VI.—ON THE FISH-CULTURAL ESTABLISHMENTS OF CENTRAL EUROPE.*

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A.—NOTES ON FISH-CULTURAL ESTABLISHMENTS VISITED BY DR. BETTONI.

List of the establishments visited.

Location of establishment.	Character of establishment.	Name of director.	When founded.
Switzerland:			
Zurich, Canton of Zurich	Cantonal	Dr. Asper	1882
Dachsen, Canton of Zurich	do	Maendli and Dr. Asper	1875
Neuhausen, Canton of Schaffhausen	do	Moser-Ott	1877
Germany:			
Hüningen, Alsace	Governmental	H. Haack	1854
Selzenhof, Baden	Owner, Mr. Schuster	C. Schuster	1872
Radolfszell, Baden	do	Dietrich	1877
Seewiese, Bavaria	Owner, Mr. Zenk	M. Hartmann	1881
Cosmandorf, Bavaria	Owner, Mr. Mittag	Mittag	1880
Wilthen, Saxony	The Catholic Church at Bautzen.	Teubner	1880
Lübbinchen, Prussia	Owner, Mr. Eckardt	R. Eckardt	1868
Berneuchen, Prussia	Owner, M. v. d. Borne	Max von dem Borne	1877
Michaelstein, Brunswick	Governmental	Wegener	1881
Netherlands:			
Velp	Joint stock company	Bontjes	1871
Apeldoorn	Owner, Mr. Nordoek-Hegt.	Nordoek-Hegt	1880

I.—Salmon and trout culture.

The water in general.—In consulting various treatises on the subject I have found that, in founding a fish-cultural establishment, it is necessary to take into account the origin of the water to be employed, so that it may be used for that branch of fish-culture to which it is best adapted. In fact the water of springs, brooks, and rivers may all be employed in the incubation and raising of salmonoids, provided, of

* *Sugli Stabilimenti di Piscicoltura visitati all'estero dal Novembre*, 1884, *all'Aprile*, 1885." From *Annali di Agricoltura*, Rome, 1885. Translated from the Italian by Herman Jacobson.

course, that it meets all the necessary requirements of purity, nutritive substances, sufficient aeration, and suitable temperature.

Spring water, which does not contain mineral substances, is to be specially recommended for hatching, provided it is not so warm as to exceed 10° C. [50° Fahr.]; as owing to its even temperature it appears cool in summer and warm in winter.

On the other hand, brook water commends itself, because generally it is easy to obtain, and contains a good deal of air, in which latter respect it is excelled by river water, which is well adapted to the purpose, if it does not carry too much mud. In northern countries, however, this water is apt to freeze.

In view of the above it will not seem strange that the first request which I made of the directors of the establishments visited by me was to inform me in relation to the quality of the water employed by them. I have below tabulated their statements regarding the quality and temperature of the water employed in their hatcheries.

Establishments in which only spring water is used, which rises in close proximity to the hatching chambers.

Establishments.	Number of springs and their course.	Temperature.			
		In winter.		In summer.	
		°C.	°F.	°C.	°F.
Dachsen	Two springs, close to the hatching chamber.	8	46	10	50
Neuhausen	One spring, at a distance of about 500 feet from the hatching chamber, and led to it by underground pipes.	9	48	10	50

Establishments in which spring water, brook water, or river water, either each by itself or mixed, is used.

Hüningen	Several springs which rise in the extreme southwest of the territory occupied by the establishment; a portion of their water being led to the hatcheries through pipes, 2,050 feet long.	10	50	10	50
	Rhine water from a canal connecting the Rhone and the Rhine, led into the inclosure, and brought into the hatching houses by means of turbines.	Varying.		Varying.	
Selzenhof	A spring at a short distance	8	46	12.5	55
	Water from a brook which rises at the distance of half an hour.	2.5–8	37–46	12–15	54–59
Soewiese	Several springs rising within the inclosure of the establishment.	8	48	8?	46?
	Water from the brook called "Fischbach," a tributary of the river Saale.	.....	.....	.....	.....
	A mixture of the two waters	11	52	11	52

*In the official report, "*Notice historique sur l'Etablissement de Huningue*," Strasburg, 1862, it is stated that the temperature of the springs is even, but during the winter 1884–'85 very noticeable variations of temperature were observed. The only mention made of such variations in said report is that of 1856, during the winter of which year the temperature fell to zero.

Establishments supplied from springs led to the hatching house through long open courses, or through ponds and canals.

		°C.	°F.	°C.	°F.
Wilthen	A spring rising at the distance of one kilometer [about 1094 yards], led into a basin, and thence to the hatching chamber.	0-2	32-36	High.	
Lübbinchen	Three springs, one of which rises close to the village, and the others at a distance of one kilometer, whose waters, after being united, are, through a canal of 650 feet, led into a pond, whence through another canal of half a kilometer they are led into the hatching chambers.	0-10	32-50	20-25	68-77
Michaelstein	Distant springs furnish water to some ponds, from one of which the water is led to the hatching chamber.	0-0.5	32-33	High.	
Velp	A spring at a distance of three-quarters of an hour; the water is led through open canals to a small pond in view of the establishment.	0-1	32-34	20	68
Apeldoorn	It is doubtful whether the water comes from a spring, as its quantity is truly exceptional (10,000 cubic meters [about 350,000 cu. feet] per day); it comes a distance of three kilometers [nearly 2 miles] in open canals.	2-3	36-37	11	52

Establishments which use other water.

		°C.	°F.	°C.	°F.
Radolfszell	Drinking water of the country	1	34	10	50
Zurich	Drinking water of the city, drawn from the lake.	4	39	21.5?	71?
Cosmandorf	Mill canals coming from the river Rotho	1.5-8	35-46	19	66
Berneuchen	Mill canals coming from the river Mietzel	0-3	32-37	25	77

Temperature of the water favorable to hatching.—It is at present almost impossible to say which of the various temperatures under the influence of which the hatching process is accomplished is absolutely preferable; but in general it may be stated that, in the cold of winter, a temperature which does not rise much above 10° C. [50° F.] is favorable for salmonoids; nevertheless there are facts to show that salmonoids have been successfully hatched both at a much lower and at a much higher temperature (at Torbole in water of 11° C. [51.8° F.], and at Garda in water of 14° C. [57.2° F.]). But it is certain that the development of the embryo succeeds better if the hatching water has an even temperature than if it exceeds certain limits of heat or cold; and this condition is more generally found in spring water than in other water. It should be understood, however, that favorable conditions of temperature may also be found in other than spring water; and if these conditions do not exist, we have seen fish-culturists endeavor to obtain them by mixing waters of different origin, as is done or can be done at Hüningen, Selzenhof, and Seewiese; or by having recourse to a stove, which in several places I have seen in the hatching rooms, as an indispensable article of furniture. The objection might be raised that the mixing of spring water with other water, or the substitution of other water, the placing of the hatching chambers in the ground, as is done in some northern countries, and the stoves, have no other object than to ward off the dangers of freezing; but we may be allowed to suspect that practice employs all these means in order to obtain or to approximate that evenness of temperature which otherwise could not be obtained.

As it is necessary, therefore, to know whether sudden changes of temperature during the hatching period can be averted and whether they are hurtful, and to find out what are the final consequences of accelerated and of retarded hatching* on the life of the young fish which have been hatched from eggs treated in different ways, it follows that fish-culture is, strictly speaking, experimental. The answers of theoretical fish-culture on these points cannot be entirely evasive and categorical. Meanwhile, however, by carefully interpreting all that practice teaches, and by applying physiological analogies, we find that the changes from a relatively high to a relatively low temperature are to be feared, while there is not so much danger in changes from a low to a high temperature, because if there is a certain given degree of warmth care can be taken to maintain it.

Fish-culturists distrust hatching at a relatively high temperature, not because they think that it may unfavorably affect the development of the embryo, but because, as Max von dem Borne states, the young fish which have been hatched before their proper time are in need of food earlier than they would have been otherwise, and nature, still wrapped in its winter sleep, may not yet be able to furnish the food.

Hermann Haack also verbally stated the same, relative to hatching accelerated by comparatively too hot water, as, in his opinion, the young fish hatched too soon and placed in a lake immediately after the absorption of the umbilical sac, would miss the food furnished by the eggs of insects which can not be obtained until mild weather sets in. In view of this circumstance, he is inclined to prefer slow hatching in river water, which is generally colder in spring than spring water, or in brook water coming from springs, which, however, during a long course has had time to lose some of its original warmth. It appears to me, however, that Mr. Haack's suggestion does not yet furnish a complete remedy. He proposes to plant the young fish later, which may become possible by feeding them for some time artificially in the same water in which they have been hatched.

But is it really true that young fish placed in a lake too early must necessarily die? Fish, like most other animals having blood of a variable temperature, can, as is well known, remain without food for a long time; but we desire to know, as regards salmonoids, and for purposes of fish-culture, which are the extreme limits of the period of fasting which the young fish can reach, and whether this will not more or less exercise an influence on their bodily development, on their health, and on the condition of their offspring. And this is a question which can only be solved by experimenting.

Filtration of the water.—It is well known that water conducted in open canals through a country covered with vegetation carries with it leaves and other vegetable matter, which has either fallen into it or

* According to Ainsworth's observations the duration of hatching varies with the salmon from 1 to ½, at a temperature varying from 2.5° to 12.5° C. [36.5° to 54.5° F.].

which has been brought there by winds and showers; it is therefore a common practice to keep these objects out of the water by means of gratings and chains, or similar contrivances, even in cases where the water is not to be used for such delicate objects as the hatching of fish. But water invariably contains other particles, principally belonging to the mineral kingdom, which remain floating, as their weight is very light, and which are sometimes so diminutive that they can not be discerned with the naked eye, the water being to all appearances perfectly clear; and it is these particles which, if allowed to remain in the water for any length of time, cover any objects submerged in it with a sediment.

The best authors on the subject of fish-culture state that this sediment is injurious to the eggs of fish. Max von dem Borne does not hesitate to say that, next to mold, this sediment is the most dangerous enemy of fish; and Benecke, not satisfied to call attention to the dangers of this sediment, accurately describes the means by which it can be removed, and states that even the clearest water will always contain some of it.* Hence filters are used, which I do not deem it necessary to describe here, as they are well known, and have been described in many treatises on the subject, the object of which filters being to remove by mechanical means many of the small impurities, sediment, and diminutive animals. Prof. P. Pavesi also attributes the mortality which several times made sad ravages in the hatching-houses of the fish-cultural establishment of Torbole to the lack of filtration.†

The theoretical knowledge which I possessed, and the practical knowledge derived from experiments made at Torbole and Garda, caused me to start on my trip to foreign countries with the firm expectation that I would find filters universally adopted. But my surprise was great to find their use not near so general as I had supposed, and that they were entirely wanting even in establishments where the quantity of sediment had for a long time formed the cause of serious complaints, as, for instance, at Hüningen. In consulting the historical notice of this establishment I found that the turbid character of the water of the Rhine was deplored, and the wish expressed (in 1862) that filtering apparatus might be introduced, which was entirely wanting; and that then, as now, the water from some neighboring ponds was used for the hatcheries, because the Rhine water contained so much sediment.

In only five of the fourteen fish-cultural establishments which I visited did I see filtration properly practiced, namely, at Seewiese, Berneuchen, Wilthen, Michaelstein, and Velp, and a rudimentary filtration at Dachsen and Selzenhof. At Zurich the water of the lake is led into reservoirs for public use, and is sufficiently filtered for that pur-

*B. Benecke: *Fische, Fischerei und Fischzucht in Ost- und West-Preussen*, Königsberg, 1881, p. 459.

†P. Pavesi: *Esposizione Internazionale di pesca a Berlino*, Rome, 1882, p. 105.

pose; but the process of filtering should be repeated near the fish-cultural establishment.

Mr. Haack justifies the absence of filtering apparatus by saying that practice has shown the sediment to be harmless, and I can state from personal observation that fish eggs have been successfully hatched at Hüningen even in hatching-boxes and in California apparatus, supplied with water directly from ditches without any grating at the entrance.

At Max von dem Borne's establishment I saw in operation the filter with several chambers, terminating with the so-called American filter (of flannel), but in answer to my inquiries he stated that for filtration there might be substituted the washing of the eggs by letting water fall on them from a certain height from the pierced spout of a simple watering-can. This proves at any rate that this eminent fish-culturist has not abandoned the idea above referred to, that the sediment is hurtful, as long as he tries to remove it in some way or other.

Those who maintain that filtration is useless can not say that they follow the example of nature, because if it is true that the trout cover the eggs which they lay in brooks, they do it with small stones and not with mud; and the sediment cannot adhere to the eggs, because they are continually kept floating by little currents passing through the crevices between these stones.

I am not able to explain the difference of opinion in this respect among such competent persons; but I have no doubt that in every case the opinion is based on experience drawn from the peculiar practice prevailing in the different localities. It is generally agreed that if the quantity of the sediment exceeds certain limits it becomes hurtful to the eggs, preventing free respiration. But as regards allowing a small quantity of sediment, people should be guided by its quality, which in one place may be such as to render its removal necessary, while in others it may be left without running any risk.

Of whatever description the filtering apparatus may be, the filtering should be done through thick or relatively indestructible matter, sand, or fine gravel, alternating with layers of charcoal, sponges, &c. Even then it may not be entirely efficacious in directly preventing the development of the minute spores, which are among the most dangerous enemies of pisciculture. But if sediments of a mineral nature are combined with organic matter, which may sometimes happen (although the combination may greatly vary in its character), I think a mechanical process of filtration may indirectly be successful by keeping the parasites away, or at least diminish their spreading, since only organic matter contains the conditions favorable to their growth. There is no doubt, however, that the antiseptic property of coal, which is largely employed as a means of filtration, is lost after a short time, so that after a certain time the filters will only act in a mechanical way. For this reason I would like to know whether any experiments have been made in pisciculture with filtration by "carferal" (carferal, or iron sponge,

is a compound of aluminium, iron, and carbon, the preparation of which is kept a secret: it is used largely in the British navy), which, even after having served for a long time, will not leave in the water which passes through it any traces of ammonia or any spores, which does not happen when charcoal is employed. In my opinion the use of carferal for filtering the water to be employed in hatching fish eggs would at least keep away the mold; and perhaps it would be possible to use water containing a large quantity of organic substance of another nature.

To reach a conclusion in this matter I should say that under certain circumstances filtration may be unnecessary, especially if the sediment is so light that it remains floating in the water; but it will be necessary, if the sediment forms deposits on any bodies submerged in the water, or if, owing to its peculiar nature, it possesses injurious qualities. But filtration may be recommended under all circumstances, if for no other reason, because one would rather see the eggs clean, and also because inspection would become easier.

Aeration of the water.—A defect which is sometimes found in spring water, especially if it flows into the hatching-box after having for some time passed through closed canals, is the scarcity of air, which is not the case in brook or river water which has for a long distance passed through the open air, and which through its constant contact with it has retained a large supply of this vivifying agent.

Some fish-culturists, as, for instance, Mr. Schuster, consider the aeration of the water of such importance as to favor it and to increase it artificially, when there does not seem to be a sufficient quantity of air in the water. I cannot but think that artificial aeration of the water is absolutely necessary in cases where the air is lacking, and is a laudable precaution when such lack of air is suspected, though there may be no means of proving it, and superfluous when water is used which contains a superabundance of air; but under no circumstances will aeration prove hurtful. Moreover, the different kinds of apparatus used for artificially aerating water are so simple and so little expensive that economical reasons should never prevent people from using them.

I am sorry that I have lost the design of the air-injector of Mr. Schuster which I saw in position at the mouth of the outflow of the water into the hatching troughs, but I will give a description of the principle on which it is based. It simply consists of two concentric metal vessels, into the lower one of which the water flows from the other through holes in the bottom. The water in forcing itself through these holes produces air, which enters at the upper part of the central tube and mingles with the water.

At Neuhausen the water destined for hatching is aerated by means of pipes which carry it underneath the hatching-house. These pipes are placed near the surface of the water in distributing canals, and are of

such a diameter that the water rising above the outer edge does not completely fill them.

The water descends like a long veil along the inside of the pipe, producing a strong current of air, which rushes down with the water. I do not think that these pipes are constructed for the express purpose of acting as air-injectors; but, howsoever this may be, it is none the less true that they serve this purpose in a very efficacious manner.

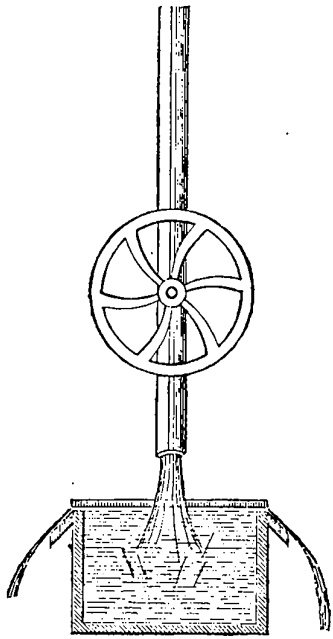


Fig. 1.

The manner in which the water enters the individual hatching-boxes may also be a means of introducing air into the water. I refer particularly to the practice which I observed in the establishment of Neuhausen and also in that of Dachsen. In the Neuhausen establishment the water, which from the general distributing reservoir is made to gush through a pipe at same height above two troughs, first enters a square box, whence it descends along the short sides like a waterfall, as shown in Fig. 1.

At Dachsen the water flows through stop-cocks into common terra-cotta flower-pots, the bottom hole of which is purposely somewhat enlarged. The pot rests on a piece of metal sheet, on which are placed a number of small pebbles. As the distance between the mouth of the stop-cock and the pebbles in the flower-pot is sufficient to allow the stream of water to spread out somewhat, and to break itself on the pebbles with a certain force, the water comes in constant contact with the air, as shown in Fig. 2.

I must also state that the water may receive some air in the open canals through which it is led into the hatching-houses at Hüningen, Selzenhof, Neuhausen, Dachsen, Zurich, Berneuchen, Michaelstein, Velp, and Apeldoorn. This small quantity of air is, however, entirely lacking at Cosmandorf, Wilthen, and Seewiese, where the distributing canals are entirely closed. This remark should not be misunderstood, since the object in view may be fully attained, as the water contains a sufficient quantity of air, either owing to the fact that it is either river or spring water, or by flowing open for a considerable distance after it has left the spring.

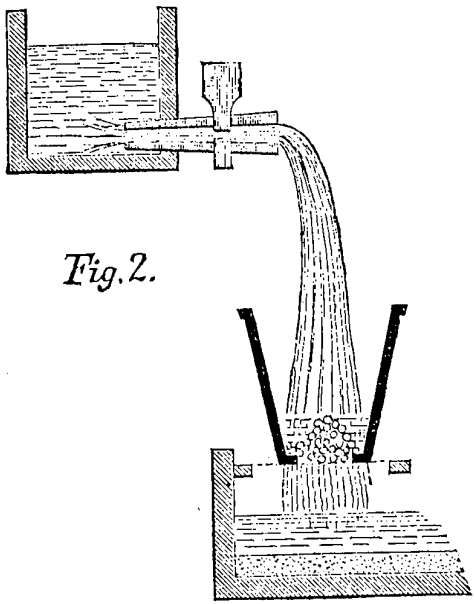


Fig. 2.

Hatching apparatus.—The character of the hatching apparatus which I saw in operation to some extent partakes of the nature of the period in which the establishments to which they belong were founded; but they also reflect the special views and the degree of technical education of their directors.

It is certain that among the very large number of models of hatching apparatus which I have seen there is not one which could be said to answer the purpose better than the others; but if we take into consideration the requisites which they must possess, it will easily be understood that these requisites may be obtained in many different ways, and by different means. For the sake of clearness I will enumerate the principal requisites which the hatching apparatus must possess, as follows:

1. They must furnish a suitable, continuous, regular, and uniform supply of aerated water.

2. They should economize space as much as is compatible with the proper performance of the hatching operation and with the least possible hinderance to the renewal of the water.

3. They should be constructed of impervious, durable, and clean materials.

4. They should be placed in such a manner as to facilitate the operations which should be carried on during the hatching process, especially the separation of the spoiled eggs from the healthy ones.

According to their typical character I may classify the hatching apparatus which I have seen in operation as follows:

1. *Coste's system:* (1) Stairs of troughs; (2) hatching tables; (3) subterranean canals.

2. *Simple troughs:* (1) Troughs of carbonized wood; (2) troughs of cement or zinc.

3. *Hatching tables:* (1) Williamson tables; (2) Zenk tables.

4. *Holton's system:* Holton hatching apparatus.

5. *California troughs:* (1) Eckardt troughs; (2) California boxes; (3) funnel-shaped troughs; (4) automatic selectors.

6. *Ice boxes:* The Haack box.

The defects of the Coste troughs are well known, and have been clearly shown as fish-culture has further advanced. It is, therefore, not astonishing that they have been everywhere abandoned, even at Hüningen, where the present director of the establishment does not use them at all. I saw a Coste stairway in white enameled clay at Neuhausen, but it was not in use. Hatching tables (Coste's system) I saw, however, at Hüningen, where they are still used, and form part of the material which the imperial German Government acquired with the establishment. These tables are about a meter long, with a somewhat deep edge, and are placed on an incline; the first receives the water direct from a spout in the short side of the table. A perforated partition of zinc plate, running parallel with the lower edge, lets the water pass, which then flows from this edge through small leaden pipes upon the table placed below. Some of these pipes are kept closed with a stopper, while others are left entirely open, so as to maintain the desired level. The large compartment (lined on the inside with zinc) is placed between the edge and the partition running parallel with the lower edge, and is destined for the eggs, which are placed on a soft bed supported by the well-known network of glass stems, for which, in some cases, a more economical construction of metal wire is substituted.

Similar to the Coste tables are the large troughs in cement, placed on an incline, which fill the large hatching-hall of the Velp establishment. They are placed in a row of five double compartments having a common edge, and leading to a compartment which is double the size of the others, and which is the last of the row. Some troughs intended for hatching are 86 centimeters [about 34 inches] broad and 2 meters [about 79 inches] long. Here likewise the eggs are placed on Coste frames,

many of which are set in terra-cotta, and have, in place of the glass beams, beams of chalk. In these tables the water flows over the eggs more easily, and does not flow among them; the aeration, however, is not and can not be so defective as in the Coste stairway, since the water flowing through pipes from the front edge on to the table below rushes down upon it, and rises again a little, and in every compartment spreads advantageously over a large surface. But it is certain that the renewal of the water must form the proper test, whether apparatus can, in the establishment which possesses it, be used to advantage or not. The Coste tables at Hüningen show, by their state of preservation and by their dimensions, that they are not so expensive as those found at Velp.

The spring water at Hüningen is in part made to flow through canals of cemented brick-work which are laid in the ground under the hatching hall. They may be compared to veritable brooks, while by their bottom, arranged in long steps ending in perforated cross partitions, they resemble the Coste tables.

This system of subterranean canals has one great inconvenience, as it compels the person who places the frames for the eggs in position, or who has anything to do about them, to work kneeling on the pavement. This inconvenience is not found in the hatching tables at Hüningen and at Velp, as they are placed at a convenient height. The simplest apparatus, however, is the large wooden troughs which I saw at Neuhausen and Dachsen. The first of these were constructed according to two identical models, but differing in size. Two and two are placed lengthwise by the side of each other; their edges are about 20 centimeters [8 inches] high; their shape is that of a parallelopiped; they have a partition 25 centimeters from the short edge, opposite to which the water enters if their length is 2.68 meters and their breadth 43 centimeters [106 by 17 inches]; and at a distance of 8 centimeters, if their total length is 68 centimeters and their breadth only 22 centimeters [27 by 9 inches.] The eggs are spread on frames of iron and wire, the water, which is kept at a height of 8 centimeters, flows into the space between the partition and the outer edge through closed pipes, at the end of which there is a metal grating.

The Dachsen troughs resemble those which I have just described, but here the eggs are placed on a layer of very fine gravel 2 centimeters [¾ inch] high, above which there are 3 centimeters of water. This system of hatching in wooden troughs, the eggs being placed on very fine gravel, is practiced a good deal in America; and I have also seen it employed at Zurich, but the same result is said to be obtained by placing the eggs on the carbonized bottom of the trough, or on frames of metal wire, of switches, or glass reeds. I would, however, observe in this connection that, the general conditions of hatching being the same, which it seems to me is hard to prove, the frames represent an expensive but durable material, and the gravel a comparatively small expense, all the work required being to get it all of a suitable size, and to wash it in a dilution of mineral acids before using it. If, therefore, it was not more

to the purpose to keep the eggs on frames, it would be the most economical way to place them directly on the bottom of the boxes.

At Radolfszell, likewise, there are some wooden troughs constructed in this simple and primitive plan. I saw at Mr. Schuster's establishment, at Selzenhof, similar troughs, but constructed in cement, and therefore of more solid material, more durable, and neater in their appearance. Their length varies from 4.8 to 3 meters [16 to 10 feet]. As they have a partition of wire in the usual place, with the well-known canal which carries the water to the pavement, they do not need any special description. I will only state that those which are placed in the room to the right of the entrance have an excavation immediately underneath the place where the water rushes out for the purpose of regulating its movement and preventing it from springing up with too great force.

A portion of the very large hatching-room at Apeldoorn contains troughs in cement, placed in pairs. Each trough is supplied with water from a separate spout, and therefore there is not the least trouble to keep the water aerated. Some of the troughs are of wood, but it is intended to substitute for them, at no distant time, troughs made of the material referred to above.

The hatching-tables according to the Williamson system are well known and have often been described. They have the advantage of causing the current of water to pass below the frames containing the eggs, these frames being, in order to economize space, placed in this hatching apparatus one above the other. I have seen these tables at Radolfszell and Michaelstein. In the last-mentioned establishment they are placed over cemented tanks, which serve for fish, and are used only in case of necessity.

The Zenk tables, which are an invention of the owner of the Seewiese establishment, Mr. Frederick Zenk, although not in every respect like the Williamson hatching apparatus, still resemble it somewhat. They are troughs 2 meters long and 60^{cm} broad [6½ by 2 feet], made of pine wood, tarred on the outside and carbonized on the inside,* and their edges are 20^{cm} [nearly 8 inches] high. The water flows from two stop-cocks at the head of the trough against a partition of wood, which touches the bottom of the trough, but which is 4 centimeters lower than the edge; thence it passes into another compartment, whose partition rises to the same height as the edge, but does not touch the bottom. The water, therefore, flows over the first partition, as in the Williamson system, and passes underneath the second. A zinc pipe, starting from the distributing-pipe, is laid diagonally on the bottom nearly the entire length of the trough. This pipe passes over the first and below the second partition, and has all along its sides holes, from which small currents of water flow, which is said to exercise a very beneficial influence on the hatching process. At the distance of 9 centimeters from the end wall

*Carbonization is obtained by a piece of red-hot iron, or by applying smoking sulphuric acid.

of the trough there is a partition which has nine holes, in three perpendicular rows, which can be closed by means of small cork stoppers, with the view to regulate the depth of water in the trough. If all the nine holes are open the water in the hatching apparatus keeps at a height of 5 centimeters; if the lower holes are closed the water rises to the height of 10 centimeters; if those in the middle are closed the water rises to a level of 15 centimeters; while if the upper holes are closed the water may rise to 20cm. (See Figs. 3 and 4.)

Into the troughs placed underneath the first the water flows in the following manner: The water, which reaches these troughs from those above, has already served, but fresh water is led into them through the diagonal pipe at the bottom, which receives it direct from the distributing-pipe.

The eggs are placed on rectangular frames measuring 56 x 25cm [22 by 10 inches.] They are made of galvanized-iron wire and have perforated edges. If these frames, as is sometimes done, are not placed parallel with the edges of the trough, this is done to avoid too uniform a current. On every one of these frames there can be placed 10,000 trout eggs, and as six frames can be placed on the bottom of the trough and over each one of these three, these troughs have each a total capacity of 60,000 eggs.

The hydraulic movement of this trough is in most respects like that of the Williamson trough, only with this difference in favor of the latter, that the movement is repeated at each row of frames, partitions being interposed, which are wanting in the Zenk trough and which, in my opinion, do not present the same advantage as the pipe in the bottom of the Seewiese trough. Both models, however, have the inconvenience that it is difficult to pick out the good from the spoiled eggs, for which purpose it is always necessary to change the place of the frames so that the one which is to be operated on is always at the top.

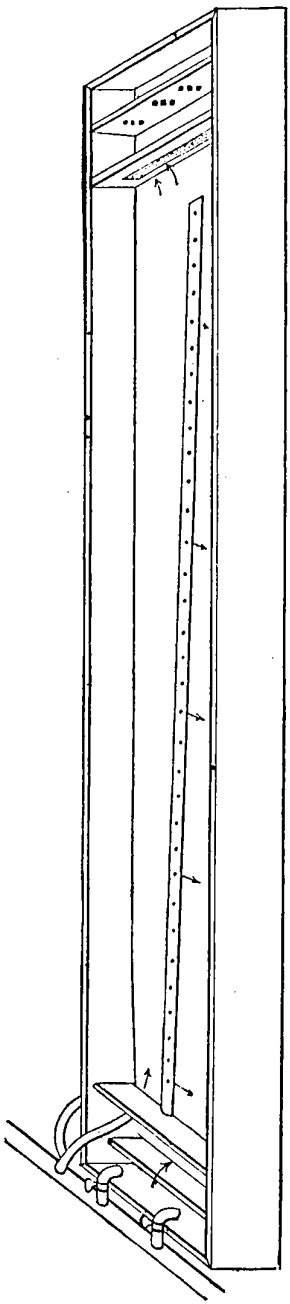
I saw the Holton apparatus at Radolfszell and Cosmandorf, but they were not in operation.

As a matter of course, Mr. Eckardt, at Lübbinchen, employs the troughs of his own invention, which, according to the movement of the water, must be classed among the California apparatus. It is not necessary to describe them here, as Professor Pavesi has already given a full description of them in his report above referred to.

The California trough is used very much, but not so extensively as might be supposed from the favor which it has found with many fish-culturists. Still, I have found establishments in which it is the only hatching apparatus in use; and many in which it is used in addition to other hatching apparatus, for the reason that owing to lack of space the number of these apparatus could not easily be increased.

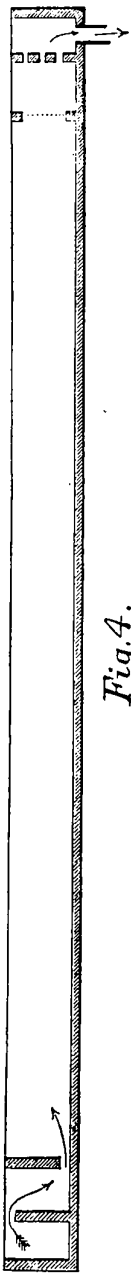
The location of Hüningen is not favorable to the use of this apparatus on a large scale, but owing to the favor which it has found with the distinguished director of the Hüningen establishment (who himself had

introduced some modifications in it), it forms part of the apparatus which has been acquired during his directorship. At Hüningen I have also seen California troughs in use in the open air.



ZENK TROUGH.

Fig. 3.



SECTION OF TROUGH.

Fig. 4.

As reserve or supernumerary apparatus I have seen these troughs employed at Selzenhof, Zurich, and Seewiese.

Fig. 5.

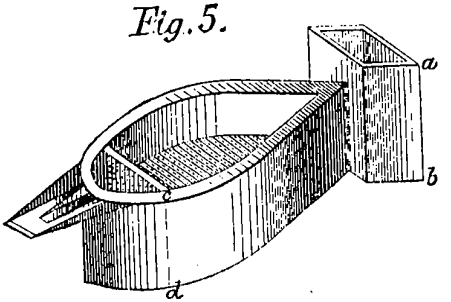
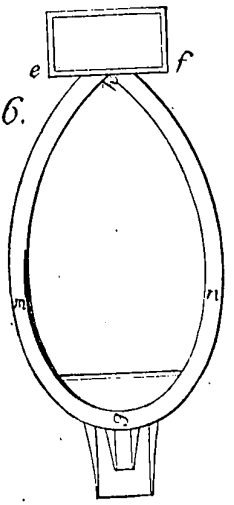


Fig. 6.



In the last-mentioned establishment I have seen it with such singular modifications that I deem it proper to give an idea of the same.

One of these models represents a small box with a rectangular base (see Figs. 5 and 6) which serves to receive the water directly from the distributing cock. Along a line in the middle of the longer side of this box there is joined to it a receptacle of oval shape, in which the box with the eggs is placed. A small pipe placed below the upper edge of the box pours the water into a second pipe which is lower, broader, and longer, which takes the water which cannot all come out through the smaller pipe and which also flows between the two partitions, the inside and lower of which supports the frame for the eggs, while the upper limits the external surface of the apparatus. The capacity of this box is 6,000 trout eggs, the exact quantity which a California trough of the normal type and dimensions can hold.

I do not consider it necessary to describe another modified type of the California box, capable of holding 7,000 trout eggs, lower than the

regular California box, but with cross-sections and rectangular sides, which I saw at Seewiese, and which, like the first mentioned, is made by Ignaz Walther, of Marktreit. At Cosmandorf, however, the California trough only is used (Max von dem Borne type) without a third box, and with the addition of the "catch-box," as also with von dem Borne at Berneuchen, and to a great extent at Michaelstein.

In the last-mentioned place some of the California troughs are of the Schuster model—that is to say, with a fixed perforated partition; but some have a movable partition. The boxes are arranged on an incline in such a manner that each incline has seven steps, so that the water flowing from one spout passes from one box to the other, from the first to the seventh in the row.

At first sight this arrangement shows the same defects which have been noted in the Coste stairway; but the better distribution of the water, the large pipe which serves for its outflow (which causes it to fall below in the shape of a thin veil), and the quicker renewal of the same, makes up in the California troughs for the scarcity of air, which in the Coste troughs is remedied by the presence of small faucets, which distribute the water in the shape of small springs.

The best way of utilizing the California boxes, economizing space as much as is compatible with the proper dispatch of the hatching process, I have seen employed at Berneuchen. Here each spring supplies only two troughs in succession, a box being placed between each couple. Three models of California troughs are employed here, namely, Max von dem Borne, normal type; funnel-shaped troughs (Bell); and automatic selectors.

The troughs are placed in cemented tanks, which successively are used for various operations connected with fish-culture; for keeping the spawners and milters which are to furnish eggs for artificial fecundation, for hatching, and finally for the young fish. These tanks are 2 meters long, 50 centimeters broad, and 30 centimeters deep [about 79 by 20 by 12 inches].

By keeping the California boxes in tanks the water is prevented from flowing on the pavement, and another useful object is reached by an arrangement for regulating the depth of water in these tanks by means of a pipe with an elbow, attached on the inside to the mouth of the discharge pipe and terminating in a box of tin or perforated zinc. This pipe may be more or less inclined by the operator, and allows him to obtain the needed depth of water, as by increasing or decreasing the contact of the water and the box he can raise or lower the level of the water in the tank.

The addition of a wooden box into which the discharge pipe passes from the tanks will not in any noticeable way influence the result of fish-cultural operations; but it will serve as an illustration of the exemplary order and cleanliness which reign in Max von dem Borne's establishment. I can not imagine anything more convenient and cleanly,

as well as healthy, than his establishment, where you can approach the tanks containing the apparatus through which the water runs on any side without wetting your feet.

I may pass in silence the Lavallette troughs (which I saw at Seewiese), and the Zug apparatus (which I saw at Zurich); the first, because made of porcelain, has a surface perforated by only a few and large holes; and for the second automatic selectors have been substituted to advantage.

To some extent ice boxes may be considered as belonging to the hatching apparatus. They consist of prismatic or cubic boxes with thick walls of wood, sometimes lined on the outside with zinc. In these boxes, which may have a double lid, are placed, at a suitable distance, one above the other, several frames with a perforated wooden or wire bottom. On these the eggs are placed on moist cloths. On the top frame ice is placed which lets its cold drippings pass through the perforated bottom. In this manner eggs have been shipped a long distance, and the embryonal development has been delayed.

In reviewing the character of the hatching apparatus which I saw in operation, I would say:

1. That on account of their convenience (suitable height of the apparatus) troughs of any kind of material, and hatching tables of the height of an ordinary table, are equally to be recommended.

2. Troughs of cement and metal are preferable on account of the durability of the material, and because they can easily be kept clean.

3. On account of the proper hydraulic movement all those apparatus are to be preferred in which the water runs among the eggs placed at its bottom.

4. An arrangement by which the eggs are more scattered is not to be recommended, unless the abundant and rapid renewal of the water fulfills the third condition.

5. Owing to the greater facility with which the spoiled eggs can be picked out from among the sound ones, those methods are to be preferred, by which the eggs are placed in a single layer.

6. I consider it better to place the eggs on frames of netting in preference to placing them on fine gravel, or directly at the bottom of the trough; the best kind of frame is that which allows the water to pass through easily (wire netting), and which has perforated edges.

7. All the hatching apparatus which I have seen answers the purpose more or less, but the ordinary California trough excels them all, because it meets all the desired requirements.

8. Automatic selectors are particularly suited for the hatching of eggs of *Coregoni;* while the ordinary California trough is specially adapted to the hatching of the eggs of salmonoids.

At Hüningen I saw in operation the Haack apparatus. It was there employed for *Coregonus* eggs from the Lake of Constance, which were hatched at the expense of the Italian Government. The eggs remained

in the box containing fine ice until it was time to separate the fecundated eggs from those which had not been fecundated, and which were opaque, and from those which through contact with moss and alga had assumed a bright blue color, so as to make them resemble colored crystals.* The eggs were gradually hatched on Coste tables.†

Hatching-houses.—It is my opinion that he who travels for the purpose of obtaining a practical knowledge of the various aids employed in an industry like fish-culture should pay more attention to a critical examination of the apparatus seen in operation in the various establishments than to the extent to which this apparatus is employed, because this will necessarily vary according to the funds at the disposal of the establishment and the importance of the operations to be performed. I shall therefore not speak of the size of the various hatching-houses, but pass in quick review the characteristic features which they must possess.

The object of these houses is to protect both the hatching apparatus and the persons who work them against the inclemencies of the weather. If in case of necessity any kind of house or shed with windows suitably placed may be converted into a hatching-house, it is none the less true that buildings erected for the purpose, in a suitable position and furnished with all the necessary requisites, will answer the purpose better. Any one constructing such buildings should have due regard to the severity of the weather, and provide them with sufficiently thick walls. Thus at Cosmandorf the hatching-house has double walls of wood with compressed straw between them.

At Cosmandorf, Dachsen, and Apeldoorn the hatching-chambers are also of wood. The large hatching-room at Berneuchen has three walls of wood, the fourth being of brick, formed by the same canal which carries the water into the establishment. The roof is formed of wooden slats, covered both on the inside and outside with tarred pasteboard. The placing of the hatching-chamber in the ground made necessary by the hydraulic movement also serves the economical purpose of affording protection to the water and the apparatus against the excessive cold of the winter.

I have already referred to the hatching-canals at Hüningen, which run in the pavement, as being made necessary by the circumstance that the water has to be brought from a spring which rises at too low a level; but they may also serve to keep the water from freezing. Whenever

* It seems to me that the vegetation which endangers packed eggs is perhaps favored by the finish of the cloth in which they are wrapped and on which they rest. I would therefore recommend the use of cloth without any finish, or from which it has been removed by a solution of lye.

† I saw at Seewiese an ice box for transporting *Thymallus* eggs to the establishment from the place where the eggs had been fecundated. This apparatus had the dimensions of an ordinary Dillen vessel used by herbalists, and is made of tin by Joseph Schwarz-Spengler, in St. Pölten, and like this can be carried slung over the shoulder. It contains six frames for eggs, and a seventh (the top one) for ice. It has two panels, one for lowering what constitutes the long side of the parallelopiped box, the other to raise the upper side.

the climate makes it necessary (as at Berneuchen, Lübbinchen, Seewiese, &c.), stoves are employed.*

The hatching-chambers at Hüningen, Selzenhof, Radolfszell, Wilthen, Lübbinchen, Michaelstein, Velp, Zurich, and Neuhausen are of masonry.

The rooms where the hatching apparatus is kept should be sufficiently lighted by windows placed in suitable position, so as to facilitate the inspection of the eggs and the separation of the spoiled eggs from the good, &c. It is also asserted that a violet or blue light is most favorable to the embryonal development of the eggs and fish. I accordingly expected to see colored glass employed in some establishments, but my expectations were disappointed.

I confess that, with Professor Verson, among others, I am somewhat skeptical as regards the influence of monochromatic (violet) light to the exclusion of the white (composed of various rays of the luminous spectrum) on animal organisms, since, as Verson thinks, the same number of rays of a given color on which it is intended to experiment, to the exclusion of others, pass through a colorless glass.

But, to return to the subject to which I referred, it is easy to guess the reason for the absence of colored glass from the hatching-houses, because according to the advanced opinion of our time the eggs will develop better in complete darkness.† Moreover, it is of little importance in industrial establishments whether some think favorably of violet and blue rays, while others have their doubts on the subject, as experiments in this matter would seem more appropriate in a zoological laboratory. Complete darkness has also its dangers, as it favors the development of mold, while light favors the generation of green algæ.

Even a simple pavement of beaten clay (at Dachsen) may suffice for a hatching room, and it is certainly preferable to some other pavement made of or covered with cement (Selzenhof, Hüningen, Berneuchen, &c.); and in this connection I cannot speak too highly of the Berneuchen establishment for the ingenious way of preventing a light and continuous movement which, if not hurtful to fish-culture, may injure the building and interfere with the work of the operator.

As regards the filtration of the water it may be stated that the filter may either be placed in a room immediately adjoining the hatching room or in that room. The selection of a place for the filter will depend on topographical circumstances and on the desire to avoid any unnecessary enlargement of the building. It is certain, however, that if the filter is placed in the hatching room itself or in one immediately adjoining it, this will be found more convenient, as it affords a better chance to watch this useful apparatus without having regard to the state of the weather.

* Although there are large stoves at Hüningen, they were not used this year, not even during a period of intense cold, when the temperature of the spring water became considerably lower.

† For this reason, as well as to protect the young fish against their enemies, the hatching apparatus is kept covered.

It is also useful to have in the hatching-rooms a place for tanks where, during the proper season, and separated by sexes, the spawning fish destined for artificial fecundation may be kept. This is done on a large scale at Hüningen, where there are great tanks in the ground constructed of concrete. It has already been said that at Berneuchen every provision in this respect has been carefully made by Max von dem Borne. It is not necessary to speak of the size of these tanks, as they will have to be in proportion to the number of spawning fish kept on hand in each establishment.

Artificial fecundation of salmonoids.—After it has been ascertained that the spawning fish have reached sexual maturity artificial fecundation may commence. This may be done either by one person alone or with the aid of an assistant.*

In the first case the female fish is taken from the water and held with the right hand over the basin destined to receive the eggs. If the fish is large it is held inclined at a sharp angle. The belly of the fish is then pressed with the thumb of the left hand, the movement being in a downward direction.

If another person assists in the operation he must hold the fish by the tail by means of a cloth. The two operators hold the fish almost vertically over the basin, the first one holding it by the head with the hand and in the manner indicated, and the second by the tail. The first has to go through the manipulation described above to cause the eggs to come forth. The male fish is subjected to exactly the same operation.

The amount of pressure should correspond with the greater or less degree of maturity of the female, without, however, passing certain limits, as excessive pressure would injure the fish without reaching the object in view. In some cases the eggs have reached such a state of maturity that they will come out of themselves when the fish is examined to ascertain whether the genital gland has swelled enough to be operated on.

In natural spawning the salmonoids will deposit their eggs at different, more or less short, intervals; while where the process is artificial they all come out at one and the same time with a certain violent movement, which, however, does not interfere with their successful embryonation. The milt of one male fish is used for the eggs of two or three female fish.

In primitive fish-culture the eggs were kept under the water to be fecundated, as people believed that in doing so they followed the teachings of nature. But it frequently happened that many eggs were not

* The male fish may be recognized by having a more slender body, and its sexual maturity by the brown color of the skin of the belly. When the male fish is large its jaws are more hooked than those of the female. The female is recognized by having a stouter body; it has reached maturity when the belly is swelled out and elastic, and particularly puffed up above the anal fin, and when the reddish genital gland begins to swell.

fecundated, and were thus lost. In nature the male fish closely follows the female, and it may be said that the laying of the eggs and their fecundation are simultaneous. But in spite of the action of the water which kills the enemies of the eggs, and the alkaline sliminess of the eggs which favors their movements, it is a fact that many eggs do not undergo the process of fecundation which necessarily takes place under the water. At the present time, therefore, nature is no longer imitated in a servile manner, and it is the general practice to employ dry fecundation, which assures better and more general success. When as many eggs have been obtained as are deemed sufficient, and artificial fecundation has been reached by mixing at proper and regular intervals the milt with the spawn, the eggs are washed and then placed in the troughs.

The possibility of fecundating eggs on the shore of the waters from which the fish have been taken is proved by the circumstance that the eggs immediately after fecundation are so elastic as to allow of their being packed and shipped to the places where they are to be hatched. As soon as incubation has commenced this is no longer possible, even if managed in the most delicate manner, as the eggs when exposed to any pressure will inevitably be lost. But transportation again becomes possible when the eggs are near being hatched; that is to say, when the eyes of the embryo can easily be distinguished through the shell. From a practical point of view it is, therefore, important to know whether fresh eggs contained in a dead female fish can be fecundated.

If it is desired to know how many eggs have been obtained, the object can be reached by measuring them in small cylinders of a known capacity, having perforated sides and bottom, and, the kind of fish from which the eggs have come of course being known, to count the eggs in one cylinder* and multiply by the number of cylinders.

Packing and shipping embryonated eggs.—I have witnessed the packing of embryonated eggs, to be sent a considerable distance, at Hüningen and at Selzenhof. The eggs were placed on a bed of moistened wadding, gathering them in a piece of cloth folded in such a manner as to prevent the eggs from touching the sides, and keeping them covered. The layer of eggs was placed on the perforated bottom of a small wooden box. The next box is exactly like the first, and the last box of the pile contains the small pieces of ice, the cool dripping of which keeps the eggs below alive. The pile of boxes has on the top a stick of the same length as the boxes, and rests on a similar stick at the bottom. The whole is kept in position by a cord placed crosswise, and is then put in a larger box, the spaces between its inner sides and the pile of boxes containing the eggs being filled with sawdust, hay, or compressed moss.

From Pavesi's report the labels are known which are attached to the outside of the package, and which contain the address of the persons

*A liter measure [a little more than a quart] of eggs contains 15,625 *Thymallus* eggs, 8,000 trout eggs, 7,000 of salmon, and 36,926 of the *Coregonus*.

to whom they are sent, and generally some directions for their treatment by the railroad employés.

In Germany packages of eggs are received in the mails as postal parcels, and the administration of posts is directed to treat the package with the greatest care, in compliance with the request "urgent" written on a piece of red card-board attached to the usual label.

Tanks and ponds for salmonoids.—My report would not be complete as regards salmon culture if I did not mention the open tanks and ponds which in many establishments are used for keeping the stock of salmonoids.

The tanks are laid in cement, and covered with an iron grating, and the salmonoids are kept in them, separated according to age. They are so arranged that the fish in them can easily be fed artificially. As regards the matter of artificial feeding, tanks are perhaps better than ponds, as a possible excess of food* can more easily be removed in the former, and as it is also easier to prevent any injurious pollution of the water.

Special mention should be made of a simple contrivance adopted at Hüningen to protect the fish kept in certain provisional tanks, with wooden sides, especially against rats, which, if they have once got into them, find no way to get out. For this purpose boards are placed at right angles with the vertical sides of the tank, and projecting a little over the water. How this contrivance may serve as a trap will be understood without any further explanation by a glance at Fig. 7.

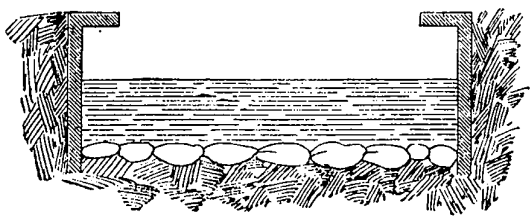


Fig. 7

Trout which have reached a certain age are generally placed in ponds, in company with other non-carnivorous fish, which rid the water from any superfluous vegetation (especially algæ), and thus enable the sal-

* Daily visits are made to the hatching-box to remove the spoiled eggs. Among the substances employed to feed salmonoids I have observed meat ground fine, meat flour, dissolved brain, heart chopped fine, cut-up entrails, and larvæ of flies bred in decaying flesh. There are many more or less complicated machines for grinding the food, but as they have been described in various treatises, I need not give any further description of any of them, not even of the ingenious hydraulic grater for meat which I saw at Seewiese, because its construction can easily be imagined.

monoids to have more ready access to small crustaceans and mollusks, which form an important part of their food.

Mr. Haack considers it also necessary to place in ponds those trout which have been deprived of their eggs by an artificial process, because here they will find more favorable conditions for gaining flesh and for recovering from the sudden exertion incidental to forced spawning.

Although on general principles it is preferable that the water in ponds destined for salmonoids should during summer be kept cool, and that its temperature should in no case exceed 31° C. [88° F.] (according to my observations the temperature did not exceed this limit in any of the establishments which I visited), it will be well to note that aeration, an abundance of water, frequent agitation of the same, and a just proportion between the capacity of the water and the number of fish to be kept in it, will allow the fish to do well even if the summer temperature of the ponds should not altogether come up to the conditions as mentioned above.

It would be useless to describe the arrangements for obtaining the best hydraulic movement in the ponds and to provide for their draining without losing the fish. This is done by putting partitions in suitable places; perforated zinc plates being at present preferred for that purpose. More or less ingenious apparatus is employed in this connection, as well as sewers and pipes; but as they are known from models, it will not be necessary for me to describe them.

In constructing the bottom of the conduits, cement or stone is at present preferred to wood, which is only seemingly more economical.

Planting young salmonoids.—When should the young salmonoids be planted? The answers to this question differ somewhat, and reflect the individual opinions of various fish-culturists.

Mr. Haack prefers to plant them when the umbilical bag has begun to disappear, stating that as soon as they are placed in the water they will hide under stones as long as they do not feel the desire to seek food, and during this time they become acclimatized in the new element.

In the Netherlands the young salmon are not planted until they have lost the umbilical bag, and after they have been kept and fed artificially for an entire year.

At Wilthen the young trout are not placed in brooks until they have been kept for a certain time in the apparatus where they were born, where they have lost the umbilical bag, and where they have been fed. After they have passed the fine season of the year in the brook they are in autumn placed in ponds, where they remain about a year; and after that they are sold, if they have reached the weight of at least half a pound.

It is not customary to place in open waters embryonated eggs of salmonoids which are near being hatched, for fear of some voracious fish, especially the *Chondrostoma nasus* and the *Barbus fluviatilis*. Although

Mr. Haack declares that it not advisable to plant eggs in large lakes and rivers, he states that he has made some experiments in small streams and lakes.

In Italy (at least in many parts of it) the *Squalius cavedanus* would have to be feared particularly; but I take the liberty to state that, when some years ago I planted eggs during spring in some large lakes of upper Italy, I invariably found the water in which I planted the eggs free from fish. Moreover, if it is logical to presume that young fish freed from the umbilical bag, lively and well able to swim, will be better prepared to escape their voracious enemies than the sluggish eggs, it will not be entirely unreasonable to suppose that young fish which are still impeded in swimming by the umbilical bag will not be particularly active, and able to escape from their enemies even if they should hide in the maze of the gravelly bottom.

Species of salmonoids which are cultivated in the fish-cultural establishments visited by me.—The post of honor among the salmonoids which form the object of artificial fish-culture in Switzerland, Germany, and the Netherlands is held by the salmon, *Salmo salar*, a veritable gastronomic delicacy, which gives rise to a considerable trade.

The variety which enters during the spawning season the large rivers of Central Europe from the North Sea and the Baltic is in German called "Lachs," while the barren variety which lives in fresh water and does not go into the sea is called "Winter Salm."

All public administrations prohibit salmon fishing during the period when these fish go up the rivers to spawn; and no fish of this kind are allowed to be sold until it has been officially ascertained that the eggs destined for artificial fecundation have been laid.

Artificial fecundation is practiced, for instance, at Basel by Mr. Glaser, at Lauffenburg by the agents of the Fishery Company, which for this privilege pays a considerable sum to the Governments of Baden and Aargau. It is also practiced at Neuhausen, in the cantonal establishments of Zurich, and at Dachsen. Mr. Glaser also furnished salmon eggs to the Hüningen establishment before Mr. Haack taught fecundation according to the most approved modern method. I have also witnessed the incubation of salmon eggs in the establishments of Neuhausen, Selzenhof, Seewiese, Cosmandorf, Velp, and Apeldoorn.

The young fish are mostly intended for open rivers, and are therefore sold to the various governments. Salmon eggs fecundated at Selzenhof have been bought by the Government of Saxony, and have been hatched at Cosmandorf, to be placed eventually in the river Wesenitz, a tributary of the Elbe. The establishment at Cosmandorf has also rendered this service to the Academy of Forestry at Tharand, in Saxony, where Professor Nitsche does his share in aiding the diffusion of fish-culture. The Saxon Government pays the Cosmandorf establishment 1 mark 30 pfennige [about 31] cents for every thousand young salmon hatched.

The Velp establishment hatches salmon for the river Yssel, and receives from the Netherlands Government 2 cents (Dutch) [about 1 cent American money] for each young salmon, and receives in all a sum amounting to 25,000 lire [$4,825], which the Netherlands Government pays to the various fish-cultural establishments in the Netherlands, which are charged with restocking the rivers.

At Velp about 500,000 salmon eggs can be hatched, 300,000 of which are obtained from fish in the Netherlands waters, while 200,000 are received from the Upper Rhine. Besides young fry, salmon one year old are also placed in the rivers; and the Government pays at the rate of 50 centesimi [about 10 cents] per fish. Another half million salmon eggs can be hatched at Apeldoorn.

At Apeldoorn the California salmon is also hatched, which develops quicker than the Rhine salmon. It is this salmon which the eminent fish-culturist, Mr. von Baer, president of the German Fishery Association, considers (as he informed me) as peculiarly adapted to the rivers flowing into the Mediterranean, owing to the fact that there is much greater analogy between that sea and the Pacific than between the North Sea and the Pacific. Mr. von Baer has, during the years 1877 to 1880, planted in the Danube, which flows into the Black Sea, 670,000 eggs of the California salmon.

The eggs of the *Salmo sebago*, another fish of American origin, also develop very rapidly; and large numbers of these fish are now found at Seewiese, where during the time of my visit 2,000 eggs were hatched, and where some tolerably large specimens were found in ponds.

Trout culture is carried on still more extensively, and I have seen it in operation in all the establishments which I visited. Fecundation of *Salmo fario* (the common European river or brook trout) is everywhere practiced with spawning fish taken in the immediate neighborhood. It is not so common to find establishments which devote themselves to the *Salmo* or *Trutta lacustris*, and the only ones where I have seen this done are Hüningen and Selzenhof.

In some cases the indigenous species do not satisfy the fish-culturists, and they have commenced to introduce some foreign varieties of the trout; among the rest the *Salmo irideus*, or the *Trutta iridea*, from California. The oldest specimens of *Trutta iridea* are found at Hüningen, where they were obtained from eggs which came direct from America in 1882, and which have already propagated their species in their new home. The value of this trout, according to Mr. Haack, is in the fact that it is an unusually hardy fish, and is therefore sure to thrive in Germany.

I have also seen some *Trutta iridea* (one year old) at Lübbinchen, and some (two years old) at Michaelstein. Mr. Schuster also has some *Salmo carpio* from the Garda lake, which he keeps in cemented tanks at Radolfszell, and which he obtained from eggs furnished to him from Torbole Trentino.

At the present time two varieties of the *Salvelinus* are cultivated, namely, the *Salmo* (or *Salvelinus*) *umbla*, and the *Salmo* (or *Salvelinus*) *fontinalis*. The second variety may now be considered acclimatized at Hüningen, Apeldoorn, Berneuchen, and in many other establishments. The *Salmo fontinalis* is a great favorite, not only on account of its rapid development, but also on account of the extraordinary beauty of its coloring.

The spawning season of the *Thymallus vexillifer* had not yet begun, and I could not, therefore, witness the hatching of the eggs of this fish; which, however, is raised in many establishments. Mr. Eckardt, for instance, keeps them in a special paved pond.

The alimentary value of the *Coregoni* is sufficiently known; and I therefore deem it proper to devote a few lines to this fish, all the more as experiments are being made to introduce it in Italy, where it is not found. But also in countries where this fish is found attempts are made to introduce new varieties, such as the American *Coregonus albus*, which is cultivated at Zurich, Lübbinchen, and Berneuchen.

The Radolfszell establishment, situated on the shores of the Lake of Constance, gives special attention to the *Blaufelchen* or *Coregonus wartmanni*. There are several varieties of this fish; and the Radolfszell establishment knows of at least three, differing from each other not only by bodily characteristics, but also by their geographical distribution. These are the *Blaufelchen*, found in the Lake of Constance proper; the *Silberfelchen*, in the Untersee (connected with the Lake of Constance), and the *Ganfisch*, found only in a certain limited portion of the lake. The *Coregoni* at Selzenhof come, as may be supposed, from the Lake of Constance. From this same lake came the *Coregoni*, hatched at Hüningen, which have been sent to the Italian Government for the Lake of Como, where they find the required food, as that lake contains the pelagic crustaceans, which, as Dr. Asper, of Zurich, has already declared, are an indispensable article of food for this fish.

Mr. Eckardt does not think that there is any specific difference between the *Coregonus maræna* and the *Coregonus wartmanni*, and bases this opinion on the reciprocal fecundation of the sexual products of these two varieties. Notwithstanding the fact that such fecundation has actually been observed—proving that even cross-breeds may possess the faculty of fecundation—this would not form a very strong proof in favor of Mr. Eckardt's opinion.

Two conditions are essential to the existence of *Coregoni*, namely, great depth of water and suitable food (insects). Nevertheless it is possible, according to Mr. Schuster's statement, to introduce the *Coregonus fera* also in shallow water, provided it contains suitable food.

The production of hybrids of salmonoids also forms part of the work of fish-culture, and has been done on a sufficiently large scale. The salmon, the *Salvelinus umbla*, and the American trout will interbreed with the trout.

I think that the attempt to fecundate, for instance, salmon eggs with milt of the trout, should not remain the only one, and that, besides endeavoring to find out whether the mixing of the sexual products of these two kinds of fish will result in successful fecundation, fish-culturists should also endeavor to utilize in some way eggs, which through the possible failure of the male fish, would run the risk of being lost.

It is said that the hybrid of the salmon and the trout does not migrate to the sea; and in this respect it resembles the "Winter Salm," with which it also shares the physiological characteristics of being barren. Haack, however, asserts that the barrenness of the hybrid of the *Salvelinus umbla* (male) and the trout (female) can not be proved. At Berneuchen hybrids were obtained from the *Salmo fontinalis* and the trout. Dr. Asper, of Zurich, has no very high opinion of these hybrids, which generally have a small head, an irregular dorsal profile and ovary. At Dachsen a great mortality has been observed among the young bastards of the salmon and trout, whose umbilical bag has the bluish color of algæ.

In the following table are given the kinds of salmon cultivated in the various establishments:

Name.	Locality of establishment.
Salmo salar	Zurich, Dachsen, Neuhausen, Hüningen, Selzenhof, Cosmandorf, Velp, and Apeldoorn.
Salmo quinnat	Apeldoorn.
Salmo sebago	Seewiese.
Salmo fario	Zurich, Dachsen, Neuhausen, Hüningen, Selzenhof, Seewiese, Cosmandorf, Berneuchen, Michaelstein, Velp, and Apeldoorn.
Salmo lacustris	Selzenhof and Apeldoorn.
Salmo carpio	Radolfszell.
Salmo irideus	Hüningen, Lübbinchen, and Michaelstein.
Salmo umbla	Hüningen, Selzenhof, Radolfszell, Wilthen, Lübbinchen, Berneuchen, and Michaelstein.
Salmo fontinalis	Hüningen, Seewiese, Berneuchen, Velp, and Apeldoorn.
Thymallus vexillifer	Zurich, Dachsen, Neuhausen, Hüningen, Selzenhof, Radolfszell, and Seewiese.
Coregonus fera	Berneuchen.
Coregonus wartmanni	Zurich, Hüningen, Selzenhof, Radolfszell, Lübbinchen, and Berneuchen.
Coregonus maræna	Lübbinchen and Berneuchen.
Coregonus albus	Lübbinchen and Berneuchen.
Osmerus eperlanus	Zurich and Lübbinchen.
Trout ♂ Salmon ♀	Dachsen, Neuhausen, Seewiese, and Cosmandorf.
Salvelinus ♂ Trout ♀	Hüningen and Seewiese.
Trout ♂ Salmo fontinalis ♀	Berneuchen.

II.—CYPRINUS CULTURE.

Carp.—The principal object of cyprinus culture is the carp, *Cyprinus carpio*, which in Central Europe has from time immemorial given rise to a very lucrative trade. The great ease with which it is multiplied, raised, and protected against its enemies, its prolific nature, the preference which it shows for vegetable food, and its rapid growth, explain the great favor which this fish has found with fish-culturists, and may even justify the expectation that its cultivation may also be extended to Italy, although we are not inclined to consider the carp a remarkable delicacy.

Carp are raised in ponds, where they are kept either by themselves or in company with other fish. Different kinds of ponds are used in carp culture, namely, spawning ponds, raising ponds, growing ponds, and winter ponds.

The water of the spawning ponds should be somewhat warm. This condition is obtained by having these ponds exposed to the sun, by changing the water slowly, and by selecting such as are not very deep, the average depth of water not being more than one meter [3¼ feet]. Vegetation should be abundant, but not excessive. Reeds and grasses which soon cover a pond, should be checked in their growth. If possible, Mr. Haack would remove all the phragmites from the numerous ponds at Hüningen. Among aquatic plants the *Glyceria fluitans* is useful, and much sought after by the carp, which deposits its eggs on it.

To regulate the spawning of carp, Mr. Haack advises to place the fish intended for that purpose in comparatively cold water, and thence take them at the proper time to the spawning ponds, where, stimulated by the higher temperature of the water, they will soon deposit their eggs. Benecke, on the other hand, advises to place the carp in the spawning ponds when their water still has the winter temperature.

The number of spawning fish to be placed in a spawning pond covering an area of from one-tenth to half an acre should, according to Max von dem Borne, not exceed two females and one male, each weighing 8 pounds, from which in a few days two to three thousand young fish will be obtained. A single carp weighing 8 pounds is, therefore, capable of producing enough young to stock 500 hectares [about 1,235 acres] of ponds. Mr. von dem Borne has had seventeen successive spawnings in water having a temperature of 31° C. [about 88° Fahr.]. It is therefore not at all surprising, if Mr. Haack states that he has realized from the above-mentioned number of carp in one pond, which costs hardly $10 to keep up, the sum of $300.

Mr. Haack informed me that, in order to preserve all the good qualities of the carp which he cultivates, he is very careful in selecting his spawning fish from among those which from time to time are furnished him for the purpose, selecting those which are not only sufficiently robust, but which also possess all the other requisites of form and color which make them desirable spawners. He therefore applies the true principles of rational selection also to these animals.

The artificial fecundation of the carp is possible, but it is very little practiced. The fish-culturist is contented in most cases to leave to the carp the care of laying its eggs. Some people inclose the spawning fish in non-floating and perforated boxes containing branches and awl-shaped leaves (juniper branches in Mr. Eckardt's establishment), which, as soon as they are covered with eggs, are placed in more suitable water. Professor Nitsche advises experiments with the artificial fecundation of carp, using frames covered with some silk stuff, like those used by Möbius for herring. Fecundation should of course be accom-

plished under the water, as with other kinds of fish that lay adhesive eggs, in recognition of the fact that the spawn of fish which spawn in summer matures less rapidly when brought in contact with water than the spawn of fish whose fecundation takes place in cold water.

I regret very much that the season was not favorable for seeing in full operation the Lübbinchen ponds described by Max von dem Borne, and arranged in such a manner as to insure the greatest possible result from the spawning of carp, and the keeping of many other kinds of fish. As it is not my intention to give a detailed description, I shall merely give the general plan on which they are constructed. The ponds are deep in the center, have flat shores, and are connected by numerous openings with canals which are much lower.. On the bottom near the shores the collectors (bushes or branches) are placed, and are soon covered with the eggs of the spawning carp. After the eggs have been laid, these collectors are placed in other ponds, or in the canals surrounding the ponds, care being taken to prevent the spawning fish from entering these canals. It is necessary to remove the eggs from the spawning fish, as the grown carp will injure them and devour the young fry. The spawning ponds should be allowed to lie dry during winter, so as to kill the small animals which are enemies of the carp, and especially the pike which may have got into the ponds. The young fish would soon suffer from want of food if this contingency was not provided for by distributing them in suitable quantities in the growing ponds.

Mr. Max von dem Borne has even the smallest carp taken out of the pond by a man who stands in the water and uses for this purpose a muslin dipper. All the fish which he catches in this way he throws into floating barrels with a bottom of very fine wire. After he has gathered a sufficient quantity, he transfers them, by means of a zinc basin with a spout, to the tin cans in which they are conveyed to the ponds for which they are intended.

The growing ponds should be proportioned to the number of fish which it is intended to raise in them, due regard being taken to the amount of food which they contain. The fish are distributed according to age; for which reason rational carp-culture requires many of these ponds.

In the growing ponds other fish may be kept with the carp; for instance, pike and bass. These fish should, however, be very small, so as not to prey upon the carp. The principal object of having these fish in the ponds is to prevent the carp from spawning, as spawning would make them lean. In these ponds artificial food is also used, consisting of flour-balls, vegetables, potatoes, bran, dung (from cattle), larvæ of flies, &c.

If the conditions are favorable, the carp can winter in the ponds; but in some establishments, as, for instance, at Hüningen, there are special winter ponds, in which the carp are kept during the cold season. For these ponds spring water is used if it is somewhat warm. To prevent

the carp from being frozen, special excavations are made in the bottom of these ponds, where the carp crowd together in a semi-lethargic state. The water of these winter ponds should be deep. But if the water should freeze, it becomes necessary to make holes in the ice, so as to introduce air into the water below. These holes are covered with sheaves of reeds, having a broad base and forming a kind of roof over the holes, thus preventing further freezing. It is necessary, however, that these holes be frequently examined, so as to keep them always open.

Tillage of carp ponds.—Mr. Haack recommends the custom which has been introduced, of using the carp ponds also for agricultural purposes. After they have served as ponds for two or three years, they are drained, and then plowed for the cultivation of grain and potatoes. According to the director of the Hüningen establishment, a pond which has undergone dry cultivation is richer in small crustaceans which form a favorite food of fish. For instance, the eggs of the *Phyllopoda* will develop better during a dry season.

It will easily be understood why it is useful and profitable to use the bottom of the ponds after a certain period for agricultural purposes, thus utilizing the large quantity of fertilizing matter, consisting of leaves, aquatic plants, animal matter, and excrements of fish, which has accumulated in the pond; while on the other hand it is difficult to explain why ponds used in this manner should be richer in fish. Mr. Haack believes that this is owing to the greater development of small crustaceans; but the greater abundance of these crustaceans has not been sufficiently explained by science. We are, however, allowed to suppose that the greater number of fish is caused not only by the increase of small crustaceans, but also by the more luxuriant aquatic vegetation which will develop in soil, which after lying dry, has been plowed and cultivated, and before being again submerged has changed chemically by the influence of the air and sun. Whether this explanation is correct or not the fact remains and deserves to be taken into account.*

Other kinds of cyprinoids which are cultivated.—As secondary objects of cyprinus culture we may mention the crucian carp (*Carassius vulgaris*), the Chinese goldfish, the *Idus melanotus*, and the tench.

As regards the crucian carp (*Carassius vulgaris* Nilsson), I would state that, compared with the common carp, it presents a great variety of forms, and will interbreed with the *Idus melanotus*, but its flesh has not so delicate a flavor as that of the carp; nor is its culture so profitable, as its growth is much slower.

The goldfish (*Carassius auratus*), owing to its beautiful color, is much sought after as an ornament for ponds, artificial lakes, aquariums, &c., and it is therefore cultivated to advantage.

The *Idus melanotus*, especially its small variety, rivals and perhaps excels the goldfish in brilliancy of color, which changes with its different ages.

The tench (*Tinca vulgaris*) is another cyprinoid which is cultivated to advantage, especially its golden variety, which is kept in aquariums. The manner of raising this fish differs but little from that of the carp, as it is quite customary to stock ponds both with tench and carp.

III.—Other kinds of fish.

Pike.—At Radolfszell, Mr. Dietrich, the manager of Mr. Schuster's establishment, has been successful with the artificial fecundation of pike (*Esox lucius*). The eggs of the pike are very small, the embryo develops very rapidly, and the young are hatched in about twelve days. They were placed in a small lake, where they did well but did not prove an advantage to the other fish. Mr. Max von dem Borne has also been successful in fecundating pike eggs. As far as I know, fecundation of pike eggs has not been attempted at Lübbinchen, where these voracious fish are kept only in the growing ponds, to keep the carp from spawning. Here they are kept in company with the *Lucioperca sandra* and the perch (*Perca vulgaris*), which last-mentioned fish is considered to diminish any excess of small fish, as they take away the food from fish which are the proper object of fish-culture.

Black bass.—Successful experiments in acclimatizing this American fish (*Huro nigricans* Cuv. & Val., *Micropterus salmoides* Lacép.) have been made at Berneuchen. The number of individuals of the first importation which survived the long journey was very small; but from the 3 which survived, Mr. Max von dem Borne obtained about 1,300 young fish. I have mentioned this new branch of fish-culture, because Mr. v. d. Borne thinks that it is adapted to the rivers of southern Italy; and I must confess that I have great faith in the opinion of this distinguished fish-culturist. But before introducing this fish, the question should be thoroughly considered, whether it would be expedient to increase the number of voracious fish. The black bass likes to spawn on a bed of large stones. I have seen some very large specimens of this fish which are considered the oldest now in Germany.

Eels.—All the eels found in the waters of Continental Europe came from the sea as young eels, forming what is called the "mounting" of the eels. The attempt to convey these young eels to places where they will break their journey, or to guide them to such places if they do not go there of their own accord, to some extent resembles the method pursued at Comacchio and Polesine, where from time immemorial the eels have been guided into the basins destined for them. The most enthusiastic advocate of the introduction of these young eels into German waters is Mr. Haack, who once procured them from France, but now obtains them direct from Pisa, Italy, where they are brought into the market in enormous quantities.

The following is the method employed by Mr. Haack for packing them and transporting them from Pisa to Hüningen. He employs large, square baskets lined with coarse cloth (jute), the inside being divided into several horizontal compartments, which are produced by pieces of cloth being sewed to one side of the cloth which forms the lining. In each compartment are placed branches of *Potamogeton pectinatum* or *Potamogeton crispum*, which afford hiding-places to the young eels, and which, owing to their peculiar elasticity, protect them from the danger of being crushed. Layers of *Potamogeton* and eels alternate, until the compartment is comfortably filled, when another cloth is drawn out, which receives other alternate layers of *Potamogeton* and young eels. If the plants are sprinkled a little they will supply enough moisture to keep the young eels alive. These packages are sent from Pisa to Basel by way of the St. Gothard tunnel, special directions being given the employés of the railroad to forward them promptly. From Basel they are conveyed to the imperial fish-cultural establishment of Hüningen on wagons.

As soon as the eels arrive at their destination they are, together with the plants which have protected them during their journey, placed in water on the hatching-tables or in open tanks, where they move about very nimbly, trying to avoid the light. The dead ones are picked out when the plants are taken away, and afterwards during the daily visits.

Fish-cultural establishments or private individuals in Germany who wish to obtain young eels get them from Hüningen. This has already been done by the Radolfszell establishment, which has placed them in the Lake of Constance, in the hope that after some time they will again make their appearance when they have reached a greater size. Although in Italy we are more favorably situated in this respect than Mr. Haack, as we have plenty of young eels, we should nevertheless follow his example and increase this useful species of fish in our waters.

At Neuhausen I saw an apparatus (eel-way) intended to favor the

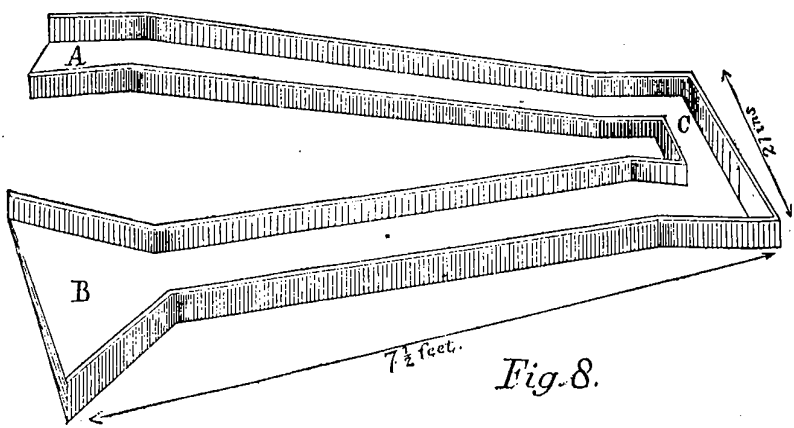


Fig. 8.

retention of the young eels which have reached the water above the famous falls of the Rhine. (See Fig. 8.)

It is a wooden canal with a smooth bottom, with wooden partitions (not shown in the figure) placed at regular intervals; the entire length is 5.07 meters [16⅔ feet]; it is divided in two arms (A, B) of nearly equal length, and connected by a horizontal arm (C); the first in the beginning runs horizontal, and afterwards slopes towards the arm C; and from this again slopes the arm B, which widens at its end. It is clear that this canal will conduct a current of water from a higher to a lower level.

I am not able, however, to understand what benefit can be derived from the use of this apparatus, which will not increase the "mounting" of the eels (which in my opinion cannot be accomplished by any contrivance whatever); but which will draw some of them away into water-courses, which, owing to the lack of communication with the streams by which the young eels usually ascend, would under ordinary circumstances not have them.

The following table will show what fish, not belonging to the salmonoids, are cultivated in the establishments which I visited:

Name.	Locality of establishment.
Acipenser ruthenus	Lübbinchen.
Huro nigricans	Lübbinchen and Berneuchen.
Lucioperca sandra	Seewiese, Lübbinchen, and Berneuchen.
Silurus glanis	Lübbinchen.
Cyprinus carpio	Hüningen, Seewiese, Lübbinchen, Berneuchen, Michaelstein, and Apeldoorn.
Carassius vulgaris	Hüningen, Lübbinchen, and Apeldoorn.
Carassius auratus	Hüningen, Seewiese, Lübbinchen, Velp, and Apeldoorn.
Idus melanotus	Hüningen, Seewiese, and Lübbinchen.
Tinca vulgaris	Hüningen, Seewiese, Lübbinchen, Berneuchen, and Michaelstein.
Esox lucius	Lübbinchen and Berneuchen.

Apparatus, arrangement, and products

Place.	Kind of water used.	Hatching rooms.	Hatching apparatus.
Zurich	Lake	1 chamber of masonry	8 wooden troughs; zinc troughs; 2 Zenk apparatus; California boxes.
Dachsen	Spring	1 chamber of wood	24 wooden troughs
Neuhausen	....do.	1 chamber of masonry	26 wooden troughs; Costo troughs.
Hüningen	Rhine water and several springs.	2 halls of masonry, with area of 165 sq. m. each. 1 hall with area of 540 sq. m. Total area of 870 sq. m. [about 1,040 sq. yds.].	Costo tables; hatching boxes; California troughs; Costo troughs; wooden troughs.
Selzenhof	Spring and brook.	3 chambers of masonry	Cement troughs; California boxes.
Radolfszell	Drinking water	1 chamber of masonry	4 wooden troughs; 3 Williamson troughs; 1 Holten incubator.
Seewiese	Spring and brook.	1 wooden house and 1 of masonry.	40 Zenk troughs; California boxes; 10 Lavalette apparatus.
Cosmandorf	River	1 small house of wood	12 California boxes; 1 Holten's apparatus.
Wilthen	Spring	....do	4 California boxes; 3 wooden troughs.
Lübbinchen	....do	1 small room of masonry, with area of 4 sq. m. [about 43 sq. ft.].	Eckardt troughs.
Berneuchen	River	Several large houses; some of masonry, some of wood.	California boxes; funnel-shaped troughs; automatic selectors.
Michaelstein	Pond	1 large chamber of masonry, with area of 81.7 sq. m. [about 879 sq. ft.].	112 California boxes; 8 Williamson tables.
Velp	Spring	1 large house of masonry, with area of 150 sq. m. [about 1,614 sq. ft.].	40 Costo tables.
Apeldoorn	....do	1 large house with area of 185 sq. m. [about 1,990 sq. ft.].	41 cement troughs; 31 wooden troughs.

of fourteen European hatcheries.

Capacity of apparatus.	Ponds, tanks, etc.	Kind of water in ponds and tanks.	Kinds of fish cultivated.
500,000 salmon eggs.	.....	.....	Salmon, trout, grayling, several Coregoni.
....do	2 ponds for malo trout.....	Spring.....	Salmon, trout, grayling, salmon-trout.*
....do.....	....do	....do	Salmon, trout, grayling, salmon-trout.*
12,000 eggs of Salmonidæ per year.	Large tanks in a great hall; several open tanks in cement; 50 ponds for salmon, trout, etc.; 1 large pond for summer fish, and 1 pond for carp; numerous ponds for goldfish, spawning carp, etc.	Rhine water, springs, waste from the hatching hall, a ditch, etc.; filtered water for several ponds.	Salmon, trout, Salmo irideus. S. fontinalis, Salvelinus, Thymallus vexillifer, several Coregoni, carp, crucian, goldfish, golden orf, tench, Salvelinus-trout.*
8,000,000 eggs of Salmonidæ.	9 ponds for Salmonidæ.....	Brook	Salmon, trout, Salvelinus, grayling, several Coregoni.
.....	Tanks in cement indoors ...	Drinking water...	Salvelinus, carp, grayling, several Coregoni.
7,000,000 trout eggs.	12 ponds for Salmonidæ; 11 ponds for either Salmonidæ or Cyprinidæ; several tanks.	Spring and brook.	Salmo sebago, S. fontinalis, trout, Thymallus vexillifer, bass, carp, crucian, golden orf, tench, trout-salmon,* Salvelinus-trout.*
120,000 eggs of Salmonidæ.	Wooden tanks for spawners.	River.....	Salmon, trout, trout-salmon.*
60,000 eggs.....	18 ponds, covering 10½ acres.	.....	Trout, Salvelinus.
.....	Over 100 ponds; 1 special pond for Thymallus; 24 concrete basins, each of 50 sq. m. [538 sq. ft.]; wooden tanks.	Spring.....	Salmo irideus, Salvelinus, several Coregoni, Osmerus eperlanus, sterlet, bass, Silurus, carp, crucian, goldfish, golden orf, tench, pike.
Very large number	22 ponds; basins with filters for young carp.	River	Trout, Salvelinus, Salmo fontinalis, Coregoni, perch, bass, carp, tench, pike, trout-S. fontinalis.*
1,120,000 trout eggs.	4 tanks in cement; 27 ponds, 4 of them for Salmonidæ.	Spring and brook.	Trout, Salmo irideus, Salvelinus, carp, tench.
600,000 salmon eggs.	7 ponds for trout; 6 for salmon; 2 for goldfish.	Spring.....	Salmon, trout, Salmo fontinalis, goldfish.
....do	88 round ponds or tanks; 54 small brooks for young trout.	....do.	Salmon, Salmo quinnat, S. fontinalis, trout, lake trout, carp, crucian, goldfish.

* Cross-breeds of the 2 fish named.

IV.—Some of the causes of the general diffusion of fish-culture in the countries visited, especially in Germany.

The process of artificial fecundation of fish is said to have been a secret possessed by some French monks towards the end of the fifteenth century. It was also discovered by the Hanoverian Jacobi (1758), and again fell into oblivion, but when it was again discovered in 1849 by two fishermen, Remy and Gehin, due publicity was given to it by Professor Coste. No practical application, however, was made of it until, at Professor Coste's suggestion, the Hüningen establishment was founded, to which Europe is certainly indebted for the modern impulse given to fish-culture, because its influence made itself felt not only in France, to which it formerly belonged, but also to foreign countries, including Germany. The new industry soon spread rapidly and made constant progress, numerous societies and journals promptly diffusing its knowledge.

But Hüningen, during the last years of the French régime, did not keep up with the progress made in fish-culture, both in Europe and America, and lost its importance, until it passed into the hands of the German Government, and Mr. Haack became its director, when it again began to improve.*

The interest taken in fish-culture by the Governments of Germany, Switzerland, and the Netherlands, which in a large measure have contributed to the restocking of public waters, and which have also furnished the necessary material for private establishments, has greatly aided the diffusion of artificial fish-culture; its further progress is assured, as the results of its operations are no longer uncertain, and as the pecuniary benefit derived therefrom becomes greater.

This industry has been made popular to no small degree by the public exhibition of fish-cultural apparatus in full operation in zoological gardens (as at Dresden, Amsterdam, Frankfort-on-the-Main), and in aquariums (Berlin), which, as is well known, are visited by large numbers of people.

In Saxony fish-culture is popularized by courses of lectures given by Professor Nitsche, of the Academy of Forestry, at Tharand. As this is the only course of instruction on fish-culture of which I have any precise knowledge, it will not be out of place to give a more detailed description of the same. At certain convenient seasons Professor Nitsche gives free lectures on fish-culture at the Academy of Forestry. He has published a large wall diagram, giving illustrations of the fish in question (trout); the distinctive characteristics of sex; the eggs, both sound and spoiled by mold; the phases of their embryonal development; the young fish with and without the umbilical sac; a figure showing artificial spawning; the gravel-filter of Mr. Ryfsell, pincers, glass pipes,

*Mr. Haack has introduced at Hüningen new apparatus; has had cement tanks constructed; has improved the distribution of the water, and the arrangement of the ponds.

vessels for measuring the eggs; California boxes, whole and in sections, cans for transporting eggs, etc.

In these short courses apparatus, fish, and eggs are shown, while in a small room of the academy, which has been transformed into a hatching chamber, the California apparatus is shown in full operation with trout eggs.

Analysis of lectures on the artificial raising of trout

A.

I.—INTRODUCTION. PROPAGATION OF TROUT IN OPEN WATERS.

1. Waters in which *trout and their kind* live.
2. The spawning of trout in open waters:
   a. The spawning season (winter), and *the spawning places.*
   b. Fecundation of the eggs laid by the female by means of milt ejected by the male.
   c. Dangers to which the eggs are exposed during their development and during the hatching.
3. Showing that in open waters only a small percentage of the eggs is hatched. Can this be remedied by artificial raising?

II.—THE ARTIFICIAL RAISING OF TROUT.

1. Idea of artificial *trout raising, i. e., an artificial* way of depositing, keeping, and hatching the eggs and protecting them against dangerous influences.
2. Method of artificial fecundation:
   a. The procuring of spawning fish.
   b. Separation and distinction of the sexes.
   c. Indications of sexual maturity.
   d. The spawning of the ripe female.
   e. Dry *fecundation of the eggs* by means of the milt.
   f. Counting the eggs by means of a measuring glass, and their introduction into the *hatching troughs.*
3. Necessary conditions for the development of fecundated eggs. Precautions to prevent any animals from destroying the eggs. *Pure water* needed incessantly:
   a. By chemical processes the water should be kept free from *injurious matter.*
   b. And by mechanical processes from mud.
   c. Its temperature should not be too high (0.5° to 8.6° C.) [33° to 47.5° F.].
   d. The *largest possible quantity of air* should pass through the water.
   e. During the hatching time it should neither cease to run nor freeze.
4. The California box, the *apparatus best adapted to raising* a small quantity of trout:
   a. Description and demonstration of the California box *and its accessory apparatus.*
   b. Instructions for placing it in position.
   c. Demonstration of the advantage of the California boxes, as compared with other apparatus, where the eggs are placed on a bed of sand. The advantages *consist in a saving of space,* and in the greater ease with which the eggs and young fish are kept clean.
5. Care of the eggs during the *hatching time:*
   a. They should be left entirely undisturbed during the first week.
   b. Dead eggs should be removed every day to prevent the formation of fungus.
   c. All sediment should be removed.
6. Young fish, and their care:
   a. The approach of the hatching is indicated by the visibility of the eyes of the embryos.
   b. The young *trout is hatched with an* umbilical sac.
   c. Change of the young fry to a small fish.
   d. Keeping the young fish clean, and *regularly removing* the dead.
7. Placing of the young fish in water adapted to their raising:
   a. The proper time for placing the fish in water.
   b. Hatching brooks and hatching ponds.
   c. Transportation of the young fish to the water; cans employed for transporting them.

III.—CONCLUSION.

Facility with which brooks can be stocked with trout; given the possibility of receiving from a distance, by mail, embryonated eggs:
- *a.* Selection of a good spring, even if it should be small.
- *b.* Treatment of the fish after their arrival.

Exhortation to make experiments on a small scale.

B.

I.—INTRODUCTION.

1. The growing depopulation of our waters, and the causes of this phenomenon:
   - *a.* Voracious fish.
   - *b.* Many streams have become unable to maintain fish alive, owing to industrial and mercantile establishments, and to the lack of spawning places, and of suitable places where the fish can live.
2. Desirability of using for the raising of fish any waters which may still be adapted to the purpose.
3. Trout are best adapted to this purpose.
4. Artificial raising is the best means.
5. The artificial raising of fish is a German invention (invented by the Hanoverian Jacobi in 1758; first published, 1763–'64). After it had fallen into oblivion it was invented anew by a fisherman of the Vosges, Remy, in 1849, and practiced on a large scale at the establishment of Hüningen, in Alsace, which passed into the hands of Germany in 1871.

II.—LIFE AND PROPAGATION OF TROUT IN OPEN WATERS.

1. Waters in which trout and their kind live; the idea that trout confine themselves to mountain streams is erroneous.
2. Spawning place and season of the trout.
3. The ovaries of the female empty their contents into the abdominal cavity.
4. Structure of the egg:
   - *a.* The yelk.
   - *b.* The germ.
   - *c.* The shell of the egg and the micropyle.
5. The testicles of the male have ducts carrying:
6. The sperm:
   - *a.* The liquid of the sperm.
   - *b.* Spermatic filaments.
7. Depositing the eggs; their fecundation by means of the male semen.
8. Fecundation is accomplished by the entrance into the micropyle of at least one spermatic filament.
9. The development of the young fish:
   - *a.* Point from which the formation of the body of the young fish starts.
   - *b.* Extension of the same and formation of the back of the young fish.
   - *c.* Growth of the yelk round the germinal spot.
   - *d.* Formation of the shape of the body of the young fish.
   - *e.* Visibility of the eyes by the formation of pigment in the eyes.
   - *f.* The little fish with its umbilical sac, and its hatching from the egg.
   - *g.* The change of the embryo, which does not need any food, to a perfect little fish.
10. Conditions favorable to the normal development of the embryo:
    - *a.* The eggs should be fecundated.
    - *b.* The eggs should be daily moistened with water not chemically pure.
    - *c.* The water should be furnished with a constant supply of fresh air.
    - *d.* Mud, which hinders the access of air, should be removed.
    - *e.* The temperature of the water should not be too high (0.5° to 8° C.) [33°–46.5° F.]. Too high temperature accelerates development, while too low temperature delays it.
    - *f.* Safety from mechanical dangers. If the eggs are bruised, malformation is caused. Safety of the fish against enemies belonging to the animal kingdom.
11. Which conditions of success are not all found in open spawning places; and how a large part of the eggs run a great risk.

III.—THE RAISING OF TROUT.

1. The nature of trout raising.
2. Procuring fish for artificial fecundation:
   - *a.* Obtaining spawning fish.
   - *b.* Distinguishing the male from the female fish.
   - *c.* Indications of the maturity of the spawn.
   - *d.* The spawning of the mature female.
   - *e.* The spawning of the mature male.

III.—THE RAISING OF TROUT—Continued.

2. Procuring fish for artificial fecundation—Continued.
   f. Different methods of fecundation (dry and moist).
   g. Counting the eggs by means of measuring glasses; and placing them in the hatching troughs.
3. Necessary conditions for placing a hatching trough:
   a. A hatching trough may be placed anywhere where there is a current of not too warm water, which may be conducted to a place secure against freezing.
   b. Water of ponds, rivers, and springs may be used, each having its peculiar advantage.
   c. Chemical purification of the water, and freeing it from injurious matter, is indispensable.
   d. Cleaning the water from mud may be effected by means of clearing basins or by filtration. Arrangement of a small sand-filter.
   e. It is desirable that the water should fall into the hatching troughs from a certain height, thus producing air.
   f. A space protected against frost may be arranged by means of a very simple apparatus, as a small wooden shed covered with substances which are non-conductors of heat, such as reeds, straw, sawdust, etc.
   g. The pipes through which the water is conveyed should be so arranged that they can easily be cleaned.
4. A good hatching trough should be:
   a. Of durable material.
   b. Easy to handle.
   c. Easy to clean.
   d. Well protected against the enemies of fish.
   e. Should have room for a suitable quantity of eggs on a small bottom.
   f. Should be so arranged as to render easy the care and management of the eggs.
5. All these requisites are possessed by Max von dem Borne's California trough:
   a. A description and demonstration of the trough and its accessory apparatus.
   b. Showing the disadvantage of placing the eggs on a bed of sand.
6. Care of the eggs and the young fry:
   a. Necessity of daily visits to the apparatus; special attention during rain-storms and snow-fall.
   b. Treatment of the eggs during the first stage.
   c. Removing every day the dead fish, to prevent the formation of fungus.
   d. Removing all sediment.
   e. How to recognize the approach of the hatching by means of the points of the eyes which become visible.
   f. Keeping the hatched embryos clean.
7. Placing the young fry in the waters where they are to be raised:
   a. Proper time for transporting the fry.
   b. The brook for the young fry, and its character.
   c. Transporting the young fry to the places where they are to be raised.
   d. Cans for transporting them.
8. Some brief hints as to the management of trout ponds.
9. Stocking with trout such waters as are adapted to the purpose, but where no trout are found:
   a. Various methods of stocking with grown fish, young fry, and with eggs; hatching of the same near the waters which are to be stocked.
   b. The last-mentioned method to be preferred; accustoming the fish to the water in which they are to live.
   c. Choice of a good spring for embryonated eggs; a spring which has been tried and found to answer the purpose, even if far away, is to be preferred to one which has not been tried.
   d. Facility of sending eggs by mail.
   e. Treatment of the eggs, when they have arrived at destination, in the hatching troughs.
10. Management of trout ponds; their character:
   a. If there is only one pond, it can be used only as a growing pond.
   b. If there are at least three ponds, young fish may be raised in them.
   c. Hatching ponds, raising ponds, growing ponds.
   d. The food of trout in ponds.
11. Growth of the trout:
   a. The growth of trout is possible wherever there is suitable food.
   b. Growing basins for trout; conditions of soil, abundant supply of suitable water; the proper control of this supply.
   c. The growth of the trout depends on ample food, and a limited space for moving about.

III.—THE RAISING OF TROUT—Continued.

12. More extensive arrangements for raising trout:
   a. Circumstances under which they are made; if the object is to stock a large area of water, or if a large sale of eggs is looked for.
   b. Principal ideas which should guide persons in arranging a large establishment.
   c. The hatching house; conditions of soil and abundant supply of water, with a good fall. Essential characteristics of the hatching house: Protection against frost, sufficient light, so the eggs can be properly taken care of, close proximity to the dwelling of the inspector.
   d. Samples of hatching troughs adapted to large establishments; Williamson troughs.
   e. Apparatus for filtration and aeration.
   f. Packing and shipping of embryonated trout eggs.
13. Hints on the raising of other species of salmonoids; where are such fish raised?
   a. Raising of *Thymallus vexillifer*.
   b. Raising of *Salvelinus*.
   c. Raising of salmon.

IV.—CONCLUSION.

   a. Brief review of legislation relative to the fish in question.
   b. Advantages of large fishery associations.
   c. Exhortation to found small fishery associations.
   d. The German Fishery Association, and its influence.

V.—FINANCIAL STATEMENT OF THE HÜNINGEN ESTABLISHMENT FROM APRIL 1, 1884, TO MARCH 31, 1885.

INCOME.

From the German ministry of agriculture for placing young salmon (one million) in the Rhine	$5,497.80
Sale of embryonated eggs of salmonoids:	
(*a*) To Germans	1,904.00
(*b*) To foreigners	357.00
Sale of embryonated eggs of Coregoni	71.40
Sale of carp	714.00
Sale of ice and reeds	238.00
Reimbursements for packing	238.00
	9,020.20

EXPENSES.

Salary of director, besides lodging	856.80
Two keepers, besides lodging	456.96
Secretary and treasurer	471.24
Wages of workmen	714.00
Traveling expenses of director	380.80
Rent (ground rent)	499.80
Purchase of eggs of salmonoids and fish	2,380.00
Food of fish	476.00
Packing eggs	238.00
Library and experiments	142.80
Maintaining and improving ponds, &c	952.00
Maintaining and improving buildings	357.00
Unforeseen expenses	142.80
For new constructions	952.00
	9,020.20

BRESCIA, *June* 21, 1885.

B.—NOTES ON FISH-CULTURE IN GERMANY, SWITZERLAND, AND THE NETHERLANDS, BY DR. VINCIGUERRA.

I.—GERMANY.

1. *Hüningen.*—The imperial establishment of fish-culture at Hüningen is situated in Alsace, at a short distance from the Swiss boundary, and only 8 kilometers from Basel. Founded in 1854 by Professor Coste and two engineers, Berthot and Detzem, it passed through different phases and finally into the possession of the German Government; and since that time Mr. Hermann Haack has been its director.

The establishment has no fixed allowance from the Government, because it should, if possible, be self-supporting, but the expenses have, so far, always considerably exceeded the income; and the deficiency has been made up by the German Government, in the shape of a compensation paid for young salmon placed in the Rhine every year.

The ground on which the establishment stands belongs to the village of Blotsheim, covers an area of 39.56 hectares [97¾ acres], and is rented for an annual sum of $465.22.

The water of the establishment is supplied by copious springs, of which there is a sufficient number in the neighborhood, from a small brook called the Augraben, and from the canal connecting the Rhone and the Rhine. For the hatching of the eggs Director Haack prefers this water to brook and spring water, because it seems that the latter contains larger quantities of the germs of the much-dreaded mold; moreover, it is too warm, having a constant temperature of 10° R. [54.5° F.], while the temperature of the brook and canal water falls even to the freezing-point. The water is no longer filtered in the true sense of the term; but before being distributed through the establishment, it passes through grates and fascines, in order to keep out any large foreign bodies.

The ground floor of the principal building and that of the left wing are devoted to the hatching of the eggs of salmonoids. The eggs of the common trout are gathered and fecundated in the establishment from fish raised there; the eggs of lake trout, salmon, *Salvelinus*, *Thymallus*, *Coregonus*, &c., are received from abroad. Of the five kinds of American salmonoids introduced into Europe a few years ago through the efforts of the German Fishery Association, two are raised in the establishment. These are the American trout, or "Bachsaibling" (*Salvelinus fontinalis*), and the California trout, or rainbow trout (*Salmo iridcus*), both distinguished by their beautiful color and their fine shape. The former has already been sufficiently spread by fish-culturists; while the latter is not yet found so generally; although Mr. Haack thinks, if specially cultivated, it will yield very fine results.

The Hüningen establishment carries on an active trade in the eggs of salmonoids, $2,332.40 worth of these eggs having been sold during the

season of 1884–'85; live fish are also sold, especially carp, and also trout, after they have for two or three years furnished sexual products for reproduction. Every year young salmon are placed in the Rhine to the number of from 500,000 to 1,000,000, and in return the establishment receives from the German Government a sum sufficient to cover the annual deficiency, provided it does not exceed $5,950.

The hatching apparatus used in the large halls of the Hüningen establishment are still substantially those invented by Coste, having frames with a bottom of glass stems, although for these there have been substituted, to a large extent, other frames with a bottom of metal staves, or a network of metal wire, used particularly when eggs of the finer kinds of fish, such as *Coregoni*, are to be hatched. Generally the eggs which are to be hatched in the establishment are, when near being hatched, placed in troughs made of pine-wood, about 3 meters long, 40 to 50 centimeters broad, and 15 to 20 centimeters deep [about 10 × 1½ × ½ feet], at the lower end of which there is a metal grating to prevent the escape of the young fish. They are covered with a strong wooden lid to prevent mice and rats from getting in, and to have the development of the eggs carried on in darkness, which greatly favors such development. These troughs are then placed in the open air, and after the eggs have been hatched the young fish are fed until they are near losing their umbilical sacs, when they are immediately placed in some river or lake, it being considered better to place them in open waters a few days before they have entirely lost the umbilical sac. When the number of eggs to be hatched is very large, Mr. Haack also uses California apparatus, more or less modified; especially those recently constructed by Professor Benecke on the principle of the La Vallette apparatus.

The young fish destined to be raised in the establishment are placed in small basins laid in cement, into which water runs continually. Here they are raised and fed artificially, and are not taken out, except in very cold winters, when for some days they are placed in basins in the small wing on the right. There are also ponds for carp and for some other cyprinoids (*Tinca*, *Idus*, &c.), some small for winter, and others large for summer; these ponds are used for reproduction and the development of the young fish. The largest of these ponds covers an area of 1 hectare [about 2½ acres]. The ground where it was excavated was rented for the sum of $9.65 per annum, and the annual income from carp raising amounts to $289.50.

After several experiments Mr. Haack has succeeded in transporting from Pisa to Hüningen live young eels, known by the name of "blind eels." He keeps them for a certain time in cemented basins, and then ships them to other parts, some as far as the most remote portion of the province of Pomerania.

The imperial establishment of Hüningen is the one which has given the greatest impetus to the spread of the industry of fish-culture; but

at the present time this industry has made such rapid strides in Germany, that Mr. Haack deems it proper and advisable that the Government should cease to carry it on exclusively, but let private enterprise take hold of it.

2. *Selzenhof.*—The fish-cultural establishment of Selzenhof is situated about an hour and a half's journey from the city of Freiburg in the Grand Duchy of Baden. It belongs to Mr. Schuster, the mayor of Freiburg, who founded it in 1865, and enlarged it in 1872. It does not receive any fixed subsidy; but the Baden Government pays it for the young salmon placed in the Rhine and for the *Coregoni* placed in the Lake of Constance, on the shores of which Mr. Schuster has another establishment, Radolfszell.

It furnishes embryonated eggs to the German Fishery Association, and to many public and private fish-cultural establishments.

The eggs are hatched in a small one-story building, divided into three rooms, two large and one small. The water comes from a brook running at a short distance from the house, but as in winter this water is too cold, it is then mixed with spring water, which is warmer, so that in the hatching-room its temperature is not lower than 2° R. [36.5° F.]. The water passes through a sand-filter, which need not always be employed, as the water is very pure. The hatching-rooms are somewhat lower than the filter, and the water which enters through two pipes, one for each of the large rooms, circulates in an open canal, constructed of masonry, placed at a certain height along the walls, whence it falls into the troughs below. To each of the openings perforated metal tubes are attached, for the purpose of aerating the water, which process Mr. Schuster considers very important, and endeavors to further it by every possible means.

The kinds of fish on which Mr. Schuster operates all belong to the family of the salmonoids, and are especially the Rhine salmon, river trout, lake trout, *Salvelinus*, *Thymallus*, and *Coregonus*. A trade is also carried on in trout eggs fecundated by salmon milt, which are much sought after by fish-culturists, because the hybrids obtained by this process develop very rapidly and do not go into the sea. He has also undertaken the culture of *Salmo fontinalis* and *Salmo irideus* from North America.

The troughs which serve for hatching the eggs are cemented and 22 in number. Their length varies from 360 to 480 centimeters, and their breadth is 45, and their depth 18 centimeters. [Each trough is therefore about 14 feet long, 18 inches wide, and 7 inches deep.] They are covered with wooden lids, having some openings provided with grating. The eggs are placed on wire frames, which can be placed one above the other. There are also employed some California boxes, according to a model prepared by Mr. Schuster.

There are 9 ponds, which are used for raising young fish and for keeping the spawning fish. Two of these ponds are for carp. The ponds are arranged one above the other, so that the water passing from one pond

to the next forms a little waterfall, and is therefore always properly aerated. The Selzenhof establishment can hatch about 3,000,000 eggs at the same time.

3. *Radolfszell.*—This establishment is situated in the little town of Radolfszell on the "Untersee," a branch of the Lake of Constance, and like the preceding one it is the property of Mr. Schuster. It was founded in 1877, principally for the purpose of reproducing *Coregoni*. It consists of one large hall, which formerly served as a public bath. The water used in it is the common drinking water of the place, and is not filtered. In summer its temperature is about 8° R. [50° F.], and in winter it sometimes falls to 1° R [34° F.] The water is contained in a reservoir placed in the highest part of the hall, and thence it is by wooden conduits led into the troughs, of which there are 7, some without divisions, and with several compartments, on the Williamson system. The troughs are at some height above the ground, resting on wooden supports. For the hatching of *Coregoni* a Holton apparatus is principally employed. It consists of a kind of wooden box into which the water enters through a hole in the bottom, and gradually passes through 15 frames made of iron wire, placed one above the other. Each of these frames can hold about 20,000 eggs. The water finally flows over the upper edge of the apparatus.

Although the principal fish raised in this establishment are *Coregoni*, some other fish are also cultivated, as the lake trout (among them the famous trout from Lake Garda, some young specimens of which I saw, which had been raised in the establishment), *Salvelinus*, and *Thymallus*. They are placed in the upper course of the Rhine, and some in the lake, where formerly they were not found. After the river and lake had been stocked, people soon began to catch these fish. The German Fishery Association pays a reward of $1.19 to every fisherman who can prove that he has caught one.

4. *Seewiese.*—The establishment of Seewiese near Gemünden in Franconia (Bavaria) belongs to Mr. Frederick Zenk, of Würzburg, who founded it in 1881 on ground belonging to him, and entirely at his own expense. The establishment does not receive subsidies of any kind, and has no other income except from the sale of eggs and fish.

The hatching room is 20 meters long, 9 broad, and 3½ high [about 65½ × 29½ × 11½ feet]. The water rises to a height of 2 meters [about 6½ feet] above the floor, and runs along the northern wall in a pipe having a diameter of 8 centimeters [about 3⅛ inches.] It generally comes from a brook in the neighborhood, which contains a great many fish, and is therefore called the "Fischbach." The temperature varies from a maximum of 10° R. [54.5° F.] in summer, to a minimum of 1° R. [34° F.] in winter.

If the water flows too warm or too cold, it can be mixed by a small hydraulic pump; or there may be substituted for it spring water, having a constant temperature of about 5° R. [43° F.] The water of the brook is filtered through an apparatus containing sponges and sand.

The hatching-troughs are of wood carbonized on the inside; their number is 20, and they are arranged in groups of 4 each. The frames used are those of Coste, and others having a network of metal wire. Some California boxes of various systems are also used.

The fish raised in this establishment are river trout, lake trout, *Thymallus*, *Salvelinus*, and cross-breeds of *Salvelinus* (♂) and trout (♀); also some American species, as *Salmo sebago* and *Salvelinus fontinalis*.

Besides the above-mentioned hatching-house, there is another smaller one, fed exclusively by spring water, where, besides ordinary troughs, circular porcelain apparatus (according to the La Vallette system) are used.

There are also 20 ponds of different size for young *Salmo sebago* and American *Salvelinus*, from which, though only two years old and not more than 15 centimeters [6 inches] long, Mr. Zenk has already obtained eggs. In these ponds there are also carp, bass, tench, and golden orf (*Idus melanotus* var. *aureus*).

In the large hatching-room there can be kept and developed about 6,000,000 trout eggs.

5. *Cosmandorf.*—Near the village of Cosmandorf, between Dresden and Tharand, in Saxony, a short distance from the confluence of the "red" Weisseritz and the "wild" Weisseritz, there is a small fish-cultural establishment belonging to Mr. Mittag, one of the proprietors of the fisheries in the Weisseritz and the Wesenitz, who, among other economical enterprises has undertaken to restock these waters by means of artificial fish-culture. He does not receive any direct subsidy from the Government, but it furnishes him gratuitously the embryonated salmon eggs, which are to be placed in the Weisseritz; and also pays him 31 cents for every thousand young salmon which have been hatched in his establishment. Mr. Mittag is, however, obliged to furnish the necessary material for Prof. Nitsche's fish-cultural course at the Tharand Academy of Forestry. The establishment has been in existence about six years. Some time before this another much larger establishment was founded, but proved an entire failure.

The water is supplied by a mill canal which comes from the "red" Weisseritz, and also furnishes the water-power for a manufactory of wood material (pasteboard). The water is not filtered, although this would be beneficial on account of the sediment from the manufacture referred to above. The temperature, during the hatching season, varies from 1° to 6° C. [34° to 43° F.].

The hatching-house is small; it has double wooden walls with a layer of hay between them. The water runs along one of the walls in a wooden canal. It should be noted that the faucets of the pipes through which the water flows into the hatching apparatus are not, as is generally the case, on the sides of the pipes, but at the very end of the pipe, in order to make it more difficult for the sediment to gather. The hatching apparatus which I saw consisted of twelve California boxes,

on the von dem Borne plan, but without the third inside box. I also saw a Holton apparatus, but it was not in use. Outside the hatching-house there is a wooden tank containing trout of both sexes destined to serve as propagators.

The establishment does not have a commercial object, and only serves to stock the neighboring waters. Only trout and salmon are raised. An attempt was made some time ago to introduce *Salvelinus* in some of the ponds, but they were soon devoured by the trout.

6. *Tharand (Academy of Forestry).*—There is not a genuine fish-cultural establishment, with a practical object, near the Tharand Academy of Forestry; but it possesses only a small room for the various hatching apparatus used by Professor Nitsche in his fish-cultural course. He showed me all the material used by him in this course, which never lasts longer than a week, and which has already been followed by good results.

7. *Wilthen.*—This establishment is located near Schirgiswalde, in Saxony. Its foundation is due to the above-mentioned course of fish-culture by Professor Nitsche at Tharand. The ground belongs to the Catholic church at Bautzen, and the establishment is managed by Mr. Waurick, superintendent of forestry, who deserves credit for having founded it. But here, as in other places, the monks had in olden times already constructed some carp ponds. At present only trout are raised for the market. The establishment does not receive any subsidy.

The water comes from a spring at a distance of about one kilometer [nearly two-thirds of a mile] and is led through a conduit into a receiving reservoir, whence it passes into the hatching-house. The temperature of the water, at the time of my visit, was 2° R. [36.5° F.]; but it may fall to the freezing-point, and rise a great deal in summer. The water is filtered through two flannel filters, which are in the hatching-room. It flows through a wooden conduit, which can be opened in order to be cleaned. This conduit, outside the house, and the tank, are covered with straw to prevent the water from freezing.

For hatching, California boxes are used (Nitsche system), and wooden troughs, about 1½ meters [5 feet] long. In each of these there are two wooden frames with a wire bottom, on which the eggs are placed. After the eggs are hatched, the frames are removed, and the young fish are left free in the troughs until they have lost the umbilical sac, or even some time longer, feeding them artificially with meat chopped fine. They are then taken to the brook, fed from the receiving reservoir with spring water, where they remain till autumn, when they are caught and conveyed to the ponds, where they stay at least a year, until they have reached a weight of at least 250 grams [8¾ oz.]. Above the place where the fish are the brook is closed by a sluice, and below by a metal grating, so that the fish cannot escape.

There are a great many ponds, some of them very large; they are connected with the brook which passes through them in the shape of

small waterfalls, which serve to aerate the water and prevent the escape of the fish. In summer the temperature of the water may rise to 25° or 30° C. [77° or 86° F.] without injuring the trout contained in it.

The fish in the ponds are fed artificially with meat—ground meat (which generally serves as a fertilizer)—and with the larvæ of flies. To obtain these, poles are rammed into the bottom of the ponds, and the carcass of some animal is placed on them. The flies deposit their eggs on the carcass, and the larvæ which develop from them gradually fall into the water and serve as food for the young trout.

8. *Lübbinchen.*—This model establishment is located near the city of Guben, in the Prussian province of Brandenburg, and belongs to Mr. Eckardt, one of the men to whom the industry of fish-culture is deeply indebted. Although it may be said that there is hardly any kind of fish, to which fish-culture is applied, which he has not cultivated, there are two to which he has specially devoted his efforts, namely, *Coregoni* and carp.

The Lübbinchen property covers an area of 10 hectares [nearly 25 acres], 9 of which are occupied by ponds, but at some distance Mr. Eckardt owns 400 hectares [988½ acres], with some lakes containing a great many fish.

The water comes from two springs, distant about 1 kilometer [nearly ⅝ mile] from Mr. Eckardt's house. It passes underneath an open vault, in order to get some air, and is then conveyed about 200 meters [219 yards]. It feeds the ponds and the basins, and is again collected in a small lake. It also forms a small brook destined for young trout, and from this brook comes the little stream which enters the hatching-house. The water is not filtered.

The hatching-house covers an area of hardly 4 square meters [43 square feet]. The water runs in an open conduit of wood, bituminated. The apparatus used for hatching are the boxes invented by Mr. Eckardt, each of which can hold as many as 20,000 *Coregonus* eggs, and have the advantage that they can be placed one above the other. There are raised artificially *Coregonus*, trout, European and American *Salvelinus*, &c.

The ponds and basins are more than 100 in number, and, as has already been stated, occupying an area of 9 hectares [22¼ acres]. The largest pond covers more than 1 hectare [about 2½ acres]. The first ponds, in the immediate neighborhood of the house, are about 1½ meters [5 feet] deep, and have some small canals through which the water runs all the year round, so as to keep them clear. The oxygenation of the water is kept up by reeds and water lentils, which grow in the ponds in great abundance. Beyond these ponds there is a large pond, about 4 meters [13 feet] deep, and some smaller ponds.

There are also some wooden and cemented tanks, containing pike, *Silurus*, tench, crucians, golden orf, &c. There are carp weighing as much as 14 pounds. There are 24 cemented basins, covering each an area of about 50 square meters [538 square feet]. In these there are

sterlets from the Volga, *Coregoni* from the Madue lake and from the Lake of Constance, American *Coregoni*, *Salvelinus*, *Salmo irideus*, &c.

The temperature of the water in the ponds does not differ much from that of the air; in summer it may get as high as 20° to 25° R. [77° to 88° F.], and in winter the ponds are apt to freeze. Mr. Eckardt deserves special credit for having succeeded in hatching the eggs of the delicious *Coregoni* of the Madue lake, and artificially raising these fish, which are greatly esteemed by Germans; but still more for the impetus he has given to the industry of carp cultivation. He succeeded in transporting the eggs a considerable distance by causing the carp to spawn on juniper branches placed in the ponds, these eggs being glutinous and therefore adhering to the branches. After these branches have been in the water some time they are taken out covered with eggs, which, even when transported some distance, will, under favorable conditions, develop normally. In special and very simple apparatus he ships live carp to a great distance, even as far as North America.

9. *Berneuchen.*—The most important fish-cultural establishment visited by me is without doubt the one belonging to the distinguished fish-culturist, Max von dem Borne, located on his estate of Berneuchen, at a short distance from the city of Küstrin, in that part of the province of Brandenburg called the "Neumark." Mr. von dem Borne founded this establishment in 1876, entirely at his own expense, and he does not receive any subsidy whatever. As a general rule he does not carry on the business of selling eggs or fish, and merely labors in the public interest for the German Fishery Association.

The water of the Berneuchen establishment is brought from a stream called the "Mietzel," by means of a canal, which also furnishes the water-power for some mills. Its temperature varies very considerably; in winter it falls as low as zero (when I visited Berneuchen its temperature was 2° R. [36.5° F.]), and in summer it may get as high as 20° R. [77 F.]. The roof of the hatching-house is covered with tarred pasteboard, under which there are two thicknesses of boards, to which recently one of pasteboard has been added; one of the walls runs along the canal and is of masonry, while the others are of wood. Inside, the house is divided into 2 rooms; in the first there are 4 basins, 1 large and 3 small ones, intended for young carp; and the filtering apparatus. The water is made to pass through four compartments filled with sand, and through a flannel filter. From these filters the water passes into the second room, in the middle of which it runs in an open conduit of cement, from which by means of common faucets it is distributed to the right and the left. On both sides, and a little lower than the central conduit, there are cement basins, 7 on each side, about 2 meters long [6½ feet]. Each of these basins contain 4 California boxes, the 2 upper ones large, and the lower ones somewhat smaller, which serve for hatching salmon and trout eggs. For hatching *Coregonus* eggs a special apparatus is used, invented by von dem Borne, and called the "automatic selector." To

each of these hatching apparatus there is attached a small box, intended to gather the young fry after they have slipped out of the egg. When this has taken place, the young *Coregoni* fall into the basins below, which have about 3 centimeters [1⅕ inches] of water, while the young salmon and trout are left in the hatching-boxes. The hatching apparatus have covers, because otherwise one rat could in one night destroy the entire contents. The room can be heated artificially. Besides eggs of various German salmonoids, I saw in process of hatching eggs of American *Coregoni* and *Salvelinus*.

Mr. von dem Borne also has 22 ponds, the largest covering an area of 11½ hectares [about 28½ acres]. In these there live and are raised fish of many different kinds—salmonoids, cyprinoids, &c. In the majority of the ponds, however, there are carp, the ponds being arranged according to the Dubitsch system, already described by me in another report. Among the foreign kinds the black bass (*Huro nigricans*) from Florida deserves special mention, as Mr. von dem Borne has succeeded in propagating this fish in his ponds. This kind, like the bass and some other fish, deposits its eggs among stones; and it is therefore necessary to prepare a bed of small stones in the place where it is intended they shall spawn.

10. *Michaelstein.*—In 1880, by an agreement between the Governments of Prussia, Brunswick, and Anhalt, for the purpose of stocking the public waters of the Harz Mountains, a fish-cultural establishment was founded in Michaelstein, near Blankenburg, with Mr. Dreckmann, superintendent of forests, as director. After his death Mr. Wegener became its director. As far back as the Middle Ages there were in this neighborhood carp ponds, constructed by the monks.

The water comes from one of the ponds close to the establishment and passes through a small grating; thence it passes into a filter composed of six boxes, the first containing pieces of sponge, the second sand, the third again sponges, and so on, alternating. In winter the temperature of the water falls to the freezing-point. After the water has reached the hatching-room it is, by means of faucets, to which small flannel bags are sometimes attached with the view to better filtration, distributed through the apparatus, which are California boxes modified according to the Schuster system. These boxes are arranged on 9 wooden staircases, each of the 14 steps containing two boxes; therefore in all 252 boxes. Each box may contain about 10,000 trout eggs. There are also 4 large cemented tanks for grown trout, and some wooden troughs, which are only used in case of absolute necessity. Besides river trout, *Salvelinus* and American trout are raised in this establishment. Some of these, two years old and weighing about 3 pounds, have already propagated the species under artificial cultivation.

There are a great many ponds, some of which might possibly be used for trout, and others for salmonoids, while in others carp alone can be raised, because the bottom is too muddy for others. In these ponds are

kept the fish which are to serve as propagators, and they are caught when the time for fecundation has come.

II.—SWITZERLAND.

11. *Neuhausen.*—This establishment is located about 300 meters [328 yards] from the celebrated falls of the Rhine. It belongs to the canton of Schaffhausen, which founded it in 1877. It is under the superintendence of Mr. Moser-Ott.

The water comes from a spring about 200 paces from the establishment, and is carried through a conduit about a meter and a half [5 feet] below the level of the floor. The temperature is not very high, nearly always 7° R. [about 48° F.]. It is not filtered. It rises to the ceiling of the hatching-house, whence it falls into a long, rectangular wooden basin, from which through vertical pipes it descends into the hatching-room below. To each pipe there are two troughs. These are of wood, about 2½ meters long, 40 centimeters broad, and 20 centimeters deep [about 98 × 16 × 8 inches]. They are arranged in couples, each couple having one pipe through which the water flows into the troughs, and one common outlet pipe. The number of troughs is 16. The water inside the troughs reaches a height of about 6 centimeters [2⅓ inches] during the hatching of the eggs, which are placed on frames of varnished iron wire, but after the eggs have been hatched the height of the water is reduced to 3 centimeters [1⅙ inches]. There are also in use small wooden troughs 80 centimeters long [31½ inches]. In the hatching-room, 10 meters long and 7½ meters broad [about 33 × 25 feet], there is also a large tank for live fish.

The only kinds of fish raised at Neuhausen are trout, salmon, and *Thymallus*, with the view to placing them in the Rhine, on the account of the canton; but a small trade is also carried on, principally in fecundated salmon eggs which have not yet become embryonated.

There are two small ponds for keeping trout, especially males, which are to furnish the material for reproduction.

In the Neuhausen establishment about 500,000 eggs can be hatched at one time.

12. *Dachsen.*—On the opposite bank of the Rhine, a little farther distant from the falls, there is the establishment of Dachsen, on territory belonging to the canton of Zurich, which founded it in 1875, but reduced it to its present condition in 1881.

It is under the management of Director Asper, of Zurich. The water comes from springs close to the establishment and is collected in a reservoir, whence through a pipe it flows into the hatching-house. It is not filtered, but the end of this pipe has a grating to prevent any mud, leaves, &c., from entering. In winter its temperature is 5° to 6° R. [43¼° to 45½° F.], and is somewhat higher in summer. Inside the room the pipe conveying the water rises vertically from the floor and flows into a canal in the center, constructed of masonry, and raised about 2

meters [6½ feet] above the pavement. From this central canal the water flows into troughs, arranged perpendicularly on either side of the same, through pipes about 20 centimeters [8 inches] long, which empty into a flower-pot without bottom filled one-third with sand, resting on the network of metal wire, which covers the upper part of the trough. Thus the stream of water is broken in its fall, and is aerated. The troughs are of wood, 24 in number, and of the same dimensions as those used at Neuhausen. No frames are used, but the eggs, as well as the young fry, rest on a bed of sand and very fine gravel, at least 4 centimeters [1½ inches] high. Each trough may contain about 20,000 eggs.

As at Neuhausen, there are two ponds for trout, especially for males, selected as reproducers. The kinds of fish raised are salmon, trout, and *Thymallus*, for stocking the Rhine. No trade, properly so-called, is carried on; but exchanges are made with other establishments, for instance, with Hüningen.

13. *Zurich.*—The Zurich establishment is located at the place where the river Limmat flows out of the lake, and is under the immediate supervision of Dr. Asper. Like the Neuhausen establishment it belongs to the canton of Zurich.

The water comes from the Lake of Zurich. It is brought into the city by pumps, and is used by the people of Zurich as drinking water. Before being used it undergoes a thorough process of filtration. In winter its temperature is generally 3° to 4° C. [37.4° to 39.2° F.], while in summer it can reach and exceed 20° C. [68° F.]. It circulates inside the hatching-room by means of a pipe suspended from the ceiling.

The establishment is provided with hatching apparatus of different kinds: Wooden and zinc troughs, California boxes of various systems, small troughs of cement, &c. In the troughs the eggs are at first laid on frames of metal wire, but when they are near to being hatched they are placed directly on the bottom covered with gravel or sand. Salmon and trout eggs are hatched for the Limmat and the Rhine, and *Coregonus* eggs for the Lake of Zurich.

For the latter kind of fish the American method answers well; it consists in keeping the eggs in a kind of large cylindrical bottle of glass, with a large mouth, closed by a perforated tin lid, pierced in the center by a pipe through which the water passes, and again flows out through the holes in the lid. In this manner the development of the much-dreaded parasitical fungi is prevented, especially during the first period of the development of the eggs. When the eyes become visible the eggs are placed in an ordinary California box.

At Geneva, Zug, and in some other places another apparatus was used with considerable success, consisting of a large glass funnel, 30 to 40 centimeters [about 14 inches] high, which is filled with eggs till within a short distance from the top, and into which the water enters through the lower aperture, keeping the eggs in motion and carrying away the dead and spoiled ones, which are lighter than the others.

Dr. Asper has also been successful in hatching eggs of the American *Coregonus*, and has placed some young ones in the lake.

14. *Geneva.*—In the quarter of Geneva known as "Sous Saint Jean," is located the fish-cultural establishment belonging to the canton of Geneva, which at present is under the direction of Mr. Covelle.

The water comes from the Lake of Geneva, and is the same which is used as drinking water in the city. In winter its temperature is 6° C. [42.8° F.] and sometimes it falls to 4° C. [39.2° F.]; in summer it is very warm, but during that season no operations are carried on in the establishment. Generally it is not filtered, but when a north wind (the so-called "*bise*") prevails, it becomes turbid, and at that time it is, when coming out of the faucets, made to pass through a zinc box divided into two compartments, half filled with gravel. Mr. Covelle, however, proposes to substitute for these apparatus a large filter, to be placed outside the building.

The water runs along the walls of the hatching-room, which is 13 meters long and 12 broad [nearly 43 × 40 feet], in iron pipes, which are preferable to wooden ones, because parasitical fungi are not so apt to form in them.

In the hatching-room there are 28 troughs, placed in two double rows, each containing 7; they are cemented, 2½ meters long and 70 centimeters broad [about 98 × 28 inches] on the inside. The one standing against the wall is 20 centimeters [nearly 8 inches] higher than the outer one. For each trough there is a faucet, to which is attached a winding appendage of brass, with a small hole at the end; so the water does not flow out more than at the rate of 6 liters [about 6⅓ quarts] per minute. Inside this tube is placed a small grating, which prevents all matter from stopping up the hole. The water flows from the upper trough into the lower one through a zinc pipe, to which is attached a distributing apparatus, which may also be attached to the upper faucet. The lower troughs have as an outflow a straight iron pipe, terminating at the top in a small grate.

These pipes, joined two and two, lead to a conduit under the pavement, which ends in a large basin placed at the end of the room, which serves for keeping, separately, the male and female propagating fish.

For hatching *Coregonus* eggs the funnel-shaped apparatus already referred to is used. It is provided with a metal edge with a vertical grate, which runs along a peripheric canal, whose opening communicates with the conduit of the edge, from which the young fish and the spoiled eggs fall, while the good ones remain at the bottom.

The hatching frames which Mr. Covelle places in the large troughs have a bottom of metal wire with very narrow interstices. I think, however, that a network with larger openings is preferable, which would allow the young fish to pass through soon after they are hatched. The bottom of the troughs is generally covered with very fine gravel.

The Geneva establishment hatches eggs of the Swiss and American *Coregonus*, *Thymallus*, and *Salvelinus*, but principally eggs of lake trout, of which about 500,000 are raised per annum. The attempt has been made to introduce salmon in the lake, but it has not proved successful.

III.—NETHERLANDS.

15. *Velp.*—The Velp establishment is near Arnhem, at a short distance from the castle of Billiom, on the river Yssel. Its director is Mr. H. E. Boutjes. It was founded in 1871, with a view to placing young salmon in the Yssel; but now it distributes them in nearly all the rivers of the Netherlands. The Dutch Government pays about 1 cent for every young salmon, and about 10 cents for every one-year-old salmon placed in public waters, expending for this purpose a total sum of nearly $5,000. The establishment consists of a large and very high hall, 15 meters long and 10 meters broad [about 49 × 33 feet].

The water used is spring water. It comes in an open canal, a distance of 4 to 5 kilometers [about 3 miles]. In winter its temperature sometimes falls to 1° C. [34° F.], and even lower, while in summer it rises to 20° [77° F.]. Near the establishment it is collected in galvanized-iron pipes, through which it flows into a basin placed in front of the house, whence it passes into another basin inside. The water first goes into a little room, and is gathered in a cask, through a metal grating intended to keep out all impurities; thence it passes, through a funnel filled with small sponges, into a large vat, half filled with gravel, and from this it goes into the hatching-room. In this room there are four rows of double troughs, in cement, arranged on six steps. The lower trough, however, is not divided, and each row therefore consists of ten vessels, each 2 meters long and 86 centimeters broad [about 79 × 34 inches], and of a last one twice as broad. In these troughs the salmon eggs are placed on Coste frames, which often have a network of clay pipe-stems. Above the cement troughs others, made of wood, can be placed. The water flows under the pavement of the hall, whence it rises vertically in pipes, through which it flows into the troughs.

Besides the two basins referred to for trout and one-year-old salmon, there are five basins for salmon, six for trout, and two for Chinese goldfish. During the first state the young fish are fed with brains chopped fine, then with heart, &c.

The establishment makes a specialty of hatching salmon eggs, of which it can hold 500,000. The eggs are mostly obtained from fish caught in the Netherlands, and in that case from dead females and from fish from the Upper Rhine. Besides salmon I have seen the eggs of trout and the American *Salvelinus* hatched in this establishment.

16. *Apeldoorn.*—The establishment of Apeldoorn, founded in 1880 by Mr. J. Noordhoek Hegt, is 4 Dutch miles from Apeldoorn. It receives its water from a spring at a distance of about 3 kilometers [nearly 2 miles],

which yields 10,000 cubic meters [about 350,000 cubic feet] of water per day. Close to the hatching house it falls about 4 meters [13 feet], and is partly gathered in an open wooden canal, which serves to bring it into the hatching house. It is not filtered. Its temperature, even in very cold winters, is 2° to 3° C. [35.6° to 37.4° F.].

There are in all seventy-two troughs, generally double, arranged in three rows. Some of them are still of wood, but they will soon be replaced by others of cement.

There are many ponds and basins for fish of different kinds, intended for raising fish and for selling them. The principal object of this establishment is to raise young salmon for the Rhine, but it also hatches eggs of common trout, lake trout, American trout, American *Salvelinus*, and California salmon; likewise crucians, carp, gold tench, and other cyprinoids.

IV.—Fish-Cultural Methods.

There are two methods in use for increasing the number of different kinds of fish: The first, in which human influence is reduced to its minimum, consists in placing the fish under the most favorable conditions for spawning. This may be called protective fish-culture, and is known by the name of "pond-culture;" it is particularly adapted to the cyprinoids, and among these specially to the carp.

By the second method the eggs are taken from the fish, mixed with the milt, and hatched, and the young fish are cared for and fed, until the suitable time has arrived for placing them in the water; natural processes are followed as closely as possible, and all hurtful influences kept away. This last is genuine artificial fish-culture, and is especially applicable to fish which, like the salmonoids, spawn in winter, and consequently do not develop too rapidly.

Protective fish-culture does not demand so much care as artificial fish-culture, and can easily be carried on even on a large scale. In following the protective method the fish-culturist should confine himself to providing favorable conditions for the fish which he intends to raise, leaving all the rest of the work to nature. If carp are to be raised, there are placed (in the spawning-season) in a small pond, covering an area of 1,000 square meters [10,764 square feet], which has been kept perfectly dry until a few days beforehand, two male and one female fish, which have been carefully selected. These fish will spawn in a few days, and the young fry will develop very rapidly. After they have lost the umbilical sac they should be placed in a larger pond, covering an area of at least 1 hectare [2½ acres], or in the waters for which they are intended. The bottom of the pond used for reproducing carp and other cyprinoids should be muddy; while for bass, American perch, and other fish it should be gravelly. By allowing the carp to spawn on juniper branches Mr. Eckardt has succeeded in conveying the eggs from one pond to the other, and he ships them by railroad in the same manner in which the

eggs of salmonoids are usually shipped. An important condition for raising carp is that the ponds can be laid entirely dry.

The rules to be observed in artificial fish-culture are, however, much more numerous. According to Benecke they may be classed under the following categories: Obtaining and fecundating the eggs in an artificial manner, hatching them, raising the young fish until they have lost their umbilical sac, shipping them, and placing them in suitable waters.

The artificial fecundation of fish eggs is, at present, generally practiced according to the dry method, the Russian method of Wraskij. By a gentle pressure on the abdomen the mature eggs are extracted from the body of the female, and allowed to drop into a dry vessel; over the eggs is poured the seminal liquid obtained in the same manner from the male; the mixture is gently stirred with the hand, gradually adding a little water. Eggs have even been successfully fecundated which had been taken from female fish which had been dead several hours.

The best fish for propagators are those which are not too old; this applies particularly to the male fish. It is advisable not to use the same fish as propagators for several years in succession, with the view to avoid the evil consequences of the fatty degeneration of the genital organs, advanced age, and consanguinity. If the fish selected for the purpose of reproduction are healthy and fine, their products will be so likewise. It is possible to produce hybrids; but these, besides being barren, show a very high rate of mortality, and in my opinion their raising can not be recommended.

The eggs, after having become fecundated, are subjected to the hatching process. In a temperate climate this process may be effected in the open air and in open waters, in apparatus either floating or placed on the bottom of a brook or some other water-course; but it is always safer, and in most cases absolutely necessary, that the hatching should be done in covered and inclosed places, which are called hatching-houses. These should be constructed in such a manner that the water inside is not liable to freeze; they should have sufficient light, so that there is no difficulty in selecting the eggs; but the light should not be too strong, because this favors the development of algæ and parasitical fungi.

The principal question which should engage the attention of fish-culturists, is the selection of the water destined for the hatching-house. It should be clear, free from impurities, have a low and even temperature (possibly from 2° to 5° C. [35.6° to 41° F.]), and, what is still more important, should be abundantly aerated. These conditions are found particularly in brook water, which has only one fault, namely, that it is frequently muddy. Spring water is generally too warm and too little aerated, but both these defects may be remedied by letting it, before entering the hatching-house, run for some distance through a covered canal over a bed of gravel, and forming some little falls. Wherever

these two kinds of water are found in the same neighborhood, it will be best either to use only one or to mix the two. Whenever brook water, and even when spring water is used, one should not fail to let it pass, before being used, through a filtering apparatus, which usually consists of one or more vats or basins half filled with gravel, through which the water is made to flow. Small pieces of sponge may also be used, and the American filters of flannel have also been found to answer the purpose very well. The modern hatching apparatus, in which the eggs can be stirred and washed without difficulty, render it less necessary to filter the water.

In cold countries all possible precautions should be taken to prevent the freezing of the water, by placing the pipes through which it flows before entering the hatching-house at a certain depth below the ground, and by enveloping them in straw or other non-conductors of heat.

Inside the hatching-house the water should be gathered in a reservoir, or should run in a canal (an open one to be preferred) at a height of at least 2 meters [6½ feet] above the pavement; the canals may be of wood, cement, or metal, according to circumstances, and from them the water should fall vertically into the hatching apparatus placed below. The object of letting the water fall from a certain height is to add to its aeration; special contrivances attached to the pipes may also serve this purpose.

The hatching apparatus generally used in large fish-cultural establishments are cement troughs, as being the most durable and less apt to favor the development of parasites on the eggs. The eggs may be placed in these troughs, on frames with a wire bottom, the bottom being covered with very fine gravel. Wherever water is abundant it is advisable that each trough should have a separate faucet, because if parasites should develop in any one of them the infectious germs can easily be removed. Even wooden troughs may be used, provided they are carbonized on the inside, or at least tarred. In small, especially private, establishments the most useful hatching apparatus is the California box, of whatever model it may be. Those, however, are preferable in which the water flows through a very large opening.

After the eggs have been placed in the apparatus strict watch should be kept over them to remove immediately all those which have not been properly fecundated, which show traces of disease, or have become opaque. The eggs should be kept in the dark, because light favors the development of fungi and parasitical algæ. All hatching apparatus, no matter of what kind, should be provided with strong covers to prevent mice, rats, &c., from entering.

When the eggs are near being hatched they can, if they are on frames in large troughs, be taken off the frames and placed on the bottom, or placed in special apparatus. If, on the other hand, they are in California boxes, it is not necessary to do this. Great care should be taken to remove at once spoiled eggs or dead young fish, as the presence in

the apparatus for any length of time of one dead body may cause the death of thousands of healthy eggs or young fry. To obviate this difficulty, the water should never cease to run into the apparatus freely. Whenever the fish begin to be less lively than usual and there is reason to suspect the development of the much-dreaded fungus (*Saprolegnia*), endeavors should be made to prevent its spread by throwing a large quantity of salt into the water. In some cases excellent results have been obtained by raising fresh-water fish in sea water. When the young fish are intended for public waters it is best to place them there some days before they have lost their umbilical sac, so they may become somewhat accustomed to their new element before they are compelled to seek their food. They should not all be put into the water at the same time and at one and the same place, but be scattered over a larger surface of water, selecting localities which contain the conditions favorable to their existence. Instead of quite young fish it would be preferable to put into open water fish about one year old, which are stronger and are not exposed to so many dangers. If the young fish are to be fed artificially the first food should consist of brains chopped very fine; afterwards they may be given meat chopped fine, fish eggs which have not been fecundated, ground meat (meat flour), and larvæ of flies. When they are two to three years old fish begin to be capable of propagation.

Fecundated eggs may be transported without any danger at two periods, immediately after fecundation and after the points of the eyes begin to show in the embryo, while during the first stage of the development even the least shock may cause the death of the embryo. The eggs are wrapped in a small piece of moist muslin and placed on a bed of moistened wadding, which in its turn rests on a bed of moss. They are covered with a similar layer of wadding and moss, on which another layer of eggs may be placed. In this way they can be shipped a considerable distance, placing on the top of the whole pile a small piece of ice, which serves to keep the temperature low, and which should be renewed from time to time. The box containing the eggs is placed inside another larger one, and the space between the two boxes is filled with sawdust, hay, &c.

The American fish-culturist, Fred Mather, has invented an apparatus, a sort of chest with different bottoms, which is used for transporting the eggs which the German Fishery Association receives every year from the U. S. Fish Commission. The first attempts to convey eggs such a distance were not successful, but at present they are shipped with perfect safety.

It is much more difficult to transport young fish, owing to the necessity of having the water aerated. For this purpose Schuster and others have constructed vessels to which air-pumps are attached, but according to Haack and others, these are not absolutely necessary; if great precaution is taken, and the water is changed as often as possible, using

also ice, so that the water does not get too warm, the young fish may be shipped a considerable distance without great loss. The consignment of fish should in every case be in charge of a practical, intelligent, and reliable person.

There is of course much less difficulty in transporting grown fish. Director Haack has succeeded in transporting alive from Pisa to Hüningen young eels, known under the name of "blind eels."

In Italy the first attempts to stock the public waters with fish were made by Professor De Filippi, and continued during the last few years, by the aid of the ministry of agriculture, industry, and commerce, by Professor Pavesi. But in order to make these experiments with the certainty of favorable results, they should be preceded by investigations relative to the physical and biological conditions of our fresh waters, such as Professor Pavesi has made in some of the lakes of northern Italy, Lake Trasimeno and Lake Albano.

All the kinds of salmonoids found in Central Europe, with the exception of the Rhine salmon, the Danube salmon, and the different kinds of *Coregonus*, are also found in the fresh waters of Northern Italy; and it is therefore certain that these efforts to increase the fish in our waters will be crowned with success. The trout, the *Salvelinus*, and *Thymallus* could easily be cultivated, and there is also reason to hope that the *Coregoni* introduced at first in Lake Maggiore by Professor De Filippi, and recently in Lake Como by Professor Pavesi, will become acclimatized and will propagate.

In Central and Southern Italy only trout are found; but it would not be difficult to increase their number in the upper tributaries of the Arno, the Tiber, and in all the streams of fresh waters coming from the Apennines. I have not yet been informed of the results of the attempts made during the past year to introduce Rhine salmon in the Po and the Pescara. During my stay in Germany, I was advised more than once, especially by the illustrious president of the German Fishery Association, von Behr, to attempt the acclimatization of the California salmon (*Oncorhynchus chouicha*), which lives in localities whose natural conditions greatly resemble those of Italy. The non-migratory salmon of the Schoodic Lakes (*Salmo sebago*) might be raised to advantage in the deep lakes of Northern Italy, and the volcanic lakes (craters) of Central Italy.

Throughout the whole of Italy, but especially in Central and Southern Italy, the industry of carp culture is, as I think, destined to be developed veloped on a large scale; so far it has been introduced in some lakes and ponds. Mr. Max von dem Borne also advised the cultivation in Italy of the American black bass (*Huro nigricans*). It is true that it is a very voracious fish, but the same may be said of the pike; and yet they do not destroy all the other fish in the waters in which they are found; suitable precautions and careful watching may prevent much of this evil; and there is no reason to exaggerate the dangers to which one kind of fish is exposed by another.

Fish-culture in Italy, especially in its southern portion, presents doubtless fewer difficulties than in Central and Northern Europe, by reason of the milder climate, which does not expose the water in the hatching-house to the danger of freezing, and renders unnecessary many of the precautions which have to be taken in a more northern climate.

There are two methods of stocking with fish the fresh waters of a country: The founding of large central establishments of fish-culture, or of small fish-cultural stations scattered throughout the country. It has now been demonstrated that the second method is the better and more practical of the two. Large fish-cultural establishments are in nearly all cases more subject to diseases which destroy the eggs and the young fish than small ones. "Splendid results may be expected from fish-culture only when every one has become his own fish-culturist," says von Behr, and with good reason. But in order to obtain these results it is necessary that this industry should become more general and should be prized as highly as it deserves, and this can only take place after long and patient labor, and if the proper impetus is given by the Government. This is the grand service which the Hüningen establishment has rendered to the whole of Europe. But when fish-culture has entered the field of private enterprise the Government should cease to carry it on. This is also the opinion of the eminent director of the Hüningen establishment, Mr. Haack. The large fish-cultural establishments should be the centers from which this industry is spread, and they should make efforts to start as large a number as possible of small establishments throughout the country.

This result has been reached perhaps in the most satisfactory manner in Saxony, since in that kingdom there were, at the end of 1882, not less than 73 fish-cultural establishments, both large and small, or one to every 40,000 inhabitants and to about 200 square kilometers [77 square miles]. This result is due particularly to the efforts of Doctor Nitsche, professor of zoology in the Academy of Forestry at Tharand. Since 1878 he has given a special course of lectures on fish-culture, lasting not longer than a week. These lectures have been attended by the students of the academy and by many other persons, among the rest several fish-culturists. In most cases the inspectors of forests, both Government and private, have founded the different fish-cultural establishments, and have done their share in diffusing the practice of fish-culture. The same could be done in Italy. The Institute of Forestry at Vallombrosa possesses, as I think, all the necessary material for a course of fish-culture. This course should be made free to all, so that it could be attended not only by the students of the institute, but also by persons employed in the superintendence and care of forests. The course should not merely comprise theoretical instruction relative to the physiology and reproduction of fish, the histological development of the embryo, &c., but it should be essentially practical and brief, occupying in all not more than three or four weeks, divided into different

periods, and thus it will be possible for the employés of the forest service, the only service which at present can be counted on in this respect, to become practically acquainted with fish-culture.

In conclusion it cannot be denied that in Italy the sea fisheries are of greater importance than the fresh-water fisheries; but at the same time it should be stated that even in the sea man may exercise a beneficial influence on the propagation of fish. We have an example of this by what is done in this direction in America as regards the cod, and in the Baltic as regards the herring. Some of our efforts should, therefore, be directed to salt-water fish-culture, which is destined in time to produce still greater results than fresh-water fish-culture.

GENOA, *August* 6, 1885.

[*After visiting and studying the principal fish-cultural stations of Germany, Switzerland, and the Netherlands in 1884–'85, under orders from the Italian Government, Dr. Bettoni and Dr. Vinciguerra advised the establishment of two somewhat similar stations in Italy. The principal fish which they pointed out as suitable for cultivation were salmon, trout, and carp. Bolsena was mentioned as the most favorable place in Central Italy for one such establishment. The plan for the station contemplated a hatching-house, with all the necessary apparatus, an artificial canal from a small stream to the Lake of Bolsena, and the construction of two large ponds, each with an area of 1,000 square meters [nearly ¼ acre] and a depth of one meter [3¼ feet]; these ponds being intended for the cultivation of carp on the Dubitsch system. Besides these ponds, two rectangular basins were to be laid in cement, each with an area of 12.5 square meters [134.5 square feet], and two other basins, one round and the other elliptical, to be used as stock and winter ponds for carp and other fish. The total estimated cost for starting this station was about $2,350. Brescia was proposed for the location of the establishment in Upper Italy, on a somewhat larger scale than the one at Bolsena. The plan contemplated making a large canal and two small ones, emptying into a pond of irregular shape, having an area of 246 square meters [2,648 square feet]. From this pond another canal is to start, feeding a large hatching-house and supplying water for three circular ponds with an area of 495, 128, and 110 square meters, respectively [5,328, 1,378, and 1,184 square feet]. There are to be also four rectangular ponds, in pairs, each covering 414 square meters [4,457 square feet], and two large rectangular ponds, each with an area of 506 square meters [5,447 square feet]. The building is to contain, besides hatching-rooms furnished with the latest improved apparatus, a room for the director, one for a laboratory, and one for a small museum. The total estimated cost for the Brescia station was about $4,650.]

*This paragraph is not a part of Dr. Bettoni's report, but is from an article by Prof. P. Pavesi relative to the establishment of fish-cultural stations in Italy. It is inserted here as showing one of the results of Dr. Bettoni's work.—EDITOR.

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