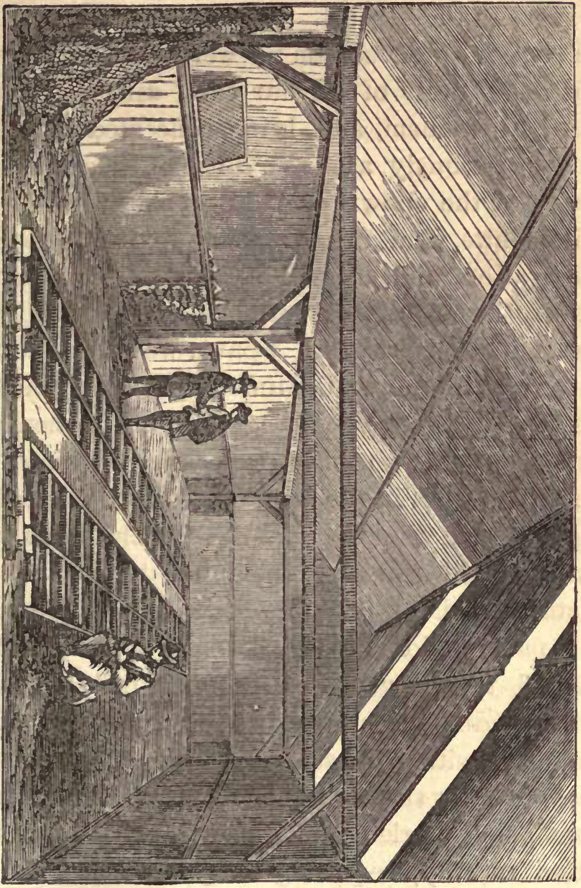

FIG. 4.—TROUTDALE HATCHING-HOUSE IN 1868.

ment we found that the spawn deposited in the lowest division of the trough did equally as well as those in the highest.

From our first season we were dissatisfied with troughs. Spite of all our care, dirt would find its way into them, and, lying concealed amid the gravel, seriously affect, by its putrefaction, the health of the spawn or young fishes; the gravel being white, dead ova would too frequently escape observation, and, as will hereafter be explained, destroy large numbers of eggs before their presence could be detected. Spawn would die buried in the gravel, and at the time of the emergency of the young fish from the egg, a period when perfect cleanliness was most especially required, the amount of filth in the troughs would be greatest. Again, upon the wood a thick, gelatinous substance would appear, slimy to the touch and disgusting to the eye, and which no precaution on our part could prevent, though we have since learned that covering the entire inside surface with window-glass, bedded in pitch, has been practiced with success. The difficulty of removing spawn for supplying customers was great, and, from being buried in the damp earth, the wood rotted rapidly, requiring frequent repairs. We were delighted on reading of the small hatching-trays invented by Mr. Caron, of France, though erroneously attributed to M. Coste, Professor of Embryology in the College of France, the latter gentlemen having only used it in connection with his well-known experiments. It appeared to us to afford every facility for examining, handling, and keeping clean the spawn. As its use, on a large scale, would necessitate the changing of the site of our hatching-house and involve considerable expense, we commenced upon a small scale, but the results being perfectly satisfactory, we, in 1870, rebuilt our hatching-house in a new

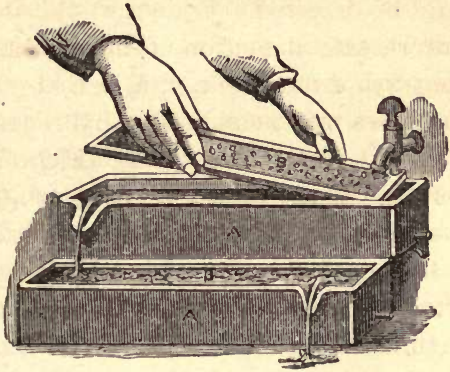

FIG. 5.

location, using only the trays; and have never regretted the change, considering that, at least, one-half of the manual labor is saved by their use. A pair properly arranged is represented by Fig. 5. The box, or body of the tray (A), is of galvanized iron, about No. 29 guage; it measures twenty inches in length, six inches in width, and three in depth; at each corner is soldered, one and a half inches from the top, a triangular piece of galvanized iron, upon which the grille or frame rests; a spout is placed near one corner, and a tube for drawing out the contents, when necessary, is attached to one end. This, when the tray is in use, is closed with a cork.

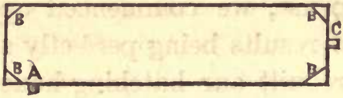

FIG. 6.

Fig. 6 represents a section of the metallic portion of the tray, A the spout, B, B, B, B the triangular corner-pieces upon which the grille rests, and C the drainage tube. The grille (Fig. 5, B, B,) is composed of glass tubes, from $\frac{3}{16}$ to $\frac{5}{16}$ of an inch in diameter, inclosed in a frame of black walnut, measuring, inside, exactly eighteen and a half by four and a half inches. This exact length was chosen as it will include, on an average, one hundred eggs, and thus the amount taken may be readily estimated. The width was chosen, after consultation with a tinman, that there need be no waste in cutting the material—a point of no small pecuniary importance, when large numbers are to be manufactured. The tubes are lightly yet firmly bound together by copper wire, which allows slight, lateral motion if required, and binding them together allows a shock to be distributed over the entire set. The force of a blow which would cause breakage of a single tube is thus divided over a number, and they escape unharmed. The ends of the frame are fastened with screws, and, should any of the glasses become broken, they may be readily removed and others substituted. A single tray, or, at most, a pair, are all that are required for experimental purposes; they may be supplied with water from any bath-room, and have, as an adjunct to the aquarium, met with great favor from persons interested in natural history or physiology The shell of the egg being transparent, the young, at all periods of its development, is plainly seen. We were, as far as we can ascertain, the first to introduce this beautiful piece of fish apparatus into America, and met with some opposition from those who were wedded to their gravel troughs. We desired to select a location as unfavorable as possible for fish-hatching, and finally decided upon the lecture-table in the laboratory of the University of Pennsylvania, during the height of the lecture season; yet, amid this atmosphere, contaminated by all the noxious gases which the ingenuity of man can eliminate, many of which are highly soluable in water, exposed to great variations of temperature, and to the constant vibration caused by the arrival and departure of hundreds of students, ninety per cent. of spawn deposited on the grille, as soon as the eyespecks could be distinguished, hatched. To Prof. Rodgers we would here return our thanks for his kindness in allowing us to perform this experiment. Where several boxes

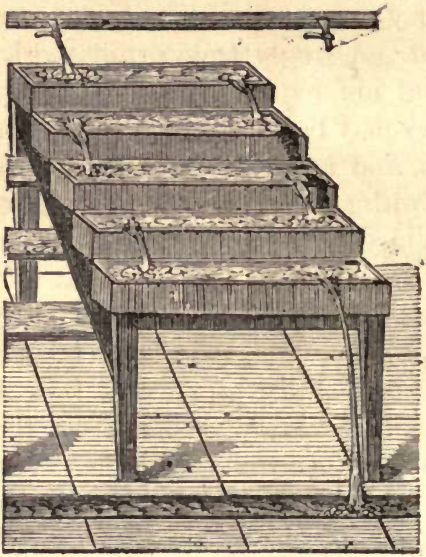

FIG. 7.

are used they are arranged in flights, the spouts being alternately right and left. The above engraving (Fig. 7) represents what is called the single flight. The quantity of water represented by the artist as rushing through the boxes and falling in a graceful parabolic curve to the floor, is entirely too great; a slight stream, which has been described as a severe trickle, will be all that is required.

As the boxes have an average capacity of fifteen hundred spawn, seven thousand five hundred can be hatched in a flight of five boxes, occupying a space of but twenty-one by thirty-one inches; while the double pyramidal flight (Fig. 8), eight

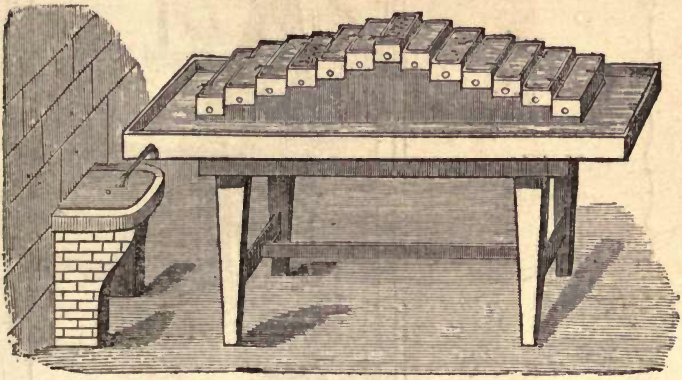

FIG. 8.

feet by three, will accommodate about twenty thousand spawn. In the Troutdale hatching-house, of the interior of which a cut is presented (Fig. 9) on the following page, it will be seen that along the wall, to the right and left, these trays are arranged in double, lateral flights, the water entering from a two-inch pipe directly from the spring

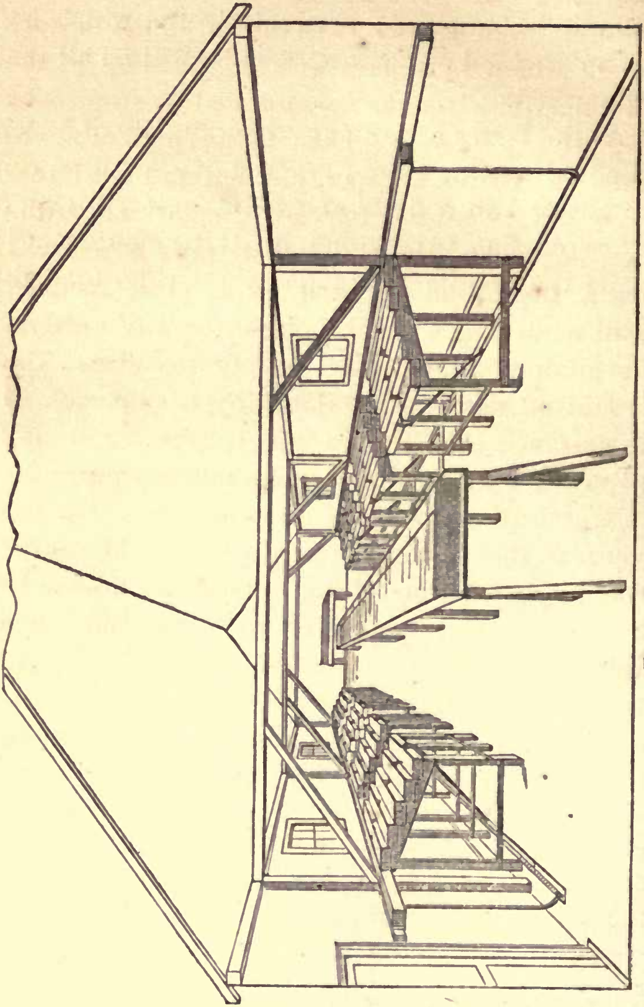

Fig. 9.—Troutdale Hatching-House.

into the filtering-box at the extreme end of the building, from whence it is carried to the supply trough which runs parallel with the sides of the building. The troughs are supplied by stop-cocks of pewter. These we have found preferable to brass, as they are cheaper, cleaner, and not liable to get out of order. Instead of splashing on the floor, the water from the lowest trays is received into a funnel and passes by a pipe, inclined at an acute angle, to the out-of-the-way gutters, immediately beneath the supply troughs. The amount of water is regulated by a stop-cock at the entrance of the main supply pipe. For this purpose a molasses faucet answers every purpose; a slight leakage being of no importance. In the center of the building are a pair of old gravel troughs, elevated breast-high; these are used only for keeping the young fry for some time after hatching, and are called the nursery troughs. They are of little use, except in large establishments, and will be again mentioned when we arrive at the alevin or babyhood stage of the young trout. The floor of the hatching-house is a matter of some importance, dry feet are a luxury which we fully appreciate, and india-rubber boots an abomination. A dry floor of a hatching-house, be it of wood, earth, asphalt, or cement, is almost an impossibility. The best arrangement that can be made is to lay what is called a spar floor, composed of pieces of shingle lath (2 × 1) laid upon 2 × 3 inch scantling, the laths being one inch apart, and rounded slightly, or, as it is technically termed, "the corners taken off" on the upper side; any water which may drip will, of course, fall between these, and a comparatively dry footing will be obtained. By means of overflow pipes in the supply and breeding troughs, a proper height of water may always be retained.

The advantages of the tray over the trough system are numerous: First, it is almost impossible for any dirt to settle upon the glass and destroy the vitality of the egg; secondly, the eggs are always in full view, not only can their development be watched, a matter of great interest to every true fish culturist, but any dead or dying ones can at once be detected and removed. The number of rods in each grille being known, the number of spawn on hand can be at once estimated; and, when eggs are to be packed for shipping, the uncertain method of measuring and the tedious one of counting can both be avoided. The young fishes, when hatched, fall through the interstices between the tubes into the water beneath, and by withdrawing the cork can be "drawn off" into a pan of water and removed to the nursery trough. If no trough is on hand, they may be retained in the pan until the trough is thoroughly cleansed and a little gravel spread over the bottom, when they may be returned to the tray and kept until ready for the pond. If it is intended that the tray be used as a nursery, it should have the orifice of the spout covered with fine wire gauze, to prevent the sudden disappearance of the fish after the sac has been absorbed, an event of no unlikely occurrence. The windows of the hatching-house should be protected by thick blinds, as the dim, religious light, so often mentioned, is appropriate for the spawn. Direct sunlight is decidedly injurious and frequently fatal. We have found a small reflecting lantern convenient in examining spawn. Candles should not be used, as grease falling into the trays may seriously injure their contents.

The mixed system is a combination of the trough with the grille—a slight saving in expense is the only benefit to be derived from it, and this is more than counterbalanced by the difficulties met with in their manipulation. If the troughs are long, a slight motion at one end will cause a wave which will be transmitted throughout its entire length, and, as we have found by experiment, seriously disturb the spawn. It will be found to be very difficult to keep the trough clean, and the young, after hatching, fall directly upon the dirt, which has for some time been accumulating, and which can not readily be removed. Two troughs, with one set of grilles, which might be transferred from one trough to the other to allow cleansing, might answer; but the tray is by far the most convenient; it is simple, substantial, neat, and cleanly; and what more can be desired?

The ground around the hatching-house should be made to slope away from it in every direction, and should this be, from the lay of the land, impossible, wide ditches should be dug, of sufficient capacity to carry off all surface-water. Our old hatching-house was built at the foot of a hill, and more than once, during an unusually heavy summer shower, have we found the water standing on the floor, once to the depth of nearly a foot.

Unless the fish-farmer is abundantly supplied with cash, we would recommend that the hatching-house be built as plainly as possible. We have seen them of cut stone, with handsomely ornamented cornices, but are not aware that the percentage of spawn hatched in them was greater than that in other and more unpretending structures. Inch hemlock with strips at the joints of the boards is all that is required, and a good and cheap roof may be made by covering boards with felt paper, on which is placed a good coat of plastic slate, or even thick mineral paint, well sanded. The roof should be perfectly water-tight, as the disturbance of the spawn by the dropping of water is apt to cause serious injury to them. A strong spring upon the door to prevent it from being carelessly left open is of more consequence than may at first sight appear, as fowls and birds of all descriptions are very fond of the spawn, and will eat it upon every opportunity, probably taking it for some new species of grain. Rats and mice are sometimes very destructive, if they make their appearance late in the season, as may be known by finding of a morning the spawn piled in heaps, instead of lying neatly upon the tubes. The trays must be covered; half-inch boards, cut to proper lengths and notched to admit the spouts, will answer well, and then poison the rats. Be not deceived by venders of nostrums—"Dead Shot," "Sudden Death," "Phosphorus Paste," etc. We have fed rats and mice on these, and they seemed to enjoy them; but arsenic and strychnine act, and act promptly, and no second dose is required. With any proper amount of care there is no danger of injury to outside animals.

For conducting water from the spring to the filtering-box, iron pipe is the best. This can be obtained at a low cost,* and will last a life-time. Lead will, in some cases, affect the water, and terra

* We can furnish it at five cents per pound.

cotta can not be relied upon. It is but little cheaper than iron, when the cost and risks of transportation are taken into consideration, and we have known it to crumble from the action of frost. The supply pipe is the main artery of the hatching-house, and any derangement may cause the loss of hundreds of thousands of spawn. The spring end of this should project some distance into the water, that the supply may be of the purest, and a perforated filter should be attached to the end. Bored wooden pump logs are the worst means yet devised for conducting water, and should never be used, as we know by experience.

A two-inch pipe, with a fall of two feet, will supply ample water for the hatching of one hundred and fifty thousand spawn, if the trays be used. The trough system will require perhaps one of two and a half inches, or even larger.

As previously mentioned, all water should be carefully filtered; this is most conveniently done by means of the filtering-box, located at the extreme end of our hatching-house (Fig. 9), the water entering near the center of the box passes, first through haircloth or grasscloth, then through coarse, and afterward through fine flannel. A set of these is placed on each side of the pipe. Our method of attaching the flannel to the frames is somewhat peculiar. The old plan was to fasten them on with small tacks, but as the flannel rapidly rotted, it was a work of some time and labor to renew them. Our present plan is, to make two frames, fitting one within the other; between these the filters are fastened, in the manner of a drum head. They can readily be removed and washed, or, if necessary, replaced.

No whitewash should be used in oı on the building; a small fragment falling into the nursery trough might cause the death of thousands of young trout. Lime, in any form, seems to be peculiarly fatal to them, and must be avoided; and no paint of any description should be placed on any wood work on which young fishes are to be kept.

CHAPTER V.

THE SPAWNING RACE.

FROM one of the simplest appendages to the ponds, the spawning race has of late become, perhaps, the most complicated. Its use is, of course, apparent to all. It is the place to which the fishes resort for the purpose of depositing their ova. In some cases this action upon their part is forestalled by the proprietor, and the result is artificial impregnation; while in others, by means of screens, the eggs are collected and transported to the hatching-house, after having been fertilized without human intervention; while in a third form, the fishes, after depositing their ova, are driven out, and the naturally impregnated spawn allowed to incubate in the gravel in which they were deposited.

Let us first glance at the operations of the trout while in a state of nature. In the months of November or December, in our latitude (40–41°), the pregnant female, accompanied by her attendant male, seeks a shallow, shady spot, generally at the mouth of a small, cool stream, where the bottom is covered with fine gravel. Together they work, and by slow, but steady and oft-repeated sweeps of their tails, a hole of a circular form is excavated, varying from one to three feet in diameter, and from one to five inches in depth. This work being accomplished, they both remain perfectly quiet for some time, the period varying from a few minutes to several hours. During this time they appear almost entirely unconscious of the approach of their enemies, and may frequently be seized by the hand and captured without resistance. In fact, before the enactment of the present admirable laws, this was the favorite period of their capture, as a loop of wire, attached to the end of a short stick, was all that was required. Suddenly, however, the female bends her body into a curve, the tail and head elevated, and the abdomen pressed against the bottom of the excavation. On seeing this, the male at once takes his position at her side, his head being about even with her dorsal fin, both fishes heading down stream. Pressing her abdomen firmly upon the gravel, the female moves herself forward about one-third of her length, at the same time emitting a number of eggs. At once a few drops of milt are ejected by the male, and both back up stream to their former position. Again and again is this process repeated, until all the ova are deposited, when oth at once cover them with a few sweeps of their tails.

It is rarely that the most practiced observer can see the ova emitted, his first knowledge of the fact being obtained by the clouding of the water by the ejected milt, which follows so instantaneously as at once to obstruct the view.

Thus far, nature has done its work, and done it well; but, alas! the enemies, which nature sends, soon appear. Another pair of trout, seeking a spawning ground, may appear upon the field, and while excavating their own nest, discover the eggs deposited and impregnated by their predecessors, and regarding them as a savory morsel, at once *eat them up* before proceeding with their own work, which may, in turn, become the food of another happy pair. A duck or goose arriving on the ground, seems to recognize, by intuition, the precious deposit below; his head disappears beneath the surface, his broad bill dips deep into the gravel, and the eggs pass into his voracious maw. A freshet may bring down upon the clean, shining gravel a mass of mud, covering up the spawn and depriving it of the oxygen so indispensable for its existence. But not only above the surface appear the enemies of the spawn; others and more dangerous, being more concealed, are found below. The larvæ of many insects are aquatic in their habits and carnivorous in their tastes, as has been ascertained by sad experience. Seventy thousand salmon spawn destroyed in one season by these minute pests, at Stormonfield, bear witness to the truth of this statement. And even in the eggs themselves lie a source of death.

The dreaded byssus may appear, and there being no one present to remove the infected spawn, the loss of the entire nest may ensue

Having thus noticed the method of spawning when the trout are in their natural state, we learn by it the points necessary for the proper preparation of the spawning races, and the dangers which surround the spawn after impregnation. The object of the fish culturist is to imitate the former and obviate the latter. The races should be attached to every pond, except that in which the youngest fishes are kept, and should be prepared with care, as the object will be to entice the trout into them, that the spawn may not be lost The sides should be of two thicknesses of brick, well laid in cement. We have tried earth, boards, slates, and other cheap substitutes, but have abandoned them all for the brick, which alone we have found to be reliable. We have known the water rushing through a knot-hole in a wooden side plank soon wear a hole in which a pair of fishes could and did readily conceal themselves.

As previously stated, no gravel, under any circumstances, should be allowed in any pond, except that in which were placed the youngest fishes; but the bottom of the spawning race, of whatever character, should be well covered. Between the head of the race and the pond should be a fall of at least six inches, and should it be so great that it might be difficult for the fishes to ascend, recourse must be had to the fish ladder. This is readily formed by placing across the race boards equal in length to its width, and in width somewhat greater than the depth of the water. Wide notches, varying in size according to the amount

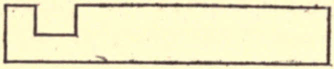

FIG. 10.—BOARD FOR FISH LADDER.

of water, should be cut in these near the end. These boards should be placed across the race, at distances determined by the height of the fall, and so arranged that the notches be on alternate sides

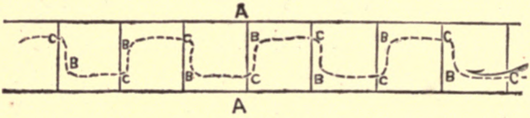

FIG. 11.—FISH LADDER.

of the stream. A plan of a ladder so arranged is to be seen in Fig. 11.

A, A represent the sides of the race; B, B, B, B, B, B, B the notched boards placed across the race, at right angles to the natural current; C, C, C, C, C, C, C, C the notches through which the water flows, the dotted line indicating the direction of the current. It is thus readily seen that the fish, on passing through the notch, at once finds himself in comparatively still water, and is thus able to rest himself and prepare for his ascent to the next pool. The boards may be held in place by a few twenty-penny nails, driven into the cement between the bricks upon the lower side, the force of the current retaining them well in their places.

Over the whole should be placed a cover. Loose boards have been much used, but we have objected to them from the time occupied in removing and replacing them. Covers formed of three-eighth inch pine boards, well-nailed to battens with wrought iron nails, and provided with hinges, pulleys, and a counterpoise weight, can be made to raise or lower at a touch. They are, it is true, somewhat more expensive than old odds and ends of hemlock boards, but when once made and thoroughly painted, will, if put away carefully at the end of the season, last a life-time.

Having thus shown how the important requisites of shade, gravel, and easy access are afforded our fishes, we will next consider the four varieties of spawning races used in the natural impregnation of ova, reserving for another chapter the entire process of artificial fertilization. Long ere fish culture was oknwn and recognized as a science, it was the custom of many who owned trout ponds to allow the fishes, during the spawning season, access to the spring-head, and after all their spawn had been deposited they were driven back to the pond, and their return prevented by a screen. In some parts of our country, especially, we have understood, upon Long Island, series of ponds were constructed in pairs, as in the annexed cut. Let A represent the main pond, connected by a sluice with the pond B by means of a short

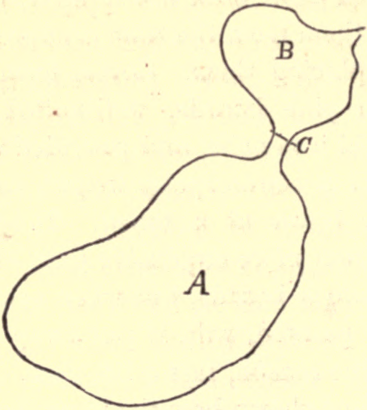

Fig. 12.

race-way and gate C, the water flowing from B to A. During the spawning season the gate (C) was opened, and the fishes ascended to B, the bottom of which was covered with clean, bright gravel. When the season was over the fishes were driven back to A, and the gate being closed, the spawn were allowed to hatch without disturbance. Being closely watched, all danger from aquatic birds was avoided, and thus two enemies of the spawn were removed, beside the young were protected for one year at least from the adults, whose love for their young has been previously noted. An improvement on this was suggested by an ingenious gentleman (or rather, if all are to be believed, several gentlemen, for, like "Beautiful Snow," the invention is claimed by more than one). A wire screen covered with gravel, arranged parallel with the bottom of the race, would allow the trout to deposit and naturally impregnate their spawn, which would then fall through the interstices of the wire gauze, of which the screen was composed, and thus at once be out of harm's way. This method has been found to succeed well; but the spawn are still exposed to the dangers beneath. Where the eggs can pass, the larva of insects can pass, and the ravages of the byssus can neither be detected nor prevented.

Thus far the process of both impregnation and incubation had been left to nature. That in the former she succeeded well there can be no doubt, but in the latter there was, to say the least, great room for improvement.*

This improvement was made by Mr. Ainsworth by a most simple yet effective arrangement. A second screen of fine wire gauze was placed below the one previously used; both screens were so arranged that they could be readily raised, the spawn collected on the lower one, removed and transported to the hatching-house, where all hitherto concealed enemies could be detected and contended against; and thus the happy

A, Race Box; B, Water Level; C, Upper Screen; D, Lower Screen; E, Bottom of Race; F, Trout Pond; G, Supply Pond.

FIG. 13.—DIAGRAM OF AINSWORTH'S RACE.

* Let us here not be regarded as irreverent. None more than ourselves admire the works of the Creator and the wonders of his hand; yet man is placed upon the earth to work. The crude material in small quantity is furnished him, and he must improve and increase it. The Creator gave the crab-apple, from it man has produced the Newtown Pippin; he causes the corn to grow, but man must manure and cultivate it; he created upon the mountains of Persia a coarse, poisonous shrub, with fruit dangerous to life, yet from this, man, by work and a careful following out of the rules indicated by an observance of other works of the Creator, has derived the luscious peach. Hundreds of similar and well-known instances might be mentioned. Nature, to a certain point, does her work, but it is for man to complete it.

combination of natural impregnation with artificial incubation was successfully accomplished.

In regard to the impregnation of the ova, nothing more could be asked, yet there were some objections to this form of race. In the first place, time and labor were required to raise the screens and remove the ova. Unless the sections were very small, the weight of frame, grating, and gravel were by no means light. The fishes must be driven from the race each time the eggs were taken, and, as previously mentioned, quiet is one of the requisites for successful natural impregnation; the spawn at an early stage were subjected to rather rough handling; and last, though not least, the hands of the operator were alternately immersed in comparatively warm water and suddenly exposed to the wintry air.

Mr. A. S. Collins, the friend and partner of the redoubtable Seth, has invented and patented an arrangement by which all these evils are removed, and the fish culturist can now take and remove to his hatching-house his impregnated spawn without wetting his hands. This is indeed the luxury of fish-culture. The following is his description of his invention:

The improvement consists in a new and convenient method of collecting the eggs. Fig. 14 represents a small spawning box with a portion of the side removed. Fig. 15 is an enlarged view of the front of the same box. At A is seen a double row of coarse wire screens (three meshes to the inch), eight in number. Instead of being made singly,

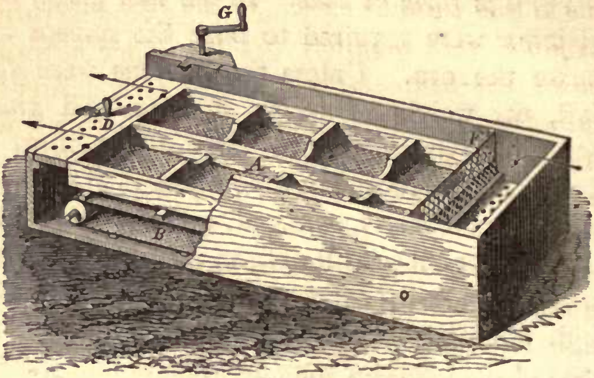

Fig. 14.

each two feet square (as usually made), they are put together in one frame, eight feet by four. These screens are to be filled with coarse gravel, and the eggs pass through, as in Ainsworth's screens. Under these is an endless apron of fine wire cloth (B), passing over rollers at the two ends of the box. This apron is about one inch beneath the upper screen, and is kept from sagging by small cross-bars (two of which are seen in the cut), corresponding to the divisions of the upper screen.

These cross-bars are supported by, and, when the rollers are turned, slide on an inch square strip nailed to the side of the box. A similar strip one inch above supports the larger screens.

The cross-bars also keep the eggs from being carried down by the current. By using two small beveled cog-wheels the front roller can be turned by the handle seen at G. As the roller is turned forward the endless apron moves with it, and the eggs, as they come to the edge of the roller, will fall off. The pan, C (Fig. 15), is placed in front of the roller, and receives the eggs as they fall. The

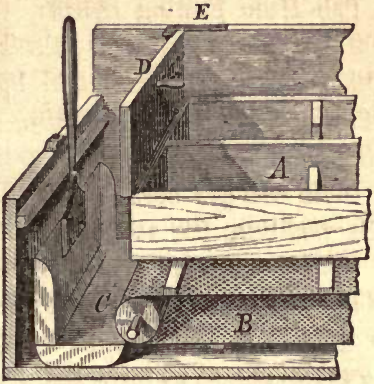

FIG. 15.

box need not be more than two feet deep; the depth depending upon the size of the rollers, which, in a short race, may be quite small, and the box not more than eighteen inches deep. The box is set directly in the race-way, and intended to fill it completely. The water enters in the direction of the arrows, and may either enter with a fall over the top of the box, as seen in Fig. 14, or the top of the box may be cut down until the water will enter on the level at which it is intended to stand over the screens.

F (Fig. 14) is a screen intended to prevent the fish from running beyond the race, or getting into the lower part of the box. It may extend to the bottom, or be arranged as seen in the engraving. D is a screen at the front of the box, also intended to prevent the fish from getting below. When the eggs are to be taken this screen is raised on hinges to an upright position, and confined by a spring catch or latch, as seen in E (Fig. 15). This confines the fish which may happen to be in the race, and none of them can get below. The pan is then lowered to its position, the roller turned, and the eggs taken. When the operation is finished, the screen (D) is again lowered, the button turned, and the work is done. If the box is wide, say four feet, it is more convenient to have the pan made in two or three sections, inserted in a light frame, as the eggs can be more easily carried in and poured out of a shorter pan. It is better, perhaps, to make the screen (D) to open in the middle, having hinges at both sides. Then one half will keep the fish in the pond, and the other half the fish in the race, from running into the well. The box can be made of any length from four feet to sixty feet, or even longer, and of any width from two feet to six or eight. If it is made very wide, an additional longitudinal support must be provided for the revolving screen. We recommend the following dimensions for speckled trout races: two feet wide and from ten to twenty feet long; or four feet wide and from twenty to forty feet long. The upper screens may be made in convenient sections, the whole width of the box, and six or eight feet long.

The screens F and D are so made that while a full current is permitted to flow over the upper screens (A), only a gentle current can flow through the under part of this box. This current is meant to be so regulated that when the pan (C) is placed about an inch from the turning roller, all the small stones which the trout may whip through the upper screen will fall short of the pan; the eggs, being lighter, will be carried by the current into the pan, while a great part of the dirt, etc., which may collect on the under screen will be carried up over the pan and entirely out of the box. The revolving screen *may* be made of tarred muslin or mosquito netting. But wire cloth (of ten or twelve meshes to the inch) keeps much the cleanest, and we are inclined to think it best for the purpose. We make our aprons half wire cloth and half tarred muslin, furnishing the wire only with cross-bars and always leaving it uppermost. This apron is fastened around the rollers by a lacing of cord. At the end of the season the water in the pond can be drawn down a foot and everything taken out but the rollers. Give the screens a coat of paint or gas tar, and lay them away in a dry place until the next autumn. A stiff brush may also be placed under the forward roller, so that every time the roller is turned to remove the eggs, the screen will be perfectly cleaned.

The box can be so arranged that the rollers also can be removed each season, but as this involves extra trouble and expense, and as the axles of the rollers and even the cog-wheels can be made of hard wood (little strain coming upon them), we generally leave the rollers in through the season.

This box looks at first sight somewhat complicated, but is in reality very simple and easier to make than to describe. Any one who has the knack of using tools can make one which will answer the purpose perfectly. The cost is very little more than that of the Ainsworth screens (of the same area) as generally used. The cost for wire being the same in both cases, the lumber in the box itself being extra, and also the rollers, hinges, and cog-wheels (or windlass wheel).

A few of the advantages of the plan are as follows: Let us compare a double row of forty Ainsworth screens, each two feet square and occupying a space in the race-way forty feet long and four feet wide, with one of the new spawning-boxes of the same dimensions.

1st. By the old way it would take two men a good half day to remove the screens singly, feather off the eggs in a careful manner, and return each (double) screen to its proper place.

It would take the new spawning-box about fifteen minutes to do the same work with one man.

2d. The weight of the gravel which has to be lifted in the old way every time the eggs are removed, amounts to many tons in the course of a season.

In the new box the gravel is not lifted at all.

3d. By the old way the operator's hands must of necessity be more or less wet during the whole operation. Now, as the trout and salmon spawn during the winter season, when the thermometer generally stands below the freezing point, taking eggs in the old way is not only inconvenient and painful, but often impossible.

By the new way the hands are not made wet and may be kept comfortably gloved.

4th. By the old way more or less of the eggs are lost by careless feathering, exposing the eggs to the freezing atmosphere, clumsiness in handling the screens (caused by cold fingers), tipping of the screens, wash of the current, etc., etc.

By the new way every egg is saved.

5th. By the old method every fish is driven out of the race when the eggs are taken. Some of them will not return, but will seek a spawning place in the pond, and many eggs will be unavoidably lost.

By the new way the fish are not driven from the race. And as the boxes are always covered during the season, the fish will not even be disturbed. In fact, they may spawn *while the eggs are being taken*, and yet not a single egg be lost.

This race has been tested with the greatest care, and the results have been favorable in every case. In many establishments where the Ainsworth race had been used, it has been superseded by the Collins, and tales marvelous even to the pisciculturist, whose ears are well accustomed to "fish stories," have been told of its merits. By it the greatest difficulties of fish culture are met and conquered, though many still remain to be contended against. Yet, with us, we still hold to artificial impregnation, believing that by it *we* can obtain the best results. By long (and sometimes sad) experience we have gained a delicacy of touch and facility of manipulation which, with us, needs nothing more to be desired. During the first season we have hatched from eggs impregnated by hand over ninety-five per cent. of the spawn taken, and we desire nothing better. Yet, we fully believe that, had we been possessed at the commencement of our piscicultural career of the Collins race, our fishes would have exceeded by ten-fold their present numbers. We regard it as only second in importance to the shad hatching-box of Seth Green.

CHAPTER VI.

ARTIFICIAL IMPREGNATION.

As stated in the last chapter, we still hold, for reasons there mentioned, to artificial impregnation, believing that in *our* hands, at least, that a larger percentage of spawn can be properly and thoroughly impregnated than by any race, however ingeniously contrived. It is about the first of November that female fishes make their first appearance in our race.* Males have appeared some weeks earlier, but the average of several seasons fixes November 1 as the period at which the females ready to spawn first appear. The fishes in this condition are technically called ripe ; and a singular change has taken place in the form and color since the previous spring. The females, instead of the bright colors in which they formerly appeared, have become sombre in hue, putting on, as one author has expressed it, a grave and matronly attire, the abdomen being greatly distended

* To prevent misunderstanding we would mention that the word "race," as used by us, means simply the one with gravel-covered bottom. If screened races are intended, the words Collins or Ainsworth will be used.

with eggs. The section of the body taken just behind the dorsal fin would be an oval, ○. Her movements are slow and sluggish. In the male, however, the reverse is the case. The colors, especially of the fins and abdomen, are far more brilliant than at any time; in flesh he has sensibly diminished in weight, and from this cause his jaws, especially the lower one, appear to be unusually prominent, and frequently a curved knob-like projection appears at the point. This has been noticed and commented on by an English writer as a wondrous adaptation of means to ends, enabling the fish to excavate the nest and cover the impregnated spawn with more facility, but as the tail is the only organ used for this purpose, some other use for this appendage must be found. There is no difficulty in distinguishing the sexes; a cock and hen are no more unlike than a male and female trout during the spawning season; at other times they assimilate more in shape and hue.

To properly remove the fish from the race that they may be manipulated, is a matter of great moment. They should be touched by hand as little as possible. And here let me mention that there are but two portions of the body of the trout where pressure even of a moderate character can be applied without injury. The first is directly behind the gills, on the strong, bony arches which are there found; the other, the tail, behind the vent. In front of the former, pressure is made upon the gills, the organs of respiration, the most delicate portion of the fish's system, while compression anterior to the vent may cause rupture of the air-bladder or other viscera, which would of course result in death. We have examined numbers of fishes which have died after having been improperly handled, and death has been found invariably to have arisen from one or the other of these causes. The race should have a fall of at least six inches in twenty feet; and by placing a bag or clap-net at the lower end, and shutting off the water at the upper, the water will run off, and to avoid being left high and dry the fishes will rush down stream and be taken in the net. During the past season another plan has been adopted at Troutdale. A hole some two feet in diameter and eight inches in depth was dug at the lower end of the race, into which the trout rush on the stoppage of the water by means of the gate. The object of this is that in case a large number of fishes should be in the race they need not all be at once removed, but are taken from the hole as wanted with a scoop-net. From the net they are transferred to broad, shallow tubs—such as are used for bathing infants answer well; two of these are required, as the separation of the males and females facilitates greatly the handling of the fishes. The operator loses no time (which, with the thermometer at zero, is doubly precious) in selecting his subjects for operation. The form of the pan in which the impregnation is to be accomplished is a matter of little moment. It has been done in the top of a tin wash boiler; yet some suggestions on this point may be important. Whatever is used it must be thoroughly clean; a drop of grease will prevent the fertilization of thousands of spawn; it must be smooth, as the freshly-taken spawn may be killed by coming in contact with any rough surface. Perhaps the best articles for the purpose are china soup-plates of the largest obtainable size. These will hold about one thousand eggs each. The only objection to their use is the ease with which they are broken; and a good, new, well-polished tin basin ten inches in diameter and three deep will, if kept clean, answer the same purpose, with less danger of breakage. If it is desired to know at once the number of spawn taken, it is readily ascertained by having a depression sunk in the bottom of the pan eight inches long, five wide, and one-sixth of an inch in diameter; this will hold one thousand average spawn. All things being ready, the pan is filled to about one-third of its capacity with pure water, and a female is taken and held in the position represented in Fig. 16, the right hand grasping the head, the pressure of the thumb and forefinger falling just behind the gills.

FIG. 16.

The effect of this will be that the eggs, acted upon both by gravity and the muscular contraction induced by the position, will fall downward toward the vent, and sometimes a few will be ejected ; it is therefore well to hold the fish above the impregnating pan, that all ova may be saved.

The method of holding the female during the process of artificial spawning varies greatly with different operators. Each of course prefers his own plan, yet in principle all are the same. The eggs, it must be remembered, are not squeezed out, as is the general impression among those but little acquainted with the subject; but the fish is held in such a position (Fig. 17 represents the position which we have found most convenient) that the eggs naturally flow from the vent. It will be seen that the fish is bent somewhat in the form of the letter *S*, the right and left hands being respectively placed on the head and tail, with the thumbs and forefingers

Fig. 17.

pressing upon those parts where, as previously mentioned, pressure can be made without injury. With a left-handed person the position of the hands is of course reversed. If on holding the fish in the proper position no eggs appear, the belly may be gently stroked from above downward with the forefinger of the right hand, and if the eggs are still retained, the fish should be returned to the water, as she is either diseased or unripe, in either of which cases the eggs would be useless. If, however, the eggs flow freely, the curve is to be gradually increased until they have ceased to flow, when, by the gentle motion of the forefinger, the few remaining in the cavity of the abdomen may be safely forced out. When the spawn of one female is taken, they should at once be impregnated by treating the male fish in the same manner—milt instead of spawn being emitted. It is recommended by some authors that the male be first taken, for the reason that he is more unmanageable than the female, but we have found on experiment that the eggs are better impregnated when they are taken first. If there be a scarcity of males (no uncommon occurrence toward the end of the season), use only water enough in the pan to cover the eggs. The milt having been emitted upon the spawn, they should be stirred gently with a feather, or, better still, with the tail of the male fish. Some care is here required, as too energetic stirring will destroy the new life which has but just been imparted; but if the eggs be not stirred, a large percentage will fail to impregnate. From careful observations we have found that the ratio of non-impregnation between stirred and non-stirred eggs was as five to forty. If the eggs be examined at once, they will be found to be wrinkled, the shell or enveloping membrane being apparently much too large for the contents; but immediately upon coming in contact with the water, absorption takes place through the membrane, in a manner known to scientists as "endosmosis," and the eggs rapidly assume a full, round, and plump figure. It is during this absorption that the spermatozoa, with which the milt of the male is filled, pass in with the water and vitalize the egg. It is therefore evident that after the absorption has once taken place, any attempt at fertilization would be useless. The spawn, until the process of absorption is finished, adhere to each other and to the bottom of the pan. It was formerly supposed, and we ourselves have repeatedly stated it, that the spawn were agglutinated together by means of a gummy substance insoluble in water, and only soluble in the milt of the male. This, recent observation has proved to be a mistake. The egg membrane not being filled, the sides are flattened by pressure against each other, and adhere by cohesive attraction; when full, this surface is reduced to minimum, and the eggs are readily separated. This *freeing* of the spawn, as it is termed, shows that absorption has been finished, and that they have obtained all the vitalization which they are capable of receiving. The experiments of Mr. Vrasski upon this subject are excessively interesting. His first essays were upon the system laid down in the primitive French works upon fish culture, in which the eggs and milt were obtained in separate vessels of water and afterward mixed. The result, as might be premised, was anything but satisfactory. A careful series of examinations and experiments showed him that the spermatozoa of the milt upon being placed in cold water survived only but a few moments, many dying at the expiration of a minute and a half, while at the end of five minutes not one was left alive. The period during which absorption was taking place was about half an hour. He now takes his spawn dry, pours upon them the pure milt, and with this most novel and most unnatural method has obtained the most gratifying results. The milt of one male will impregnate thousands of spawn. Mr. Thaddeus Norris mentions in his "American Fish Culture" (page 54) a case in which Mr. Ainsworth fertilized as many eggs as would cover the bottom of his pan (dimensions of pan unfortunately not given) with a single drop of milt. And Spallanzani records a similar instance. Yet it is well that plenty should be taken. Barren males, whose milt is only to be distinguished from that of their prolific neighbors by the aid of the microscope, are by no means rare, and it is well to always be upon the safe side. Enough should be taken to render the water opalescent or pearly in hue.

During the process of absorption the water in the pan should be kept at an even temperature. The nursery troughs in our hatching-house are well suited for this purpose, keeping it at the constant temperature of 50°. Be in no hurry to transfer the eggs from the pan to the hatching troughs or trays—the process of impregnation is soon accomplished; but the eggs are very easily injured at this period; and when the temperature of the water can be kept constant, half an hour's repose should be allowed them before the transfer takes place; then gently pour them, after thorough washing, on the spots where they are for some time to remain. Should they be heaped, gently, with a feather, or better still, a broad camel's hair brush, distribute them evenly upon the grille of the tray or the gravel of the trough. The washing is not absolutely necessary for the health of the spawn; yet the water being rendered somewhat opaque by the milt, its removal will enable the operator to see his way much more clearly. The eggs should so lie that they in no case be heaped one upon the other. Touching does no harm, but we have in many cases found heaping fatal. In moving the eggs we again say, be gentle; the time will come in the life of the egg when it will bear rough handling, even the handling of the express agent, whose mercies are by no means tender; but the time is not yet. Gentle movement beneath the water with feather or brush they will stand, but a sudden jar is to them at this age certain death. We have known a pan-full of eggs to be destroyed by the slipping of the feet of the operator and the knocking of the pan against the side of the hatching-house. We have frequently endeavored to transport freshly impregnated ova for the benefit of friends who were desirous of studying their development; we have packed them with the greatest care, carried the vessel in which we had placed them in our hands, and, in short, taken every possible precaution, but in every case miserable failure was the result. Ten days after impregnation is the earliest period at which we have been enabled to save even a small percentage after a short journey. The only method we can suggest for this purpose is the transportation of the parent fishes and performing impregnation upon the spot. This difficulty of obtaining early spawn has greatly retarded the study of the embryology of fishes in our country; and should a plan be devised for their removal, a great impetus would be at once given to original research in this most interesting branch of natural history.

CHAPTER VII.

INCUBATION.

We will suppose that our spawn has been taken with all possible care and safely deposited in the hatching-house, that the supply of water is ample and of equable temperature, and that filtering apparatus, stop-cocks, and other accessories are in perfect order. Yet still we must not feel too sure of a happy and successful result. Until at least seven days have elapsed, we know of no means, even with the microscope, of positively deciding between impregnated and non-impregnated spawn. "Never count your chickens before they are hatched," is a proverb which must be borne in mind; the character and standing of more than one fish culturist has suffered from a contrary course. The crop is at best a somewhat uncertain one, especially in inexperienced hands. All contracts for "yet to be" fishes or spawn should be made with the proviso, "if on hand." We have known all the eggs of a large fish to fail in impregnating; and those taken from fishes of over a und weight obtained from other waters must always be regarded with suspicion. We have found that large females, as a rule, become barren from a change of locality; and in all cases the operator is most successful with those raised in his own waters, in fact "to the manor born." A careful daily inspection of the entire crop on hand must be made; every egg should be examined and the dead ones removed. As no sunlight should be allowed to enter the hatching-house, a small bull's-eye lantern, or one furnished with a parabolic reflector, will greatly facilitate operations. In this stage the benefits of the hatching-tray are plainly recognized. All dead spawn must at once be removed; they may readily be recognized in the trays, as their dead alabaster white color contrasts strongly with the black of the box seen through the transparent tubes, or the pearly translucent hue of the healthy spawn; but in the gravel troughs the case is different—the gravel itself is of the color of deceased eggs, and by form alone can they be distinguished. Again, some may be buried beneath the gravel, and thus escape observation until serious harm may occur. But wherever they may be situated, the dead eggs must be removed daily. The shell of the egg is very slippery, so much so that it is almost impossible to remove them with the fingers, and as dead spawn are unfortunately of frequent occurrence, numerous instruments have been devised for their removal; several of those formerly in use are shown in Fig. 18.

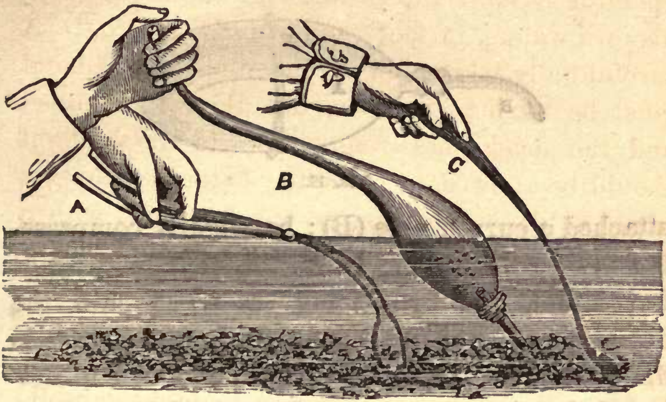

FIG. 18.

A is a pair of pincers with pointed blades; B is a pipette, while C is a scoop to be placed beneath the egg, which is to be thrown out by a sudden turn of the wrist. We have tried all these, and found them slow and by no means sure. The object should be to remove the dead spawn without disturbing others in the vicinity; with B and C this can not be done, and the difficulty of manipulation of A is much greater than would be imagined. We felt the necessity of some new instrument for the purpose, and finally suggested the bulb-syringe (Fig. 19). This has been adopted by most of our many American fish culturists, and has given the most perfect satisfaction. It consists of an india-rubber bulb (A) about three inches in length by one and a half in diameter. To this is

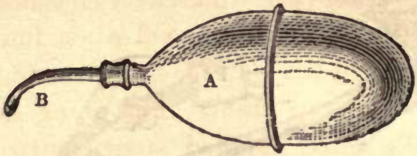

FIG. 19.

attached a curved pipe (B); by slightly compressing the bulb with the hand, the contained air is forced out, and by placing the nozzle near the dead spawn, and relaxing the grasp, the egg is driven toward the tip of the pipe, which is hollowed for that purpose, and retained in position by the pressure of the external air. Dirt of any kind—and dirt will find its way into the boxes spite of all our precautions—may be removed in the same manner. On a trial against time, by our superintendent, one hundred and fifty-four dead spawn were removed from a tray in one minute with one of these little instruments.

All who have obtained the least smattering of piscicultural lore are acquainted, at least by name, with the byssus—that terror of fish culturists, regarded by them as a devastating blight, a pestilence walking in darkness, an unpreventable and incurable disease, liable at any time to attack and destroy an entire crop of eggs, against which no precautions can avail, and for which no remedy can be devised. The word is applied to two very different vegetable growths, the one appearing upon wood when immersed for the first time in the water,—a gelatinoid substance of disgusting appearance, but doing no possible harm. We have hatched spawn surrounded on all sides by this much-dreaded material, the appearance of which can be easily prevented by coating all wood-work with black asphalt varnish, or by charring. As the charring of the hatching-troughs by fire has been made the subject of a patent, and from ten to twenty-five dollars is charged for the privilege, it may be well to mention that strong oil of vitriol will carbonize the surface of wood in a very satisfactory manner. Small articles may be dipped in it, or, if the object is too large, it may be rubbed with a swab; the surface should then be washed thoroughly with a mixture of one ounce of salaratus to a quart of water, and afterward laid for some days in a running stream. On this there is no patent. The true byssus, however, is a different substance, though also of vegetable character, and will, under certain circumstances, attack and destroy spawn; but it will not at first appear unless upon an egg which has been dead for at least twenty-four hours. It is of a filamentous character, and the infested egg may be said to resemble a minute ball of cotton. Fig. 20, from the work of M. Coste, gives an exact idea of its appearance. Should

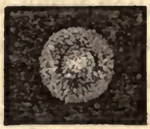

FIG. 20.

this not be in time removed, it will become the focus of contagion, the byssus will spread from it as a center, and, attacking the living eggs in the vicinity, soon involve them all in a common death. The remedy for this is simple. As has been previously insisted on, remove daily all dead eggs, and no nucleus of contagion can form. The byssus is a proof of ignorance or neglect upon the part of the person in charge. It is probable that this is one of the greatest causes of loss in natural incubation, as in that case no remedy can be devised.

We have met with severe loss from mice and rats, but by covering the boxes these pests can be readily kept off and a few well-poisoned candles will soon destroy them. In fact, whenever poison is to be used for the destruction of vermin, the poisoned candles will be found the most safe and convenient method of administration. We have seen them offered for sale, but having found some difficulty in obtaining them of late, have been in the habit of preparing them ourselves by slightly warming a common tallow dip and dusting strychnine over the surface. The advantage of applying it in this manner is that candles are not affected as food by either human beings or domestic animals, and that thus the danger always to be dreaded when using virulent poisons is almost entirely avoided. If, on examining the trays, the spawn which was left neatly arranged decently and in order upon the grilles, is found heaped or disturbed, the presence of rats or mice may be suspected.

The study of the development of the fish in the egg, from the first day of incubation to the emergence of the young fish, is one of great interest, though in our own country but little has been done in this direction, few to whom the opportunity is given having the time, patience, or scientific knowledge necessary. The work of Mr. Vogt * contains all that is known upon the subject, and to this we must refer the scientific fish culturist, confining ourselves only to those changes which appear to the naked eye, or beneath the power of an ordinary lens of from one to two inches focus. For examination the eggs should be placed in a

* *Embryologie des Salmones*, 8vo, with Atlas folio. Neufchatel, 1842.

thin homeopathic vial of water, and held between the observer and the light. Bright sunlight should be avoided, the best illumination being given by the reflection of the sun's rays from a white cloud.

When first placed in the tray, the entire egg is filled with a gelatinous substance, on which float minute granules and oil globules. Turn the egg as you will, and still they will rise to the top. No trace of division between the yolk and white appears until the second day, when the granules and globules will be found to have separated themselves into a minute drop in the center of the egg, surrounded on all sides by a transparent, colorless zone, in which it freely floats. About the fifth day a small prominence will appear upon the top of this yolk, which will increase in size daily. About the twelfth day an indentation may be observed in this protuberance, and an almost imperceptible line will be seen running from it. Daily with the naked eye, and hourly beneath the microscope, this line will be seen to increase in length and breadth. It is the *chorda dorsalis* or spinal cord, the rudiment of the nervous system of the future fish. About the eighteenth day it has extended around one-half the yolk, one end destined to form the tail being pointed, while the other, forming the head, is flattened and thickened. On the twentieth day the eyes appear, and from this time the growth of the fish is rapid. At the temperature of 50° the eggs hatch in from forty-five to fifty days—this period is lengthened by a lower, and accelerated by a higher temperature.

A short time previous to hatching, the investing membrane of the egg becomes yellowish-brown in color, and a floss-like coating envelops it, reminding one by its appearance of the much-dreaded byssus. The movements of the fish, which may have been noted as early as the thirtieth day, become more and more rapid. The previously noticed movements were gentle motions of the tail, but now the whole body seems violently convulsed. At length, with a violent effort, the shell is broken, and the little fish is born. What part first appears to the external world is a matter of perfect indifference. We well remember the consternation of one of our customers on the occasion of a whole tray of eggs hatching tail foremost, when the only work on fish culture in his possession, and in which he had placed the most implicit confidence, declared that the head invariably appeared first. By concentrating upon the mature egg the sun's rays, by means of a lens, the birth may be hastened, and the efforts of the fish, by which the shell is ruptured, plainly seen. This can only be done as an experiment, as the forced birth is generally fatal to the fish. Head, tail, back, and even the yolk sac may first appear. After breaking the shell it frequently happens that before emerging entirely the troutlet rests for a short time, apparently for the purpose of regaining its strength exhausted by its labors. Some writers have recommended that the shell be removed in this case, by gently passing over the body of the fish a fine camel hair brush. This, in our hands, has not been successful, meddlesome midwifery being followed by its usual results. If the fishes are strong and healthy they will in time clear themselves, and if not, they will surely die in a short time.

The egg shells having fulfilled the purpose for which they were designed, become dirt; and if the gravel troughs are used must be carefully picked out with the bulb syringe, as by their decomposition the health of the young fry may be seriously affected. If the Caron trays be used, they are for the most part carried away by the current through some fall between the interstices of the tubes. The young fish moves along the grille until finding an opening large enough to admit of the passage of his body, he falls through to the tray beneath; and by removing the cork at the end of the tray can be drawn off into a pan. In this operation the utmost delicacy is required.

The membrane of the sac is scarcely thicker than a spider's web, and as easily ruptured. With the fishes will be carried by the water into the pan egg shells and other dirt. By careful manipulation the lighter dirt may be floated off, and the remainder must be picked out with the bulb syringe. Remember that three weeks at least must elapse before the gravel upon which the young are placed can be washed, and that every particle of dirt must be scrupulously removed. If no nursery trough has been provided, the fishes may be reared for some time in the tray. For this the grille is removed, the box thoroughly washed, and the bottom covered with fine gravel—not only washed, but boiled, that all larvæ of insects may be destroyed. Upon this should the troutlets be placed, and a gentle current of water allowed to flow over them. Should, however, nursery-troughs have been provided, they may be prepared in the same manner, taking care that the wood work be not only washed, but scalded. Our nursery-troughs are thirty feet long, fourteen inches wide, and three deep. By screens of fine copper wire gauze, or iron well coated with asphalt varnish, they are divided into compartments one foot in length, each compartment being of sufficient capacity for the accommodation of fifteen hundred fishes, though one thousand only are usually placed in them. The supply of water must be carefully regulated; if too strong a current is induced, the fish will be carried against the dividing screens and destroyed; the amount in every case can only be ascertained by experiment. Commence by occupying the uppermost divisions; the great importance of this will be seen when we treat of the care of the young.

CHAPTER VIII.

CARE OF YOUNG IN HATCHING-HOUSE.

THE appearance of the young trout when first emerged from the egg is grotesque and curious in the extreme. A thin, semi-transparent line about three-quarters of an inch in length, one end pointed, the other knotted and furnished with two comparatively enormous eyes widely separated from each other, compose the body of the fish. To the lower portion of this body, extending from the

FIG. 21.—TROUT AT BIRTH.

throat backward to fully one-half its length, is a huge, vascular, transparent sac covered with a fine net-work of blood-vessels through which the blood may be seen flowing, all tending from a minute deep crimson red spot, the heart of the little fish. No traces of fins except the pectoral are to be seen; the gill-covers have not yet appeared, and four lines on either side of the throat represent the future gills. The motions of the little creature are slow; borne down by the weight of his huge appendage, commonly known as the umbilical vessicle, but more properly as the yolk sac, he seeks quiet and hides himself among the gravel. Strange as the sac may appear to others, to him it is a matter of vital importance. It is the food upon which he is nourished during the first six weeks of his existence. He requires no other, will accept of none; but hides himself from view and only desires to be severely let alone.

But the labors of the fish culturist know no rest. Many at this stage may die, and some surely will. Daily must the nursery be thoroughly examined and all dead removed. The bulb syringe here again comes into play. To facilitate the examination of the troughs, a watch-maker's magnifying glass, firmly attached to the eye by a broad india-rubber band passing around the forehead, will be found of great service. Care and attention is now absolutely necessary; neglect will certainly be followed by heavy loss—the dreaded byssus forming upon all dead animal matter and filling the waters with its almost imperceptible fibers. To aid its feeble respiration, the pectoral fins of the young fish are in constant, rapid motion, driving the water toward its as yet unprotected gills. Should the fibers of the byssus be present, they are driven directly into the gills, respiration is impeded, and the fish dies. A warm hatching-house, dry floor, and bulb syringe, combined with a keen eye and patience, are now all necessary. As the fishes increase in size they may be more plainly seen, but the care and attention now commenced will be constantly required until the fishes are removed to the pond.

At the end of the fifth week of life the appearance of the fish is as in Fig. 22. The yolk sac is

FIG. 22.

still present, though its dimensions have been greatly reduced. The fins may be all plainly seen, and even their rays counted. The gills are entirely covered by the gill-covers, and, in short, the whole appearance is more fishlike than that of the nondescript of Fig. 21. From this period the sac rapidly diminishes, but it is not until from the forty-fifth to the fiftieth day after hatching that it is entirely absorbed, and the fish emerges into the full glory of trouthood, becoming an independent member of the great animal kingdom, and experiencing the sensation of hunger which must be appeased.

And now for the first time we encounter the food question, that great problem on which depends, in a great measure, the future success of fish culture. This has been at length solved for the troutlet, while for the adult a proper, cheap, and healthful food is still a thing of the future. In nature the troutlets are provided with food by the numerous larvæ and adult insects which abound in all waters, as is shown by examination of their stomachs; but these it is as yet beyond our power to procure, and we, at best, can only provide a substitute. Curd, that universal food of theoretical fish-farmers, has been tried both by ourselves and others, and in many cases has acted as an actual poison, one gentleman having lost five thousand fishes, before the cause of death was suspected, the mortality ceasing on a proper food being supplied. Boiled yolk of egg has been highly recommended, but is objectionable on account of the great amount of deleterious gases evolved by its putrefaction. Boiled meats have been used with success after having been pressed and grated, but by boiling much of the nutritive material is lost. After giving all these and many other substances a fair trial, by feeding them alternately to our fry and carefully noting the result, we at length devised a plan which in our hands, and in the hands of all who have tried it, has thus far succeeded perfectly.

A beef's heart or kidney is taken, and with a sharp knife cut in pieces about an inch square. If heart is used, all skin, arteries, valves, and other fibrous portions which can not be readily cut are rejected. The pieces are then moistened with water and chopped to a pulp. This was formerly done with a hatchet and knife—a work of no small labor. We now accomplish it by means of the "American Chopper," of which a cut is annexed (Fig. 23).

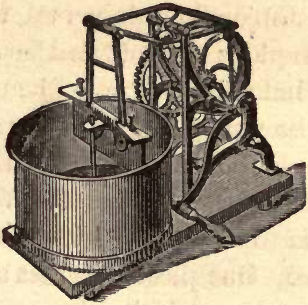

FIG. 23.

We have tried other choppers, but this alone has given perfect satisfaction. Not only is the meat thoroughly, quickly, and minutely chopped, but the machine is simple, not liable to get out of order, and can be in a moment taken apart and cleaned—a matter of no small importance in hot weather. A pound of heart can be cut by this in about seven minutes sufficiently fine for the smallest trout. Should any coagulated blood be found in the heart, it may be thrown into the chopper with it. Yet, still some minute fragments of fibrous tissue may remain, and to remove these, as well as to be sure that all the meat is chopped sufficiently fine, the pulp is mixed with water and washed (not rubbed) through a fine wire sieve of twenty-eight threads to the inch. By this means all fragments over about one-fiftieth of an inch in diameter are retained and may be returned to the chopper for further comminution. Copper wire for the sieve is objectionable, as the oxide or rust, which forms rapidly upon it in the damp atmosphere of the hatching-house, will act as a direct poison upon the young fishes. The same fault is found in brass. Iron rusts rapidly if not cleaned and dried with the greatest care. We have found the tinned iron to answer well if well washed and dried after use. One piece will last a season.

After washing through the sieve, allow the pulp to stand for a few minutes, and the meat will have settled to the bottom of the pan; pour off the clear water and the meat is ready to be fed to the young fishes. But in the feeding great care must be exercised. Enough must be given to satisfy hunger and no more, as any particles, however minute, if allowed to fall to the bottom will rapidly decompose and foul the water, seriously affecting the health of the fry, as the fragments are too small to be detected and removed. The bulb syringe here again comes into use. Drawing into it a small quantity of the pulp, the operator proceeds to the uppermost of the compartments of the nursery or hatching-trays and carefully drops a single drop into the water; the minute fragments of meat are at once seized by the fry, and when they have entirely disappeared, another drop is administered; thus in minute quantities is the minutely divided food given, and when the occupants of one compartment are satiated, the same process is repeated with the next. The meat being readily digestible, the young should, from the time of the absorption of the sac to the period at which they are turned into the pond, be fed twice a day. As may be seen, the care of fifty thousand young trout is no child's play. It has been stated that any boy of fourteen years, of ordinary capacity, is capable of taking entire charge of the young fishes; but we have never as yet met with one we would be willing to trust. Not only manual labor, but skill and, above all, patience are required. The temptation to hurry over the work, especially in a damp, cold hatching-house, is too great for it to be trusted to any but faithful and well-tried operators. The insufficient chopping of the meat, the rubbing instead of washing of the pulp through the sieve, or the throwing of it in too large quantities into the troughs or trays would be attended with severe loss. Like photography, fish culture is composed of numerous operations, the improper performance of any one of which will insure failure in the end. We speak that we do know, and testify that we have seen.

The period at which the young fishes are to be removed from the hatching-house varies according to circumstances. If they are intended for stocking a stream amply provided with insects, their natural food, they may be turned loose as soon as they have learned to feed, say two weeks after the absorption of the sac; but if for ponds, it is well to keep them some six weeks longer. During our first experiments in fish culture, we, following the advice of others, retained them in the troughs for six months, but a number escaping into a pond showed by their rapid growth that fresh air and exercise were equally beneficial to fishes as to other animals. Though abundantly supplied with food, the fishes retained in the troughs were at the end of six months less than half the size of their brethren in the pond. If turned out too soon, they seem not to have acquired sufficient strength to earn their own living; if too late, they are stunted in their growth—the happy medium, as before mentioned, is about two months. After the first few days of feeding, the gravel should be carefully but thoroughly washed. Turn on as strong a current of water as the fishes can bear, and gently place the hand in the water at the upper part of the topmost compartment of the nursery-trough. The fishes will crowd downward toward the screen. Slowly stir the gravel with the hand, avoiding all sudden motions, until all dirt is carried downward; then place the hand in the lower part, when the fishes will ascend upon the portion cleaned, and repeat the operation. If the dirt is not carried through the screens, it may be rubbed through; any large pieces, which will sometimes find their way into the troughs spite of all care, may be removed with the bulb syringe. This tedious but important process should be repeated at least as often as every third day. If the trays be used, the fish may be drawn out by removing the cork, and replaced after thoroughly washing the tray.

Sometimes, as has more than once happened to us, in spite of all our care, a sudden epidemic will break out among the fry in the troughs. They may all appear in the evening perfectly healthy, yet in the morning the dividing screens between the compartments are found clogged with the dead and dying. Unless the cause of this can be immediately traced, at once remove the fry to the pond, and then investigate the matter at your leisure, and guard against a similar misfortune (if discovered) in future. Better a crop of stunted fishes than no crop. There are many as yet unknown causes which result in the death of young fishes; and the fish culturist, after years of experience, may find himself at his wit's end to explain the cause of a sudden mortality. We have all much to learn. The science (for science it is), is yet but in its infancy; and he who declares that he knows all about fishes and fish culture must be classed with him who boasts that he can by his nostrums cure all ills that flesh is heir to. The good of self, and not of the fish-raising community, is too much sought. Already is the progress of fish culture impeded by the registration of a number of patents, many of which are of a most ridiculous character. Give and take should be our motto; and were the example of Mr. Ainsworth * followed by all, our progress toward perfection would be much more rapid. We have ourselves made more than one invention upon which a patent might have

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* *Vide* his letter, page 19.

been obtained, but from principle, doing as we would be done by, have presented them to the public. The inventor of an article like the Collins spawning race may be pardoned for obtaining a patent, but patent charred troughs, gauze spawn-carriers, and like trifles, are simply ridiculous; and it is doubtful if any have as yet realized sufficient from the sale of "rights" to pay the expense incurred in filing their caveats. We are pleased to see that much more cordiality and friendship now exists between the brethren of the spawning race than formerly. The days when visitors to Troutdale concealed the fact that they were themselves engaged in fish culture, and even accepted its hospitality under assumed names, fearing in their ignorance that were the truth known they would be unable to gain desired information, have happily passed away; and with few exceptions a pleasant acquaintance, if not personal friendship, exists, as it should between all American fish culturists. The formation of the American Piscicultural Association, under the presidency of our friend and pupil, Rev. W. Clift, has done much toward assisting in this direction.

CHAPTER IX.

FIRST YEAR.

The preparation of the pond for the reception of the young fry should be completed during the previous autumn. Our first spawn are always taken about November 1st, hatching about December 10th; the absorption of the sac is concluded February 1st, and they are ready for the pond April 1st. Our first pond is prepared for the coming crop by removing that of the previous year; this is done by drawing down the water as far as possible, mowing with a sharp scythe the water-plants, with which the bottom is thickly covered, and raking them out. It is stated by theoretical pisciculturists that on opening the gate and removing the screen at the lower end of the pond, the fishes will pass down into the next, but in practice the reverse is the case; the fishes from the lower pond will ascend, but not a single one will descend, the tendency of the fishes being up stream instead of down stream. They must therefore be removed with a net; and as many of the fishes are very small, the best material for the purpose is common mosquito netting. Of this we use the odds and ends which have done duty during the previous season in covering our paintings, mirrors, and chandeliers. These are sewn together, forming a net about two and a half feet deep and three feet wider than our pond; a well-weighted lead-line is attached to the bottom, and a few wooden floats sewn to the top; at each end a stick or brail is tacked, and the net is ready for use. The net is dropped into the water at the lower end of the pond, and, holding the brails perpendicularly, is slowly moved by two men, one on each side, toward the inlet. The object of mowing the ponds is now apparent; were the weeds not removed, the lead-line would be held up by them, and the fishes allowed to escape beneath. When the inlet of the pond is reached, the net is suddenly raised from a perpendicular to a horizontal position, and in this manner carried to the second pond and its contents emptied. This process is repeated again and again until every fish is removed. The trout is a sad cannibal, as a writer truly remarks (*Harpers' Weekly*, June 13, 1868). Dog, it is said, will not eat dog; but, when other food was wanting, we have seen in our hatching-troughs a trout of one and a half inches in length seize and devour his brother of one inch; what, therefore, would be the result if a (comparative) monster of five inches in length was allowed free quarters among our youngsters?

By removing the last year's fishes thus early, we find in April that not only have the plants again grown, covering the bottom with a green carpet, but the microscope reveals every leaf and twig covered with larvæ and minute insects. Many of these are they whose attacks were so much feared in the hatching-house; but the danger from them has passed, and the danger to them, which we care not to prevent, will soon commence. These are the proper food of the troutlet, and the greater their number in the pond, the greater will be our success. For removing fishes from the nursery, we use a net with a frame of the shape represented in Fig. 24. The bottom (A) being equal in width to the

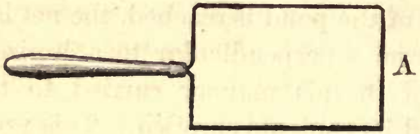

FIG. 24.

width of our nursery-troughs, and the height twice their depth. With this the entire contents of a compartment may be removed at once, emptied with care into a basin of water, and transferred to the pond, where they at once dart rapidly through the water, apparently delighted with their new quarters.

The future growth of the fish depends much upon the supply of food given during the first year. Should the supply for the ponds at any time be scant, preference should be given to the youngest fishes. One good meal per diem will be all that is required, but should that be omitted, the proprietor suffers. The trout will have food, and if no other is afforded, it is obtained at the expense of the life of some weaker brother, who thus suffers for sins not his own. No trout will starve while others of one-third less dimensions are to be found in the same pond.

The heart or kidney used as food should for some time still be sifted, though a sieve may be used of larger mesh, and at the end of six months entirely abandoned. If it is possible, however, it may be replaced by roe of fishes, which is perhaps at this stage better, though somewhat difficult to obtain. When used it should be rubbed under water between the hands, that the investing membrane be broken up and the eggs thoroughly separated.

As the weather becomes warmer, maggots should be fed, these most disgusting, but to the fish culturist most valuable, creatures being the nearest approach to the natural food of the trout that can be obtained. Several methods have been devised for procuring them. In one, a box is constructed, three feet high and two feet square; in the bottom is placed a drawer, about four inches deep, and above this a strong wire grating, the wires being about an inch apart. Numerous holes, one-half inch in diameter, are bored in the sides above the drawer, and the whole is surmounted by a cover. In this, above the grating, any offal is thrown. The maggots on attaining their full size drop through the grating to the drawer beneath, which can at any time be removed and its contents emptied into the pond. This apparatus has been christened, by a facetious visitor, the Maggotometer.*

But the emptying of the drawer is by no means a pleasant task, and the old-fashioned method of suspending offal from a wire directly over the pond, thus allowing the maggots to drop, as it were, directly into the mouths of the fishes, is perhaps preferable. But to this there are many objections. A piece of rotten meat covered with myriads of crawling maggots is by no means an attractive object. The "maggotometer" may be placed at some distance, that the odor may not affect the nostrils of visitors, but the suspended piece must be directly over the ponds. Again, dogs will make violent efforts to obtain the, to

* This word is not philologically correct, but as the term gasometer is universally applied to an apparatus for holding and distributing gas, it may not be deemed inappropriate.

them, tempting morsel, and disturbance of the ponds at least will take place. Most of these evils can be avoided by placing over the offal a nail-keg, upside down; through a hole in the inverted bottom passes a strong wire, hooked at each extremity; on one end is placed the offal, the other hooks upon a wire supported by posts and passing over the pond; a few half-inch holes are bored in the sides to afford easy access to the flies. By this arrangement not only is the offal protected, but, being shaded, it does not dry up as speedily as when exposed to the direct rays of the sun. It is out of sight, and the odor is, to say the least, greatly diminished. The importance of this variety of food can not be over-estimated. It is the nearest approach which we can obtain to the insects which form so great a part of the food of trout in streams, and even if some inconvenience to the eyes and nostrils is occasioned by it, must be in some way supplied. During one season, disgusted by the odor, we depended upon an increased supply of meat as food for our young trout, omitting entirely the maggots; but the small size attained by the fishes during the year, less than half that of the preceding, when less meat and more maggots were fed, warned us not to repeat the experiment.

The supply of water should be carefully regulated. If too much current is given through the pond the weaker fishes will be carried against the lower screen, their gill-covers closed by the pressure of the water, and death soon ensue. If too little is afforded, they may die from want of sufficient oxygen. The plants previously mentioned here again perform good service—in oxygenating the water, a less current being allowable in a pond whose bottom is completely covered with aquatic vegetation than in one in which the bottom is bare. It is well that a constant watch be kept over the pond during the first day after the transfer of the fry, and the current regulated by observation. No rule can be given on this point; practice and observation can alone suffice.

As the interstices of the fish screen must, of course, be very small, they will readily become clogged with dirt, which will, spite of all care, find its way into the water. Summer and winter, every high wind will blow into the pond a quantity of straws, leaves, and other rubbish which, if allowed to accumulate upon the fish screen, would soon entirely close it, damming the current, and causing an overflow. To prevent this, the leaf screens mentioned on page 38 must be placed above the fish screens, and if much trash finds its way into the pond, two and sometimes three of these will be required. To clean these, raise them carefully out of their grooves, and by slightly tapping them against the sides of the sluice-gate all dirt will fall off. If they are strongly made, as they should be, and are not hammered with violence, they will last for years; but for the first six months at least the fish screen must not be raised. The larger fragments are to be picked off from it by hand, and a common scrubbing-brush, attached to a handle about two feet long, will either rub through the remainder of the dirt or collect it together so that it can be readily removed with the hands. As previously mentioned, trout in ponds always seek to ascend, and the removal of the fish screen, though but for a moment, is the signal of advance to the fishes of a lower pond. Should any larger fishes be seen in the pond in which the youngest are kept, they *must* be at once removed, even if it is necessary to kill them in so doing. The number of three month's old fishes which can be eaten in a short time by a trout of the previous year is enormous. Copper wire only should be used for the fish screens, as iron, however well painted, will rust out in a few months, leaving gaps through which the older fishes can ascend. Twice a day, morning and evening, should the screens be examined and thoroughly cleaned, and duplicates should always be on hand to replace them in case of accident.

At this period are the attacks of birds, both wild and tame, to be especially guarded against. We have taken eighty-five young trout from the stomach of a tame duck shot on our ponds, and the number which would have been swallowed had she been left unmolested would undoubtedly have been much greater. It is well for fish culturists to keep an eye upon the aquatic poultry owned by their neighbors. The kingfisher is a permanent nuisance, and the great fish-hawk, during the spring and early summer, is an epicure whose fastidious taste is only to be satisfied by the largest and nnest trout in your ponds. A well-loaded gun should be always kept in readiness in some convenient place for the accommodation of these visitors. They may sometimes be trapped in the following manner: Near the ponds erect some poles about twenty feet in height, and on these set a steel-trap, securely fastened to the top of the pole. As is well known, it is the habit of both the fish-hawk and kingfisher to rest upon the tops of dead trees—for which the poles are a good substitute. On alighting, the trap is sprung and the bird caught. No bait is required. In removing the fish-hawks from the traps it is well to throw over them an old coat or blanket, as they are capable of inflicting severe wounds with both claws and bill. The night-heron is decidedly the worst enemy of the fishes, and we are sorry to say that no means for his capture or destruction have as yet been devised. Flying at night and, like the owl, having the gift of nocturnal vision, he is enabled to visit the pond with impunity; and being to a certain extent gregarious, will return, bringing with him numbers of his fellows. Walking in darkness, they are comparatively safe from the gun, and rarely alighting upon trees, can not be captured in the pole traps. Their presence is only known by their peculiar foot-prints, and a diminution in the number of fishes in the ponds. Of quadrupeds, the evils caused by the muskrat have been mentioned (page 36), and the means by which damage from them may be prevented, noted.

The otter has fortunately disappeared before advancing civilization; his presence on a fish farm would result in the disappearance of the entire stock; but his cousin, the mink, still remains, and has more than once caused serious loss. If fishes are found dead with a large gash, sometimes lengthways and sometimes across the throat, it is a sure sign that a visit has been paid by a mink. A vigorous system of trapping by an expert is the only remedy, and one of the murdered trout is the best bait that can be obtained. Water snakes are particularly fond of trout, and have, during the last year, been very abundant at Troutdale. We keep for their accommodation a large spear with six well-sharpened prongs. When alarmed, the snake hides himself in the weeds at the bottom of the pond, and can be frequently speared and killed. It may be well here to state that none of our northern water snakes are venomous, though the deadly moccasin of the south is aquatic. Craw-fishes, it is said, cause serious injury by burrowing in the banks, but though these crustacea abound in our locality, we have seen no proofs of this. The French writers denounce frogs as eaters of the young fry. This may be true of French frogs, but we know from experiment that ours are innocent of any such propensity.

But the enemy most to be dreaded is man, and will be until our legislators and the public look with less leniency upon fish-stealing. A large proportion of the trout offered for sale in the New York markets bear upon them the marks of the silken gill nets, with which they were illegally taken; and a proposed law for the protection of private fish ponds, making their robbery a felony in lieu of a trespass, was recently rejected in the Legislature of a neighboring State by an almost unanimous vote. The burglar alarm telegraph might prove valuable, though we have never heard of its having been applied to this purpose.

The amount of food required varies; atmospheric changes appear to affect greatly the appetites of the young fishes, and we have found even a difference in the readiness in which food is taken at different hours of the day. In summer they, like wild trout, feed best either immediately after sunrise or a short time before sunset, and even at these hours it sometimes happens that they appear to have lost all relish for food. The fact we know—the "why" is beyond our knowledge. As an average, fifty thousand young will require when six months old, and well supplied with maggots, about a pound of chopped heart thrice weekly, though the amount varies greatly. The practiced fish culturist can see at a glance when his fishes have had enough. Over-feeding is to be avoided, as it tends to interfere with the breeding powers of the trout.

A case in point came to our knowledge during the past year. A wealthy gentleman of a neighboring State constructed a well-appointed fish farm, with well-stocked ponds. To his surprise during the spawning season but few eggs could be obtained, and but a small percentage of these could be impregnated. We were consulted in regard to the matter, and our first look at his fishes showed us plainly the cause of the trouble. The fishes were enormous, the bodies greatly swelled, the whole cavity of the abdomen being filled with layers of fat. It appeared that the proprietor had for over a year fed them twice a day all they could eat, and the result was, as might be expected, barren and unhealthy fishes. Commence feeding always at the upper end of the pond, that the uneaten fragments may be carried downward toward the fishes in the lower portion. Of course as the fishes increase in size, the size of the fragments of meat fed them may be proportionately increased; but in no case should they be so large but that they can readily pass through the fish-screen at the lower end of the ponds. From neglect of this we have seen many screens clogged up with a mass of half-putrid meat, disgusting to the touch and difficult to remove.

CHAPTER X.

SECOND AND THIRD YEARS.

THE sojourn of the troutlet in the first pond is but short; the last of our crop are generally placed in it about April 15th, and by November it is important that they should be removed, that the aquatic plants may grow and the insects be provided for the next year's crop. The method of removing them to the second pond has been mentioned. They have now passed their babyhood and require more food, their growth is extremely rapid, and they are much more able to take care of themselves; and again we meet with the food question. Food they must have, and in full quantity; and what shall that food be? It must be appropriate, cheap, and readily obtained. Curd has, of course, been used; we have tried it, and proved it, in our case at least, to be not only not suitable, but absolutely poisonous. Our losses were at first very great, fifteen pounds of dead fishes per diem being not unfrequently picked from the bottom or screens of our pond. For a long time we attributed this excessive mortality to other causes; at length the truth dawned upon us; we changed the food and the deaths ceased. Up to the period of changing the fishes to the second pond heart, kidney, or maggots had been used, but these are too expensive to be longer continued, and are replaced by the lungs, or lights as they are most commonly called, of calves, oxen, and sheep. These can be obtained at a nominal price from butchers, except in towns where the German element abounds, where, sometimes, a high price is demanded for them, as they enter largely into a Teutonic sausage, in great demand by the frequenters of free lunches. The lights are prepared for fish food by passing them through a sausage-cutter. The American Chopper, which has succeeded so admirably in cutting hearts or kidneys, now proves utterly useless in dividing lights, and even some varieties of sausage-grinders fail entirely. The only kind which we have found to do the work well is that in which the knives are stationary, and the meat forced against them by the pegs on the cylinder; those with knives upon the cylinder do not cut well.

We have erected near our spring a meat-house with an overshot water-wheel attached, by which all our cutting machinery is run, a luxury which any one who has turned the handle of a sausage-cutter while fifty pounds of lights are passing through can readily appreciate. For the second pond it is well to pass the "chop" through the machine a second time. The lights floating upon the surface of the water, any uneaten pieces float away instead of falling to the bottom and contaminating the water by their decomposition, while the somersaults turned by the fishes in their efforts to obtain them is a sight which, after over four years of daily occurrence, is still as interesting and amusing in our eyes as when first we beheld it. Since our stock of fishes attained its present size, we have never been able to obtain as large a supply of food as we would desire; yet we find that our stock-fishes, weighing in the aggregate about a ton (2,000 pounds), thrive upon fifty pounds a week, fed them in equal portions on alternate days. Our loss by deaths has been reduced to almost a minimum, not fifty fishes having died during the past year.

Yet other and perhaps more appropriate food can be obtained in other and more favored localities. The killey fishes, which abound upon the shores of Long Island, answer this purpose admirably, being passed through the ordeal of the chopper before being fed to the smaller trout. Upon the Connecticut shore any quantity of the intestines of fishes may be procured, which are equally valuable. What is wanted is animal food; and the best which can be cheaply obtained should in all cases be used; and upon its cheapness will greatly depend the profit of the business. Trout fed for four years upon liver or heart, and then sold at one dollar per pound would certainly add nothing to the pocket of the breeder; and whether trout can be raised with profit for market is as yet an unsolved question. If eggs or fry could be sold at even one-half their present market value, it would be the height of folly to dispose of the parent fishes at even their present high market value; it would be killing the goose which lays the golden egg. A female trout of one pound weight will afford one thousand spawn, for which eight dollars can be readily obtained; and, as far as we are aware, all the pecuniary benefits of private fish-farms have, in this country at least, been derived mostly from the sale of spawn and young fry.

Many of our trout spawn at the end of their second year, but this is not always the case. As far as can be ascertained about two-fifths is the average; the spawn from these is frequently much larger than that obtained from older fishes.

The diseases to which pond trout are liable are but few, and these mostly result from ignorance or inattention on the part of the proprietor. A fungoid growth is often seen upon fishes who, by fighting or accident, have become wounded. This growth appears first upon the wound, and, spreading rapidly, soon reaches the gills, when death soon takes place from obstruction of respiration. This, however, occurs only in wounded fishes, though sometimes the wound is scarcely perceptible. Female fishes frequently die during the spawning season from disease of the ovary, causing the eggs to increase greatly in size. We have seen them at least one inch in diameter; the pressure of this enormously distended mass upon the intestines causes inflammation, resulting in death. This most frequently occurs in females who have been removed from other waters. Should the supply of water be insufficient, of course the fishes will die. Great loss took place from this cause at Williamsport, Pennsylvania, a few years since, nearly the entire stock having been destroyed. Over-feeding in fish, as in mammals, renders them peculiarly liable to disease. It is the experience of almost every fish-farmer that his percentage of loss is always in the inverse ratio to his knowledge, care, and skill. The ponds will not run themselves, but must be carefully attended to, and any neglect on the part of the proprietor is sure to be followed by disaster and loss.

The size which trout will attain in a given time varies even with the most careful attention to their food. Once a dwarf always a dwarf, is the invariable rule. We have raised fishes in one year to the length of six inches, while in the same period of time others in the same pond had not attained over one-third this size, and, strange to say, the smaller were almost invariably males. The average size is perhaps that represented on the opposite page (Fig. 25). We have *heard* of half-pounders at the age of one year, but have never seen them. It may be that some of our fish-raising brethren will think that the sizes represented in our figure are too small, but let them average the contents of a pond containing say ten thousand, and we think that they will agree with us in our estimate ; and should we even be found to have erred in this respect, we would rather under than over-rate. Fish stories are proverbial, and we have seen published accounts of fish-farms which plainly showed that these stories were not confined to wild fishes. Too frequently heavy discount must be allowed on stories of fishes of wondrous size or in marvelous numbers ; and the visitor to a fish-farm of which glowing accounts have been published, is too often sadly disappointed at the great discrepancy between the published account and the reality.

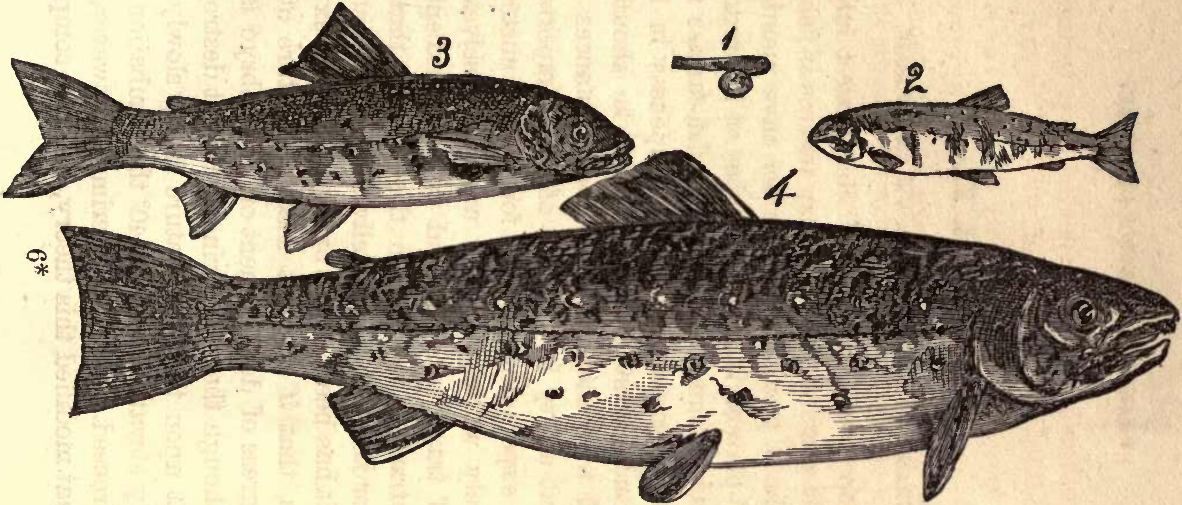

FIG. 25.—TROUT AT VARIOUS AGES: 1, just hatched; 2, six months; 3, one year; 4, two years.

CHAPTER XI.

TRANSPORTATION OF SPAWN AND FISHES.

We now reach a point of the greatest importance in regard to the pecuniary success of fish culture. In a previous chapter we have mentioned that at present it is to his sales of impregnated spawn and young fishes that the fish-farmer must look for remuneration for his expenses in time, labor, and invested capital. That he should be enabled to transport these long distances with ease and safety is a point of vital importance. In our experience we have found that customers are rarely willing to take upon themselves the risks of transportation, and with few exceptions the contract is made with the proviso that the spawn or fishes shall be delivered in good condition. It has been stated by many foreign experimenters, that if kept at the temperature of 32° the progress of development of the embryo is arrested though the vital principle is not destroyed, and that upon the temperature being slowly and carefully elevated to about 40° the incubation will again proceed. Recent experiment, however, has somewhat modified this theory, and the comparative failure of the early attempts to transport the spawn of salmon and trout to Australia has shown that at least the period of suspension can not be indefinitely prolonged. We have found that even a few hours' freezing is decidedly injurious if not fatal to the embryo. The eggs may hatch, but the young most frequently will be found weak and puny, and will rarely survive until the absorption of the sac is completed. To *prevent* freezing is one of the important points in spawn transportation. Sudden changes of temperature must be provided against. The season during which the spawn are shipped is, in our latitude, the coldest in the year, and a change of temperature of 10°, much less than the difference between a warm railroad car and the external air, would be fatal. Moisture we have found absolutely essential, the accounts we have heard of dried spawn in the Canton markets notwithstanding; one hour in a dry, warm atmosphere being sufficient to destroy the vitality. Any one who has subjected spawn to microscopic examination will remember how quickly the embryo will cease to live unless the egg be kept constantly moist.

It is rarely possible, even if the greatest care be exercised, that the spawn can survive even a journey of twenty miles, until ten days after impregnation, and unless some special reason exists to the contrary, the eye-specks should be well developed before shipment. The proper time is from the twentieth to the thirtieth day, when the temperature of the water has been 50°

If troughs have been used, the spawn should be first formed into little heaps with a feather or fine brush; then taking the cribble (Fig. 26) in the

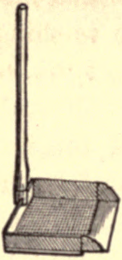

FIG. 26.

left hand the eggs are brushed upon it and transported to the packing boxes, any spawn remaining on the gravel being picked up by the bulb syringe; but if the trays have been employed, this tedious process is greatly simplified—the grilles need only be removed and their contents emptied into a large pan of water. In the latter case, the process of counting is greatly facilitated; each rod of the grille holding, on an average, one hundred spawn, their number can be readily estimated. We have been in the habit of allowing from five to ten per cent. additional, the amount depending upon the distance to be traveled. The box in which the eggs are placed for shipment is of tin, of circular form, three inches in diameter, and the same in height, with a tight-fitting cover, the bottom being perforated with small holes. In the bottom of this box is placed a layer of fine moss, such as is found on rocks upon the borders of streams in cool and moist localities; this is prepared by thorough washing and careful picking over, all dirt, such as sticks, fragments of leaves, and minute pebbles, being removed with care. The bottom of the box being covered to the depth of about half an inch with well-dampened moss, the eggs are placed upon it. They should be carefully spread with a soft brush. They may be allowed to touch and even press *against* each other, but should not be heaped one *upon* the other. When well arranged, cover these with another layer of moss, upon which spread another tier of spawn, and thus continue until the box is filled, pack it full, but not too full, only that the elasticity of the moss may keep the eggs from being jarred by any slight concussion. The whole is then sprinkled with water, and the cover tied on by a piece of twine. We have shipped hundreds of thousands of spawn in moss with perfect success, yet it has been objected against this material that it frequently contains larva of insects which may afterward give trouble in their new home. Boiling the moss will destroy these, but would render the moss very liable to decomposition. Sponge, thoroughly cleaned and cut in small pieces, has been used with success, and where moss could not be procured we have found it a good substitute. To prevent freezing and preserve an equable temperature nothing more is necessary than to place the box in a tin pail, and

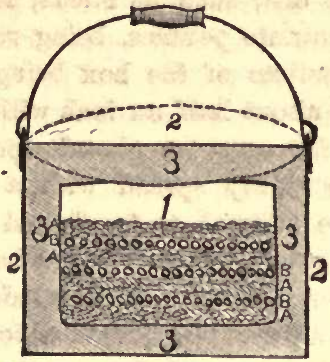

FIG. 27.—SPAWN PACKED FOR TRANSPORTATION.
A, A, A, A, Moss; B, B, B, Spawn; 1, Spawn Box; 2, 2, 2, Kettle; 3, 3, 3, 3, Sawdust.

thoroughly surround it with sawdust well packed, and all is done that can be done. We are aware of the existence of a patent spawn transporter, costing as many dollars as the ordinary one does cents, but have not been able to find that it presents sufficient advantages to compensate for the increased expense.

Great loss has occurred to spawn in transit from two directly opposite causes, viz.: carelessness and over care. "Do not let these freeze" marked upon the pail has resulted in its being placed in close proximity to a red hot stove, and the dents found in its sides, after consignment to the care of the Express Co., show how much attention is paid to the attached printed label, "Handle with greatest care." In all cases where large quantities of spawn are to be transported, they should be sent under the care of a competent special messenger.

On arriving at their place of destination the spawn should not be at once emptied into the trays or troughs, the sudden change of temperature being too often attended with serious consequences. The kettle and sawdust being removed, the box should be reversed and allowed to remain for at least one hour in the water in which the spawn are to be placed, that they may gradually assume the proper temperature. The entire contents of the box is then to be emptied into a basin of clean water. Most of the moss may be picked off by hand, and the remainder can with care be floated off by pouring in water. If trays are employed, it is not requisite that all the fine particles be removed, but with the troughs perfect cleanliness is absolutely necessary. Then with the cribble or spoon the spawn may be placed in the hatching apparatus. It is important that sufficient sawdust be placed around the box in which the spawn have been packed; less than two inches should never be used, and even with this amount we have known the eggs to have become frozen during mid-winter. A thick covering of felt on the outside of the kettle has been suggested, and would perhaps answer well.

But many are desirous of avoiding the trouble and responsibilities of hatching spawn, and it is required that the fishes be delivered sometimes at remote points. When very young fishes are desired, we have found the best age for transportation to be about fifty days after hatching. At this period the yolk sac has been nearly entirely absorbed, its presence being only recognized by a slight protrusion of the abdomen. The fishes have not yet commenced to feed, and will stand a comparatively long journey with but few changes of water. At this season (March and April), the weather is cool, and the capacity of the water for retaining air is much greater than when the temperature becomes more elevated. Water at the temperature of 50° will absorb about six cubic inches of air to the gallon, while at 212° none can be retained. It is therefore seen that the lower the temperature the greater the amount of air that will be contained in the water, and that during cool weather the greatest success may be attained in transporting the fry.

But larger fishes must sometimes be transported, and for this recourse must be had to a transit tank. The Troutdale Transit Tank (Fig. 28) was invented

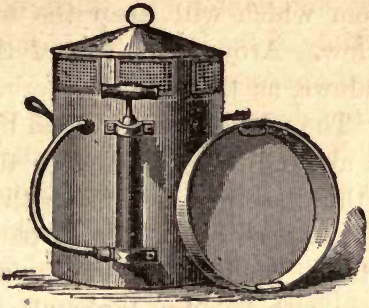

FIG. 28.

by us some three years since, and has always, in competent hands, given perfect satisfaction. The can is constructed of heavy galvanized sheet iron; to the outside is attached an air-pump, communicating by means of an india-rubber pipe with a tube leading to the bottom of the can, which terminates in a nose similar to that of a watering-pot pierced with minute holes. By simply working the handle, air is driven in, and being divided into fine bubbles by the nose, completely aerates the water, restoring the oxygen consumed in respiration by the fishes. On the interior, about half way between the bottom and top, a ring of strong wire is soldered; on this can be laid a perforated plate, dividing the can into two divisions, a matter of importance when fishes of different ages and cannibalistic propensities are to be transported. Should the weather be warm, a tray with perforated bottom is fitted to the top and filled with ice, the drip from which will keep the temperature sufficiently low. Around the top of the can are inserted windows, as they may be termed, of fine wire gauze. The whole is surrounded by a conical cover. The air-pump is attached to the sides of the can by thumb-screws, so that with the india-rubber tube it may be removed and packed inside on a return trip. We have been frequently obliged to leave home with fish by daybreak, in order to reach a distant point during the same day. To capture and count the fishes, sometimes amounting to many thousands, immediately prior to starting, would necessitate early rising, a luxury which we by no means enjoy. The windows of wire gauze are now of use. The fish are taken, counted, and placed in the tank over night, the air-pump is removed, and the can, with cover firmly attached, is sunk in swift-running water, which, passing through the windows, will keep the captives in good order. The only objection to these windows is that during transit over rough railroads the water will sometimes splash through them, causing too often profane remarks on the part of the baggage-master or express agent, and rendering the administration of another "quarter" necessary. It is therefore well in large establishments to have a special can for keeping the fishes over night.

If several cans are used at once but one air-pump is necessary, as the india-rubber tube can be removed from one can and slipped on another. The pump should be made in the best manner and with but one valve, as every additional valve will double the chance of getting out of order—a serious matter when the lives of hundreds of fishes are involved. Our first attempt at transporting large fish in this tank was in December, 1869. We desired to exhibit at the Show of the New York Poultry Society a series of our finest fishes. Seventy-one were selected, and though sixteen hours elapsed before they could be placed in the Society's tanks, but one fish died upon the passage, and this was previously diseased. But one change of water was made, and this was necessitated by the upsetting of the can and the spilling of the fishes in the bottom of the express wagon. Among the fishes were ten averaging a pound and a half each. We were honored by the Society with a bronze medal for this invention.*

* We also received the great gold medal of the Society, value eighty dollars, for our display illustrative of the science of fish culture.

Even during the hottest weather, if the ice-pan is kept well supplied, there is rarely need of changing the water oftener than once in twelve hours; often changing is injurious to the fishes. In the present age of rapid transit, every hour may bring the traveler to water of entirely different qualities. Rain-water should never be used, except in a case of emergency. Fishes will live, and sometimes thrive, in waters of entirely different chemical character from those in which they were born and bred; but when confined in a can are peculiarly susceptible to any change in the quality of the element.

No fear need be felt that the carbonic acid eliminated in respiration by the fishes will injure them. Trout are frequently found in waters saturated with this, to man, noxious gas; and, in fact, there are few of our limestone springs which are not in this condition.

We have made some experiments on the preservation of living fishes in air-tight tanks in which a large amount of air had been compressed. The results have, thus far, not been in all cases favorable; yet should this succeed, and we have not as yet given up hopes of success, living fishes may be shipped by express as freight or ordinary baggage. We hope that if any one of our readers should succeed in this method he will not at once secure it by letters-patent, as is too much the custom of late. Neither our transit-tank, nor, in fact, any apparatus invented by us, is secured to the inventor, and we will be most happy to hear of their use and success in the hands of our piscicultural brethren.

CHAPTER XII.

BIBLIOGRAPHY OF FISH CULTURE.

For the convenience of those who wish to know what has been written upon the subject, we append a list of the works on fish culture now in our library. We are aware that the list is not complete, but believe that it contains all works upon the subject which can be readily obtained. Many are more curious than useful, having been written by individuals having no *practical* knowledge of the subject. In the arrangement the alphabetical order has been observed, for, as Dibdin remarks, we may differ in our ideas of arrangement, but all know our alphabet.

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