XXXII.—POND CULTURE.*

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Die Teichwirthschaft. From the *Lehrbuch der Teichwirthschaft* (Manual of Pond Culture). Translated from the German by HERMAN JACOBSON.

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INTRODUCTION.

There are four different methods of cultivating fish:

1. POND CULTURE.—*a. Fish-culture, i. e.*, cultivating fish in spawning ponds (in which the fish spawn and in which the eggs are hatched), raising ponds (in which the fish remain till they have reached a considerable size), and stock ponds (in which the fish are fattened for the market), or in inclosed portions of streams. Fish-culture, therefore, means the natural production of fry and raising the fish for the market. *b. The keeping of fish* in raising ponds, stock ponds, or in inclosed portions of streams; in other words, raising young fish which have been obtained from abroad, and keeping them till they are ready for the market.

2. TRANSPLANTING FISH from one water to another, *i. e.*, transferring a number of sexually mature fish to water in which prior to this no such fish were found.

3. THE CHINESE METHOD, which consists in gathering from the water the spawn of fish deposited in a natural manner, and transferring it to other places to be hatched.

4. ARTIFICIAL FISH-CULTURE IN A NARROWER SENSE, *i. e.*, extracting from the fish by human agency their sexual products, uniting the male and female products, and protecting the eggs and young fish from their natural enemies until the umbilical sacs are absorbed.

In the following pages we shall treat only of the first-mentioned method, although we shall at times in the proper connection allow ourselves some digressions relative to the methods.

Pond culture can be carried on only in sheets of water in which one can arrange the water at all times according to his discretion. Such waters are principally ponds, though they are sometimes lakes and inclosed portions of streams.

The larger and smaller lakes, which are termed inland waters, are formed either by the gathering of water in low ground along the course of rivers and brooks, in other words by streams overflowing their banks, in which case these rivers or brooks flow through the lakes formed by them without undergoing any change, or divide into several branches, or occasionally find a subterranean outflow, or such lakes are the natural receptacle for the water of an entire neighborhood, and are formed by springs or by the waters flowing down from the mountains; or they owe their existence to invisible subterranean streams.

Large lakes must come under the head of the "wild fisheries," as their water cannot be let off or diminished; and the principal condition for successfully carrying on these fisheries is "to know how to catch fish." Man can make his influence felt only by increasing the number of fish, by protecting them during the spawning season, and by introducing finer kinds of fish by placing young fry or eggs in such lakes.

Lakes are never laid entirely dry, but, according to their origin, they either keep a constantly even depth of water or their water rises during a rainy season, and falls during a period of drought. If lakes are not too large, it is in many cases possible to control the water by artificial means, *i. e.*, to decrease it whenever desirable; and if this is the case, such lakes may be used for artificial fish-culture or "tame fisheries" and even for keeping fish.

But before such artificial means are resorted to, a careful estimate should be made in order to ascertain whether there is any reasonable hope that the results will justify the outlay. Special distinction should in this connection be made between the lakes which have a constantly even depth of water, and those which owe their origin to an accident, *i. e.*, which have been formed by the rain or snow water of a neighborhood. Such lakes may contain a considerable amount of water in spring or after a long continued rainy season, but it is uncertain whether the quantity of water will remain the same during summer; and they can either not be utilized at all for fish-culture or only to a very limited extent, so that the expenses of controlling the water by artificial means would be too great. It is possible, however, to transform such waters by degrees to profitable fish-ponds.

As a general rule we understand by "fish-pond" a reservoir which is suitable for fish-culture and for keeping fish, *i. e.*, which combines a suitable location, the proper soil, and water which, when necessary, can be either decreased or let off entirely. To carry on fish-culture and the keeping of fish in such ponds is termed "pond culture," and as a general rule it forms part of agriculture. Pond culture, therefore, comprises the laying out and the construction of ponds, their maintenance, the carrying on of fish-culture or the keeping of fish in such ponds, and the other uses to which such ponds may be put.

Most of our establishments where pond culture is carried on date their origin centuries back, and in the course of time their condition has naturally undergone many changes. The income from agriculture (I include in this term stock raising) made the utilization of the soil for agricultural purposes appear more profitable than pond culture. Many ponds were laid dry and used as fields with increasing profit, for the price of grain had risen, while the price of fish had declined steadily. In many parts of our country this is now reversed, as agriculture does not yield so large a profit as formerly, while the price of fish has risen enormously, in illustration of which we will only state that within a period of twenty-five years the price of carp has risen from 30 marks [$7.50] to from 60 to 70 marks [$15 to $17.50] per hundred-weight.

Nevertheless I would not unconditionally advocate at this day the establishment of new ponds with the view of carrying on fish-culture (carp-culture) on a large scale, for who could guarantee in our times, which, as regards economy, must be termed a period of transition, that the present condition will continue even for a few decades?

I do not therefore unqualifiedly advocate pond culture, and I do not maintain that pond culture is calculated to make a certain piece of ground yield the largest possible net income, or at any rate a larger income than agriculture, which, under favorable conditions of soil, and by being carried on in accordance with the demands of the time, will generally yield a larger and more certain profit than fish-culture. Even if in some localities the income is not so large, a few acres of cultivated ground will support the man who cultivates them in the proper way, which cannot always be said of the same area used for pond culture. (We do not here refer to small fish-cultural establishments, or establishments of pond culture carried on like any other branch of industry; but even these, if conducted on the same principles as large establishments of this kind, would not yield a larger profit per acre than ordinary establishments of pond culture.) The conditions referred to are mostly only of a local character, and are not permanent, either as regards agriculture or pond culture, and, as heretofore, they will, in course of time, undergo many changes.

If we take into consideration the fact that strenuous efforts are made in our time to increase the number of fish by artificial hatching and by transplanting young fish of species far superior to the carp to waters which hitherto did not contain any fish, we cannot but think that by the consequent extension of the "wild fisheries," especially as regards the finer kinds of food-fish, it will not take more than ten or twenty years to reduce the price of carp to that of twenty-five years ago, while, on the other hand, agriculture and stock raising are constantly becoming more profitable.

Although it will therefore be the first duty of a person owning large sheets of water to inquire whether he cannot drain some of them and transform them to fields and meadows, it cannot be denied that there are many lakes which cannot possibly be drained, and which naturally suggest the question in what manner their waters may be put to the most profitable use, and what means should be employed to adapt them to fish-culture.

It is often impossible to drain entirely a large area of marshy soil; but by digging ditches and constructing dikes the water may be made to recede to the lower ground, where, if not allowed to flow any farther, it will form a natural basin of water, varying in size according to local conditions. Much has been gained hereby, as part of the ground has become suitable for fields and meadows, and as the newly-formed lake may at a comparatively small expense be used for purposes of fish-culture, while formerly the entire area, being marshy, yielded only a scanty harvest of sour and unwholesome hay.

If such a lake (it becomes a pond only by constructing works for filling or draining it at any time) has had its origin in the manner described above, or if it is the natural meeting-place of waters from springs on higher ground or of the rain or snow water of an entire neighborhood, or if the water has been gathered in one place for the purpose of furnishing power for some mill or other factory, it will in all cases be possible to utilize the water for pond culture, unless it is polluted by refuse from the factories.

The main question, under all circumstances, will be, in what manner this water can be made most profitable for pond culture. On the other hand it cannot be denied that pond culture, as it is, has not yet reached that degree of development which would make it impossible to derive still greater profit from it; all the more it should be the object of our pond culturists to obtain the greatest possible benefit from their ponds, so that this culture, as far as its results are concerned, may keep step with agriculture, and furnish a means of support in times when the income from the latter is but small. Pond culture teaches how this object may be attained and how fish-culture, and more especially carp-culture, may be made to yield the greatest possible profit. It may be divided into two parts: (1) The laying out, construction, and keeping of ponds; and (2) Fish-culture in these ponds.

I.—The Laying out and Keeping of Fish-ponds.

In this chapter we shall speak only of such ponds as have been laid out and are kept for the purposes of raising and keeping fish, where fish culture, therefore, forms the object and the ponds are the means for attaining this object; while in cases where the laying out of ponds has for its object to furnish water-power for mills, &c., fish-culture appears as the means to derive still greater benefit from existing ponds.

Before laying out one or several ponds, the following points should be considered: (1) The location of the ground; (2) the configuration of the ground; (3) the quantity of water on hand; (4) the quality of the water; (5) the quality of the soil; (6) safety from inundations; (7) legal right to use the water; and (8) the cost.

All these points must be supposed to be settled in existing ponds, but even in these, there is, in many cases, a chance to make improvements; but in order to make these improvements the existing conditions should be carefully examined, and the consideration of the above points may prove useful to persons who possess old, established ponds.

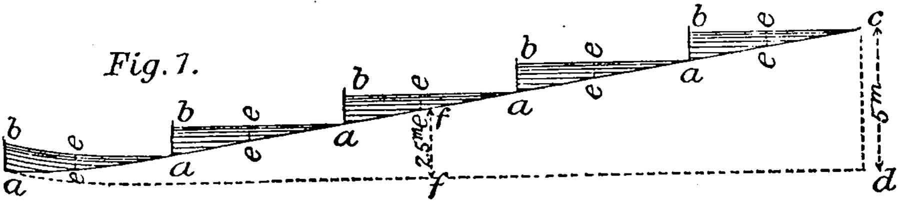
1. The location of the ground suitable for laying out a pond should be open on all sides, so that the pond may have the benefit of the sun all day long; for the heat of the sun does not only further the growth of fish, but also the development of fish-food, worms, and insects. It does not hurt, however, but on the contrary is an advantage, if a portion of the pond is, at a suitable distance, surrounded by woods and

heights, especially on the north side, so as to break the force of the wind from that quarter and prevent it from making the water of the pond too cold. It is not necessary that the pond should be located in a level plain; on the contrary, a sloping ground will prove an advantage, because thereby a natural and very inexpensive means is afforded for the water to flow off; on the other hand ponds located on low ground or in plains have the advantage of receiving the rain and snow water from the higher ground which contains a great deal of fish-food, and which forms a layer of rich mud at the bottom of the pond.

2. THE CONFIGURATION OF THE GROUND.—The plain selected for the laying out of a pond should be even in all directions, and should incline only on one side, so that it is possible to drain the pond entirely in a short time. If, however, the plain slopes on several sides, as is frequently the case in large ponds or lakes, and if this cannot be remedied the water should have a chance to flow off on all the slopes. Under these circumstances, however, the laying out of a pond becomes more expensive, because it necessitates the construction of dikes and contrivances for the outflow of the water. The most suitable ground for the laying out of a pond is that which slopes a little towards the center. Within the limits of the pond there should be no depressions, as during the time when the fish are caught, some are apt to hide in these places, thus making fishing difficult. Such depressions or holes should, if possible, be filled, and if they are too large or too numerous to do this, the ground is not suitable for the laying out of a pond, as the fisheries in such a pond will involve too great an expense. If, however, the ground possesses a depression in such a place and of such a size as to make it possible to construct the outlet for the water near it, it forms a natural reservoir for the fish, which saves a great deal of labor. If there are in the pond large shallow places it is best to construct dikes round such places, so as to prevent the fish from entering them, and plant these dikes with willows.

The first object in selecting ground for a pond is to obtain the most suitable depth of water for the fish. As a general rule the average depth of water best suited for most kinds of fish is 45 to 50 centimeters. A depth of 80 centimeters is not favorable. It is necessary, however, that a ditch measuring 1.5 meters in depth should cross the entire area of the pond from the place where the water enters to its outlet, where it should widen out, without changing its depth, thus forming a reservoir for the fish and preventing their freezing in winter. In case, however, the pond is never to be used for wintering fish, the dimensions of this ditch may be smaller, unless the quantity of water flowing into the pond requires them to be larger. Several small ditches—their number to be regulated by the size of the pond—should run from the shores of the pond to the main ditch, and the ground should therefore slope gently in the direction of these ditches. On gently sloping ground, which, however, would make the depth of the pond too great if the entire area was to be used for one pond, a suitable depth of water may be obtained by forming several ponds by constructing dikes rising on terraces one above the other.

Fig. 7.



Taking, for example, an area 700 meters long, *a c*, and 200 meters broad, equal to 14 hectares, whose grade per 700 meters is 5 meters, *c d*, and therefore 2.5 meters in the middle, we would have to divide it into five parts by constructing dikes at the points marked *a*, whereby we would obtain a maximum depth, *a b*, of 1 meter and a medium depth, *e e*, of 50 centimeters. (In order to show these depths in the limited space of the illustration different scales had to be adopted for the lines *a c* and *c d*, which, however, will not prevent it from being sufficiently intelligible.) The ground should not slope too abruptly, as, in spite of terraces, the water could not be prevented from rising too high, and as, moreover, very high and therefore expensive dikes would be required. In such cases it may be recommended to utilize the upper parts as meadows. Wherever the above-mentioned conditions, described as either necessary or favorable, do not exist at all, or only in part, the laying out of a pond (if not entirely impossible) will be very expensive, and will also render fish-culture a costly experiment.

3. THE QUANTITY OF WATER.—It should, in all cases, be possible to furnish the pond with a sufficient quantity of water, which, if possible, should be fresh. Ponds generally are found in plains or on low ground, and receive their water either from springs, brooks, rivers, or from other ponds and swamps, or their supply is furnished by the rain and snow water flowing from hills and mountains. Ponds which are supplied with water in the last-mentioned way are termed "sky ponds," as they are entirely dependent on the moisture of the atmosphere. Ponds should at all seasons of the year have the necessary and unvarying, as far as possible, depth of water, so as not to endanger the life of the fish during hot and dry summers. Before laying out a pond special attention should be paid to the way in which water is generally supplied to the ground which has been selected; and it will be necessary to ascertain what was the average quantity of water supplied during a number of years, and more especially what were the conditions of such supply during the last months of summer. The most reliable depth of water will be found in those ponds which are filled by canals from neighboring brooks and rivers, or through which rivers flow, or which draw an ample supply of water from never-ceasing springs.

Especially in the case of lakes formed merely by rain or snow water, which are to be transformed to fish-ponds, it will be absolutely necessary to ascertain whether during a period of many years there was ever any lack of water, what is their usual depth of water, and whether this depth remains the same during winters when there is but little snow and during dry summers. Even if this should be the case, it will always be advisable, in order to be sure of success, to fill such "sky ponds" immediately after the autumn fisheries. In order to secure a permanent and even depth of water in such ponds, they should have as many feeders as possible, so that at every rainfall, and during the thaws of spring, all the water from the surrounding country may flow into them.

Before laying out such ponds one ought to ascertain whether, in case of necessity, leave will be granted to carry these feeders or ditches through territory belonging to other persons. Water obtained through such feeders generally carries a great deal of fish-food into such ponds. If there is no difficulty about filling them with water—and there generally is no difficulty as regards "sky ponds" measuring 30 to 40 hectares (and even more), if one does not shun the expense of supplying them with water from distant regions—they must, especially if the soil is of the right kind, be considered as among the very best ponds, as, owing to the excellent fish-food carried into them by the feeders, the growth of the fish will be rapid and healthy.

4. THE QUALITY OF THE WATER.—It is certain that some kinds of water are better adapted to fish-culture than are other kinds, but, as a general rule, persons, in laying out a pond, will not have much choice, but will have to take the water as it is, as its quality depends on the nature of the country and other circumstances which cannot be changed. We have already mentioned from what points of view and in what manner water should be examined, before using it for a fish-pond, and we may here simply refer to what has been said before. Water containing any substances which are injurious to fish, and which cannot be purified, should of course not be used for fish-ponds. If no other water can be obtained, the idea of starting a fish-pond in the locality should be forthwith abandoned. As a general rule those ponds seem to be the best whose water is supplied by brooks and other small but never-ceasing streams. The water, however, should not come from forests in the immediate neighborhood of the ponds, as it is apt to be too cold, and contains but little fish-food; while water, which, prior to its entering the pond, flows for a considerable distance through cultivated ground, will be much warmer and be saturated with nourishing matter, thus being in every respect suitable for a fish-pond.

Director Horak says the following relative to the advantages and disadvantages of the different kinds of water which are used for supplying fish-ponds: "Such water is either—

"*a. Pure spring water*, which contains but little fish-food, is generally cold, and not well adapted to fish-culture. Fish of prey, especially trout, which live on their fellow-beings, will flourish in such water. If a pond fed by spring water exclusively has a sandy bottom, it must be classed among the so-called poor ponds; if such water contains a considerable quantity of animal refuse, it is hurtful to the fish and should be allowed to flow off. A pond containing such water can only be used for fish-culture if other and healthier water is introduced.

"*b. Snow and rain water* contains nutritive matter in a diluted form, fills the ponds evenly, and is beneficial to the fish during the rainy seasons and thunder-storms which occur during summer. Rain-water invariably contains a good deal of fresh nourishing matter.

"*c. Brook and river water* is more or less soft or hard, according to the influence which the heat of the sun has upon it and the quantity of foreign matter which it carries along with it. Ponds are generally supplied by this water which, on the whole, is favorable to fish-culture.

"*d. Peat, marsh, or forest water* is usually pure, of a dark color, and marshy flavor. It contains but little fish-food, and becomes suitable for fish only after having been in the ponds for some time, exposed to the influence of the atmosphere and mixed with snow, rain, and other water. If such water flows into the ponds from peat-bogs and marshes, the ponds will be poor, and can only be improved by being drained frequently and by introducing rain-water from the nearest fields.

"*e. Pond water* is suitable, as a general rule. It is warmer than river or spring water, and is specially adapted to the supply of winter ponds and tanks. The water of good ponds, or of ponds which at certain periods are used for agricultural purposes, contains dissolved substances and is wholesome for fish. Muddy water coming from cultivated fields carries much humus and nutritive matter. If the water of a pond when agitated by wind remains colorless and clear, this is an indication that the soil is poor, while a brownish-yellow water indicates a rich bottom. Water from peat-bogs or from iron mines, or water which is saturated with manure or particles of lime, is hurtful to the fish, and unless a sufficient quantity of pure water is introduced the fish will grow sick or die out. Reddish water, having an oily surface, contains too much iron, tannin, and gallic acid, and is, therefore, injurious to fish. Water which, during the rainy seasons, flows into the ponds from cities and villages contains much new and rich food-matter, and should, therefore, be employed whenever practicable, of course preventing any large quantity of manure water from mingling with it. Water from chemical factories is generally hurtful to fish."*

5. THE QUALITY OF THE SOIL.—The bottom of the pond should retain the water and be well supplied with fish-food. The main source of fish-food will always be the bottom of the pond, for it is not certain that the water flowing into the pond will contain a sufficient quantity of food. Sandy loam soil or loamy sand soil will contain most food.

* Horak, *Teichwirthschaft*, 1869.

The humus contained in these kinds of soil is dissolved and supplies food to the fish; it also favors the production and growth of many kinds of plants, worms, and insects, all of which are excellent fish-food. The above-mentioned kinds of soil combine two great advantages, viz., to supply a sufficient quantity of suitable food, and to retain the water. Clay soil, when containing sand, is likewise rich in food, and retains the water, even during long periods of dry summer weather, and is therefore the best for "sky ponds." If the soil is loose, or even sandy or gravelly, the water soon percolates through it, and neither insects nor plants can thrive, as the productive power of the soil is but small. It therefore affords but little food to the fish. Ponds having such bottom can only be maintained as fish-ponds by a constant and superabundant supply of water from cultivated ground.

But even as regards existing ponds the pond culturist should possess an accurate knowledge of the quality of the soil of every pond; he should therefore examine it carefully, for only thereby will he gain a thorough knowledge of the exact condition of his ponds, enabling him to make improvements wherever needed. An accurate knowledge of the nature of the bottom of the ponds is as essential to the success of the pond culturist as a knowledge of the soil and its different layers is to the agriculturist. The examination of the bottom of a pond, as regards the quantity of food-matter contained in it, will be easiest, and lead to the most satisfactory results, just after the pond has been drained, but not after it has lain entirely dry for some time, for it is of interest to the pond culturist to know what plants and animals are contained in the pond when it is full of water. If the pond has been dry for any considerable length of time most of the plants and insects which owe their origin and life solely to the water have either disappeared entirely or have decayed. After this first examination the soil of the pond should again be examined after it has become entirely dry, so as to obtain an exact knowledge of its component parts. Such an examination should, especially in large ponds, be made in a number of places, for the soil of a large extent of ground will vary considerably.

If, after the pond has been drained, a great deal of mud is found at the bottom, this is a sure indication of rich soil. In that case the bottom is generally composed of clay or loam with a slight admixture of sand, and the mud produced by the decay of the many products of this rich soil, and partly introduced by rain or snow water, will directly serve as food for fish, and also indirectly answer the same purpose by becoming the abiding-place of many insects and plants which fish eat. The water of such ponds is generally muddy, and has a brownish-yellow color.

6. PROTECTION AGAINST INUNDATIONS.—If a neighborhood is exposed to frequent inundations, special attention should be given to this matter before the pond is laid out; for if it is impossible to secure ponds against such calamities, the entire fish harvest will frequently be lost.

If ponds receive their water from springs, brooks, or rivers which rise considerably at certain seasons of the year, weirs with sluices should be constructed at the places where the water enters the pond, so that the supply of water can easily be regulated. If, however, an entire stream passes through a pond, the weirs must be placed in the stream itself, and the superfluous water must be allowed to flow out through side ditches. The superfluous water and the water of the stream may again unite below the pond.

7. Legal right to use water.—As regards the legal right to use the water coming from some distance, it will be well, before laying out a pond, to examine whether one is entitled to draw the water from the brooks, rivers, and springs which it is intended to use for supplying his pond. With "sky ponds" this is of course not necessary, but the consent of the neighbors may be required for constructing ditches through their property, so as to regulate the supply and outflow of rain and snow water. As regards existing ponds all this has probably been satisfactorily arranged long since; but when new ponds are to be laid out this may involve such difficulties and expenses as to prevent the whole scheme.

8. The cost.—After all the above conditions for laying out a pond have been examined in the manner described, and have been found favorable, the question of the cost will have to be considered, and careful calculations should be made for the purpose of ascertaining whether the expenses connected with the laying out and the maintenance of the ponds will be so large as to be utterly disproportionate to the profits which may reasonably be expected from pond culture. The decisive point will be whether the laying out of a pond will insure the return of the capital invested within a reasonable period.

II.—The Construction of Ponds.

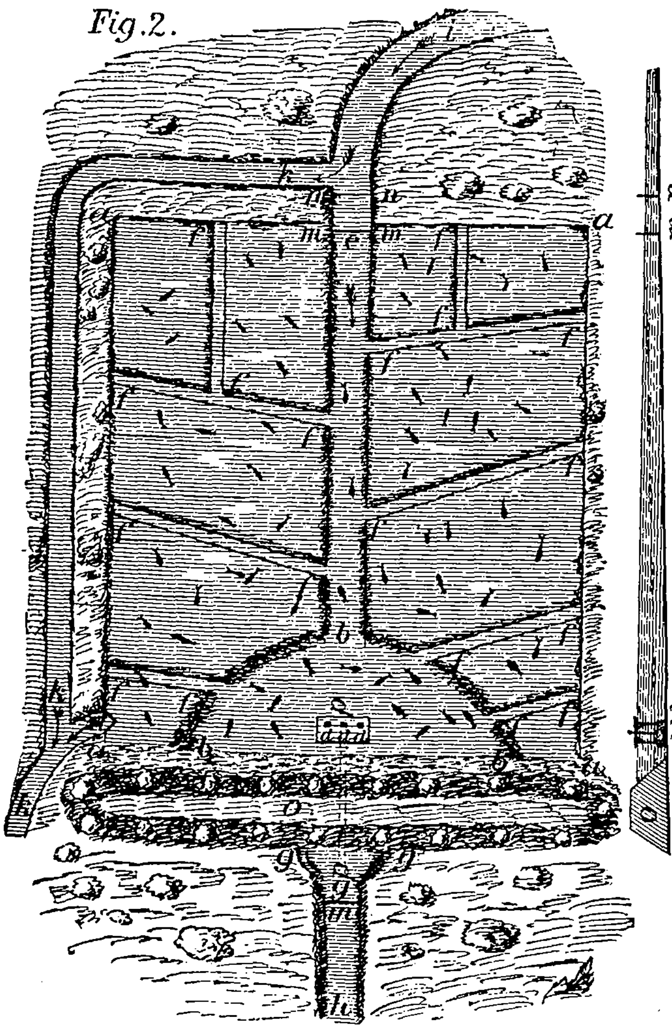
INTRODUCTION.

In the preceding chapter we have shown what conditions should be observed in the laying out of a pond; and in the present chapter we intend to show the manner in which ponds should be constructed in cases where all the above conditions are more or less favorable.

In laying out a pond the conditions of the ground should, as we have already mentioned, be carefully examined and the plan be made accordingly, one of the most important points being to secure a suitable depth of water. We have likewise indicated in the preceding chapter in what manner this should be done. The depth of the water is regulated by making the level of the water in the ditch through which it flows into the pond higher than the foot of the grate where the water flows out. The higher the foot of the grate, so much larger an area can be evenly flooded, and the lower the foot of the grate, so much smaller an area. The area of the pond should be determined by the quantity of water that can be used, and by the manner in which it is supplied, so as to prevent a lack of water in dry summers. No fixed rules can be laid down for this; and it will always be advisable in the beginning to flood only a comparatively small area by placing the bottom of the grates as low as possible, and it will soon appear whether it will be necessary to flood a larger area in order to obtain a suitable depth of water in the pond.

For the better understanding of the following, we will give here a ground plan and elevation of a fish-pond, showing its different parts.

Fig. 2.



aaaa, the pond; *bbb*, deep place where the fish can go when the rest of the pond is drained—the fish-pit; *cccc*, grates round the tap-house; *d*, tap-house; *ee*, main ditch; *fff*, side ditches; *g*, deep place where those fish are retained which escape through outlet pipes—the outer fish-pit; *h*, outlet; *i*, ditch through which the water flows into the pond; *kk*, ditch for superfluous water; *l*, grates; *m*, weir; *o*, dike; *p*, outlet pipe passing underneath the dike.

As a general rule small ponds are preferable to large ones, and the increased cost, occasioned by a larger number of dikes, will be amply repaid; for the water in small ponds can be rapidly heated by the sun, and in proportion to their size they afford more food for the fish than large ponds, and the fishing will be less expensive. This should be specially borne in mind in constructing a large pond, involving the necessity of including within its limits high ground having gravelly soil, which is of no value for fish-culture, and which would only produce a depth of water in the lower portions which would prove unfavorable to vegetation. The above, of course, applies only to the construction of new ponds; while in existing ponds inquiry will have to be made whether, and in how far, they answer the above conditions, and what improvements may be introduced either at the present or at some future time.

The work of constructing a pond may be subdivided as follows: (1) Building the dikes; (2) Constructing the principal ditches; (3) Constructing the side ditches; (4) Preparing the deep place where the fish go when the pond is drained—the fish-pit; (5) Preparing the deep place on the other side of the dike—the outer fish-pit; (6) Constructing the ditches for the superfluous water; (7) Making the proper arrangements for letting the water in and out; and (8) Placing the grates in position.

1. THE DIKE.

The building of the dike is the first work which should be done when a pond is to be constructed, for it serves to prevent the water in certain places from flowing any farther. It gathers the water, and thus forces it to spread in both directions above the dike. In large ponds, which frequently slope also toward the sides, it will sometimes be necessary to construct dikes along the side; but the pressure of the water against them will not be nearly so strong as against the main dike, and they therefore need not be built so solidly.

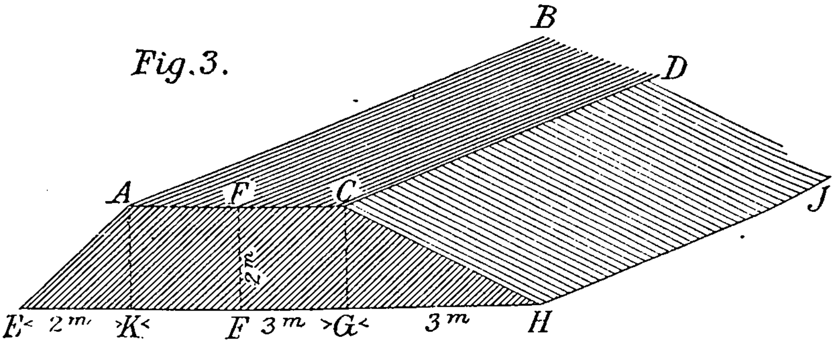
As a general rule, dikes should be constructed only on that side of the pond where the water is to be stopped in its flow. They have therefore to resist the pressure of the entire mass of water which rushes against them with full force. In order, therefore, for the dike to answer its purpose, *i. e.*, to resist the rushing waters, it must be built solidly. The larger the pond, the stronger the fall of the water, and the deeper the water, the more powerful will be the pressure against the dike, and the strength of the dike should be proportionate to the force of the water rushing against it.

In order to possess the necessary strength a dike should be solid, should have the requisite height and breadth, and its sides should slope in such a manner that the water cannot easily break through or overflow it. The solidity of a dike does not only depend on the manner in which it is constructed, but also on the material employed. Dikes are constructed of earth, wood, or stones, but in all cases the most important point will be the foundation.

The form of dikes differs according to the locality and the configuration of the ground. Dikes may therefore be either straight, or have one or several angles, or be constructed in the form of an arch, &c.

In order to answer their purpose dikes should be so high that they rise from 60 to 90 centimeters above the level of the water. In order to ascertain what height of dike will be required, the exact level of the ground which is to be filled with water should be found. If, *e. g.*, the fall for a certain space *a a* (see p. 14) has been found to be 120 centimeters, you add to this the proposed height of the dike above the level of the water, say 80 centimeters, and the entire height of the dike should be 200 centimeters or 2 meters.

Fig. 3.



The breadth of the dike at the top, AC, should be at least 120 centimeters, and as a general rule be equal to the depth of the water pressing against it. If, however, the dike is to be used as a carriage-road, its breadth at the top should be at least from 3 to 3.5 meters.

The side of the dike which slopes towards the water, also called the front scarp, CHJD, which is principally exposed to the pressure of the water, receives at least the double height, FF, as the base of the slope proper GH, and in order to make it still more solid it is covered with stones, fascines, wicker-work, &c.

The back scarp, AE, at its base equals only the height of the dike, FF, and remains uncovered.

That part of the dike which is near the outflow of the water should be particularly solid, and the bases of both its slopes, both front and back, should be of equal extent.

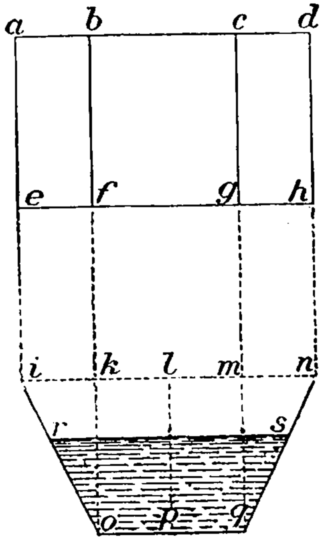
The place where the water is to flow out should be determined before work on the dike is commenced, the pipes should be laid, and the dike built over them.

If the sides of the dike are covered with anything—*e. g.*, stones, &c.—the base-line of the scarp, GH, may be shorter.

The top of the dike, ABCD, is called the crest, the lines AB and CD—*i. e.*, the lines where the scarp commences—the edge of the crest, and the line HJ the edge of the sole. The space between the front and back edge, EH, is called the sole of the dike, and the entire space is called the breadth of the sole.

As regards the ditches the same rules apply to the proportion of their dimensions and to their scarps as with the dikes, and similar terms are used. The inclined side of the ditch is called the scarp *i o* and *n g*. The lines drawn from one bank *i*, to a point *k*, and from *n* to *m*, where (at *k* and *m*) it meets a vertical line, is called the base line of the scarp. The bottom of the ditch, *o g*, is called the sole, the boundary line between the sole and the sides *b o* and *c q* are called the edges of the sole, and the boundary lines between the sides and the banks *a i* and *d n* are called the edges of the bank. The distance, *i n*, from the edge of one bank to the other is called the breadth of the ditch, and the distance from one edge of the sole to the other, *o g*, the breadth of the sole. The distance from one side to the other over the surface of the water, *r s*, is called the breadth of the water-level.

Fig. 4.



A.—*Building the dike and constructing the ditches.*

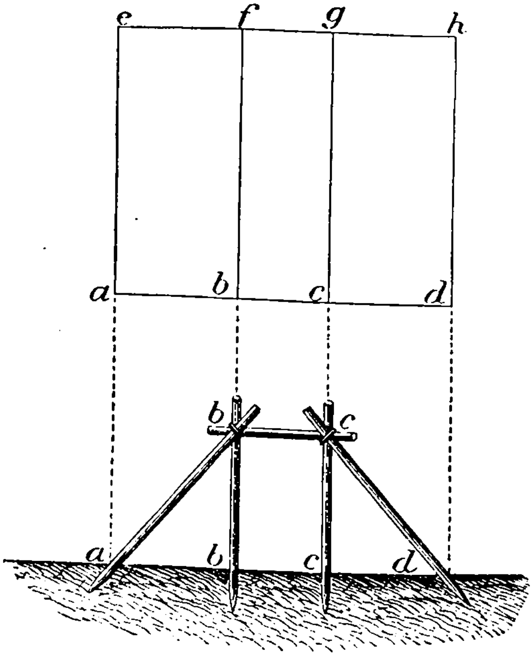
BUILDING EARTH-DIKES.

Before beginning the building of the dike it should be accurately laid out, *i. e.*, along the entire length of the proposed dike, the edge-lines of the crest, *b f* and *c g*, and the edge-lines of the sole, *a e* and *d h*, are marked by pegs and ropes.

As soon as this has been done the elevation is marked by poles and boards, (*a*) (*b*), (*b*) (*b*), (*c*) (*c*), and (*c*) (*d*), first of all at both ends of the dike, and, if it is not to run in a straight line, at every angle. Between the end points intermediate poles are placed along the proposed lines of the dike at intervals of 2 meters. In placing these intermediate poles in position one should begin from the highest points downward; and this rule should invariably be observed, as it will be impossible to find a perfect plain for the building of a dike. The scarps of the angles and the intermediate poles are determined by placing the eye close to the poles at one end and taking aim towards the poles at the other end. In order to insure successful work the poles or boards marking one and the same scarp should all incline at exactly the same angle.

Before beginning the earth-work of the dike one should commence digging some of the pond-ditches and fish-pits, and in order to further the work both should be carried on at the same time, so that earth dug out from the ditches may be at once used for the dike. It will be impossible, however, to commence work simultaneously on all the ditches, as they run in different directions, and the laborers in taking the earth to the dike would interfere with each other; nor can the earth-work of the entire dike be constructed simultaneously with the ditches, unless the main ditch is large enough to supply the earth for the entire length of the dike; but only so much of the dike should be constructed as will be supplied with sufficient earth from the ditches dug at the same time.

Fig. 5.



The main ditch should be the first to be dug, and simultaneously with this work the portions of the dike nearest the main ditch should be commenced and continued as far as the supply of earth permits; next the side ditches and the ditches for the superfluous water sould be begun, and thus, going on from the larger to the smaller ditches, the construction of the dike should be continued until it is completed. Before beginning the earth-work proper of the dike, its bed should be constructed by digging a hole along its entire length and breadth measuring 20 to 40 centimeters in depth, so that the foundation of the dike can be placed in the ground.

The width of the ditches is marked along their entire length by pegs and ropes, while their slopes are generally determined only after the bulk of the earth has been removed from them. If the slopes are to be marked prior to this, the inclination should be indicated by boards.

In order to make an estimate of the cost of the earth-work of a pond, and in order to draw up a plan for the work on the basis of the cost, it will be necessary to know what number of laborers, and what period of time, is required to complete the ditches and the dike. The following data may aid in making these estimates: The number of laborers will, of course, vary according to whether the ground is hard or soft. In this respect the earth may be classed under three heads: Easy to work (loose sand), tolerably easy (garden soil), and difficult (clayey or stony soil). In order to work conveniently with a shovel a man needs at least a space of 120 centimeters along the proposed site of the ditch, and thus it will be easy to determine the number of shovelers needed for a certain length of ditch. The above-mentioned space, of course, only applies to large ditches, such as those intended to let the water in and out, and in very large ponds also to the side ditches; but for small side ditches this space will have to be considerably enlarged, thus diminishing the number of shovelers, as the men would be in each other's way if placed so close together, owing to the more rapid progress of the work. A laborer can easily throw the earth with his shovel 3.6 meters in a horizontal and 2.3 meters in a vertical direction, which proves that for horizontal distance exceeding 3.6 meters and a vertical one exceeding 2.3 meters two rows of shovelers will be required. This will, however, hardly be necessary except in the construction of very large ponds, which need a very broad and deep main ditch for carrying a stream through them. In dividing the entire length of the proposed ditch in spaces of 120 centimeters, besides the shovelers other laborers will be needed to break the soil, to remove it to some distance, and to level and spread it on the place where the dike is to be constructed. All these men constitute a laboring squad. The distance of these squads from each other depends on the number of laborers at one's disposal, on the time in which it is intended to complete the dike, and on the size of the ditches. The greater these distances the fewer laborers will be needed, and the fewer laborers, all the slower will the work progress.

The above has been said, presuming that one has a sufficient number of laborers, that the pond and dike are to be constructed in the shortest possible time and with the greatest possible saving of labor and money, and that the earth from the main ditch is sufficient for the entire dike, because, although these conditions will in many cases be wanting, the greater portion of the dike should be constructed from the earth of the main ditch, unless this earth is from some cause not adapted to the purpose. If one knows the rules according to which the work should be carried on under these conditions, it will be easy to adapt these rules also to different conditions, and we shall, in the proper place, give some hints regarding this.

To return to the laboring squad, we know from experience that a loose sandy soil, not covered with turf, does not need to be broken, but as the soil down to the bottom or sole of the proposed ditch will often vary in its character, it will be advisable to count on employing some laborers for breaking the soil. For a tolerably easy soil (see above), as well as for sandy soil, one should count one man with a pickax to every two squads, and for difficult soil one such man to every squad, and in both cases one man per squad for leveling and pounding the soil.

Supposing that every shoveler could throw the earth to the place of its destination (which, however, will be very seldom the case, probably only in very small ponds, and in these along the fish-pit, as the main ditch does not run parallel with the dike, but strikes it mostly at a right angle, and as none of the other ditches run parallel with the dike), a squad working in sandy soil would comprise two and one-half men, and in difficult soil three men; but as soon as the earth is to be thrown farther than 3.6 meters each squad should be increased by one man for every additional 3.6 meters. In large ditches the earth has to be thrown not only horizontally, but also vertically; each squad should, therefore, be further increased by one shoveler; this would make per squad in tolerably easy soil three and one-half men, in difficult soil four men, presuming that the earth is to be thrown 3.6 meters in a horizontal direction. But as the distance to which the earth has to be thrown varies in the different squads, the number of laborers composing a squad will vary according to the greater or less need of additional shovelers.

In order to determine the number of laborers which will be required, the number of squads should be ascertained first, without regard to the shovelers needed for carrying the earth farther than 3.6 meters. The number of squads will be determined by the length of the dike, as these laborers will have to construct not only the ditch, but also the dike. The number of laborers being A, the length of the dike L, the distance assigned to each squad l, and the number of laborers per squad a, the formula is as follows:

$$A = \frac{L\,a}{l}$$

To this number should be added the shovelers who are to carry the earth to the dike.

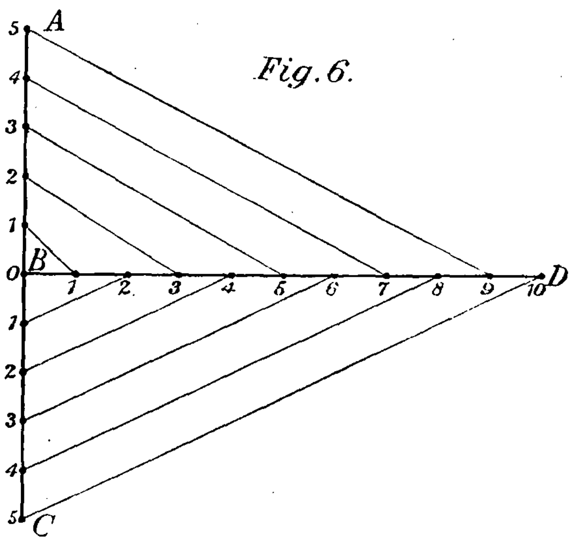
It will be necessary to know the total of all the distances to which the earth is to be removed by all the squads. The total of these distances, S, supposing the distance of the squad nearest the dike to be A, the distance of the farthest u, and the number of squads n, will be as follows:

$$S = \frac{n(A + u)}{2}$$

We must here observe that there is included in the squad one shoveler who has to throw the earth from the ditch a distance of 3.6 meters. This shoveler we do not count in the following calculations, because we do not count another shoveler for carrying the earth from the edge of the sole of the dike on the water side to that on the land side, and in the same cases on the dike itself.

The above formula is to be solved as follows: With a view of making it plainer we will describe the manner in which the laborers should be placed. This may be done in three different ways: (1) In such a manner that each squad carries the earth to the dike in a straight line, therefore by the shortest route. This is possible only if the work on the fish-pit and on the adjoining part of the dike is not commenced until the rest of the dike is finished. This is not advisable, however, in spite of its requiring one-tenth less shovelers for carrying the earth farther, because it is much more laborious, and the seeming saving of labor is lost either entirely or in part, and because the portion of the dike thus interpolated, as it were, will never join as firmly with the neighboring portions as when it is constructed simultaneously with them, although it should be particularly solid. For the sake of completeness, however, we will also make the calculation for this case. (2) In such a manner that the earth is carried away on a line running at a right angle with the line of digging. This cannot be avoided if the portion of the dike bordering the fish-pit is be constructed simultaneously with the rest of the dike, as on the shortest straight line the laborers would hinder each other in throwing the earth, as will appear from the drawing given below. (3) The interference of the laborers with each other, mentioned under 2, may be avoided by letting the men who have to remove the earth describe a curve instead of a right angle on their way from the ditch to the dike, which, moreover, has the advantage of causing a saving in shovelers, wheelbarrows, and carts.

It will be impossible, however, to lay down a general rule as to which of these first two methods should be followed, because the configuration of the ground will determine this in each case. Wherever practicable the curve is to be preferred to the straight lines running at right angles.



1. In the following figure the line A B C represents the edge of the sole of the dike on the land side, and the line B D the proposed main ditch, and it is assumed that the cubic contents of one division of the ditch corresponds to the cubic contents of earth of an equal division of the dike. Supposing this to be the case we can assign to each squad

the same space of dike and ditch. In order to make it clearer we have taken for our illustration a very small pond and a comparatively large scale, 1 to 120, which, however, will make no difference as regards the correct solution of the problem.

We now place along the line of the proposed ditch, at intervals of 1.2 meters, the squads of laborers at points 1 to 10 (we count four men to each squad, viz., one man with a pickax to break the ground, one shoveler who removes the earth from the ditch, one shoveler who throws the earth to the next shoveler, and one man for leveling the earth on the site of the dike). Squad 1 along the line of the ditch removes the earth to 1 on the line of the dike B A, 3 to 2, 5 to 3, 7 to 4, 9 to 5, 2 to 1 on the line of the dike B A, 4 to 2, 6 to 3, 8 to 4, and 10 to 5 of the same line (B A).

It would be an error if, instead of directing the ditch in a straight line towards the center of the dike and letting the laboring squads alternate on the right and left of the ditch, one was to work a part of the dike, AC, placed perpendicularly, or also at an angle at point B of the ditch, with its points A or C, as in that case the work would go from points 1, 2, 3, to 10 along the ditch towards the corresponding points 1, 2, 3, to 10 along the dike. The earth would then have to be thrown one-third farther than is the case in the plan illustrated by our figure. The case would be similar if one was to work from points 1 to 5 along the line of the ditch towards the corresponding points 1 to 5 along the line BC of the dike, and from the points 6 to 10 along the ditch towards the corresponding points 1 to 5 along the line BA of the dike. Moreover, the laboring squads would interfere with each other. This also applies to illustration of method 2, given below.

As will be seen from the figure, one-half of the dike and the ditch form a rectangular triangle, and the lines on which the earth is to be moved towards the dike divide the large triangles BCD and BAD into a number of smaller ones, whose hypotenuses are formed by the lines on which the earth is removed. If the two sides of the right angle are a and b the hypotenuse will be $\sqrt{a^2+b^2}$. As will readily be seen from the figure, the distances along which the earth is to be removed from the ditch, supposing that a is the space assigned to a squad along the dike and b that assigned to a squad along the ditch, will be as follows:

No. 1 = $\sqrt{1a^2+1b^2}$	No. 2 = $\sqrt{1a^2+2b^2}$
No. 3 = $\sqrt{2a^2+3b^2}$	No. 4 = $\sqrt{2a^2+4b^2}$
No. 5 = $\sqrt{3a^2+5b^2}$	No. 6 = $\sqrt{3a^2+6b^2}$
No. 7 = $\sqrt{4a^2+7b^2}$	No. 8 = $\sqrt{4a^2+8b^2}$
No. 9 = $\sqrt{5a^2+9b^2}$	No. 10 = $\sqrt{5a^2+10b^2}$

As will be seen, these distances increase at a certain rate from squad to squad, viz., if we always add 2 distances (1 + 2, 3 + 4, 5 + 6, &c.)

each two will increase by an equal space, so that we have here a progression which, if the number of squads is an even one (equal to the terms of a progression), would increase at the same rate from squad to squad, even if we had several hundred or any even number of squads. In this progression the first term, A, is equal to the distance between the first squad on the ditch and the portion of the dike assigned to it ($=\sqrt{1a^2+1b^2}$), and the last term, U, is equal to the distance between the last squad and their portion of the dike ($=\sqrt{5a^2+10b^2}$), and the number of all the terms of the progression n is equal to the total number of squads (in this case 10), from which results the above formula for ascertaining the sum total of the distances along which the earth has to be carried. This progression will be interrupted as soon as we take an odd number of squads (equal to the terms of the progression), because, as has been shown, the progression is only produced by adding the distances of each two squads. In order to use the formula given for progressions when we have an odd number of squads (if we could not use the calculation by progression we would have to find the distance of each squad, as was done for the 10 squads; these would have to be added, which, however, would be a very tedious work if the number of squads was large, and would, moreover, easily give rise to errors in the calculation owing to the long rows of figures), we must consider the last but one squad as the last term of the progression; we would then have to find the sum of this progression, to which would have to be added the distance of the last squad, in order to get the sum total of the distances of all the squads.

Supposing we have an odd number of squads, say, instead of 10, 9, we would get the following distances:

1st squad $= \sqrt{1a^2+1b^2}$

2d squad $= \sqrt{1a^2+2b^2}$

3d squad $= \sqrt{2a^2+3b^2}$

4th squad $= \sqrt{2a^2+4b^2}$

5th squad $= \sqrt{3a^2+5b^2}$

6th squad $= \sqrt{3a^2+6b^2}$

7th squad $= \sqrt{4a^2+7b^2}$

8th squad $= \sqrt{4a^2+8b^2}$

9th squad $= \sqrt{5a^2+9b^2}$

the sum of which, S, the first squad being A, and the last even one u (here 8), and the final odd squad Z (here 9), and the number of even squads n (here 8), would be as follows:

$$S = \frac{n(A+u)}{2} + Z.$$

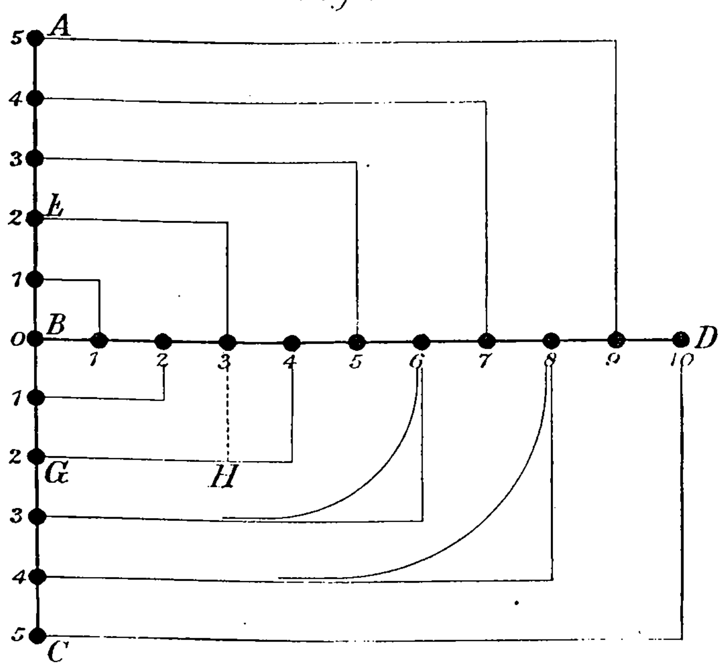
After having in this manner found the sum total of all the distances, the next question will be to find the number of shovelers required. This is found by dividing the sum of these distances by the distance which a laborer can conveniently throw the earth in a horizontal direction, *i. e.*, 3.6 meters.

It will be better, however, to divide by 3.5, as in this way a distance will be over, for which, if it is too great to be divided among the shovelers, another shoveler should be engaged, which will be an easy matter. The necessary number of shovelvers, Sh, for removing the earth will be found by the following formula:

$$Sh = \frac{S}{3.5} = \frac{n(A + u)}{7}$$

2. We have now to speak of the second method of placing the laborers.

Fig. 7.



Leaving the fish-pit for the present out of our calculation, the same formula will have to be used as in 1, for getting the sum total of all the distances and the required number of shovelers. All we have to ascertain are the distances over which the first and the last squad will have to remove the earth to the dike.

The length of each of the individual distances has been given here only for the purpose of showing the progression.

As will be seen from the figure, the individual distances of the parts of the ditch from their corresponding points along the line of the dike will—presuming the part of the dike assigned to a squad to be a and the part of the ditch assigned to a squad b—be as follows:

Squad 1 on the ditch $= 1a + 1b$
Squad 2 on the ditch $= 1a + 2b$
Squad 3 on the ditch $= 2a + 3b$
Squad 4 on the ditch $= 2a + 4b$
Squad 5 on the ditch $= 3a + 5b$
Squad 6 on the ditch $= 3a + 6b$
Squad 7 on the ditch $= 4a + 7b$
Squad 8 on the ditch $= 4a + 8b$
Squad 9 on the ditch $= 5a + 9b$
Squad 10 on the ditch $= 5a + 10b$

We have here another progression, and it will, therefore, not be necessary, as has been done in this case for the sake of illustration, to ascertain the length of each part, but it will be sufficient to ascertain that of the first and of the last squad, no matter whether the number of squads is a hundred or any other number. The formula for this has already been given under 1.

3. The same applies to the curved lines. For our present purpose I deemed it proper to choose the straight lines, because they will make the method of calculation more intelligible.

For 2 and 3 the same formula will, therefore, have to be used as for 1, in order to find the necessary number of shovelers, and what has been said there with reference to an even or odd number of squads will likewise apply here.

If the fish-pit, E F G H, is to be dug at the same time, the first terms, 1, 2, 3, 4, representing the squads working the parts 2—2 of the dike, would be dropped from the above progression, because they and the corresponding part of the ditch would be worked by the squads assigned to the fish-pit, which would also dig the portion of the ditch between 3 and 4, as soon as they do not need it for their arrangement, and the number of squads N, which would have to be used for ascertaining the number of shovelers, would now be 6 instead of 10, and the first term for calculating the progression would be the 5th term, *i. e.*, the distance assigned to the 5th squad. The placing of the laborers for the fish-pit is done parallel with the dike on line F H, which may be divided among 4 squads working in the same manner as the rest of the squads; for every distance exceeding 3.6 meters an additional shoveler should be employed.

The fish-pit is dug out in the same manner as a large ditch. The formula for ascertaining the total number of laborers required for constructing a dike with the necessary ditches, will, on the basis of the formula given above for finding the number of laborers, excluding, however, the special shovelers for any distances exceeding 3.6 meters, be as follows, (sh being the number of shovelers required for the fish-pit):

$$A = \left(\frac{La}{l} + Sh + sh\right)$$

But as the fish-pit runs parallel with the dike, and consequently the line of the work has also to be run parallel with it, the number of shovelers for each squad will be the same; and if F stands for the number of laborers required for the fish-pit, L for the portion of the dike alongside of the fish-pit, *a* for the number of laborers per squad, and *l* for the distance assigned to each squad, the formula will be:

$$F = \frac{La}{l}$$

which formula will be needed, if, for special reasons, the fish-pit is to be constructed after the main ditch and the dike, which, however, cannot be recommended. In this case it should not be forgotten, in the first calculation of the number of laborers (exclusive of the special shovelers referred to several times), to omit the portion of the dike which is bordered by the fish-pit. The fish-pit, and the portion of the dike belonging to it, may also be calculated separately, as well as the rest of the dike and the ditches belonging to it; in this case the number of laborers found for each should be added, and in this way one would get the number of laborers required for the entire dike and all the ditches.

If it is intended to commence work along the entire line of the dike with a certain given number of laborers, and to push the work to completion in all its parts, the length of a piece, *l*, should be ascertained, which should be worked by one squad, according to the following formula:

$$l = \frac{LA}{A} + Sh + sh$$

and, accordingly, each squad should be assigned that length of ditch which will furnish the necessary quantity of earth for the allotted length of dike.

In order to find the time in which, with the greatest possible or any given number of laborers, the dike can be constructed, all that is necessary is to calculate the cubic contents of a portion of the ditch which has been assigned to a squad, which will supply the demand of a corresponding piece of the dike, and to divide this by the cubic contents of a piece of the ditch removed in an hour, or in a day, and the quotient will be the number of working hours or days.

In the example given as an illustration the most favorable case was supposed, viz., that the main ditch, of equal length with the dike, would supply earth for the entire dike, that, therefore, the earth removed from the portion of the ditch assigned to each squad is equal to the cube of that portion of the dike which they strike. If the ditch is not so large it will be advisable to construct as much of the dike as can be completed with the earth supplied from the ditch. In this case it would be necessary, if one divides the line of the dike into parts measuring 1.2 meters each (greater distances should be avoided, as otherwise the pounders would be too far apart to pound sufficiently the newly heaped-up earth), to calculate the cube of each of the above-mentioned parts, and from this the length of ditch to be assigned to each squad, so as to make sure that the cubic contents of the length of ditch will supply the necessary quantity of earth for the corresponding portion of the dike, in which case, therefore, the squads working along the ditch will have longer distances assigned to them than those working on the dike. The same principle is observed as regards the distribution of labor on the other portions of the dike and the ditches supplying the material for the same. It is known from experience that one man, if the soil is tolerably easy to work in, can remove 450 cubic decimeters of earth in one hour; if the soil is sandy, 600; and if it is difficult, 300. This applies also to an entire squad of laborers, as only one of their number removes the earth from the ditch, the others being employed in carrying it farther and leveling it.

The carrying of earth in wheelbarrows should, as much as possible, be avoided, as it takes more time than throwing it; this difference is not equalized by saving some men for throwing the earth, and this method is consequently more expensive. Wheelbarrows should be employed only when a sufficient number of laborers cannot be obtained, or in cases where the distances between the ditch and the dike are very great. A wheelbarrow holds on an average 21 cubic decimeters of earth, and two men can in one hour dig out 450 cubic decimeters and load them on the wheelbarrows. One man can in twelve working hours travel over an even road 28 kilometers (with wheelbarrow, coming and going). If we let w stand for the distance traveled, the cubic contents, K, of the quantity of earth removed in one hour by a wheelbarrow will be ascertained by the following formula:

$$K = \frac{21.21.2000}{36\,w + 350} \text{ cubic decimeters,}$$

and the number of men at the wheelbarrows, A, for every two men digging and loading the earth will be:

$$A = \frac{(36\,w + 350)}{7.\,7.\,40.}$$

For a distance exceeding 1 kilometer it may be advisable to employ carts. A cart with two horses can carry 450 cubic decimeters of earth, and, on an even road, travel 28 kilometers in twelve hours. For every loading and unloading a loss of seven minutes should be counted. In going uphill the distance traveled should be increased by four times as many meters as 30 centimeters is contained in the difference between the even and the uphill roads. In going downhill the same rule applies as on an even road. The above, of course, only applies to horses; if oxen are employed only 0.7 of these figures should be counted. The cubic contents, K, of the earth to be removed in one hour is:

$$K = \frac{450.\ 7000}{6\ w + 4900} \text{ cubic centimeters,}$$

and in order to ascertain how many carts or wagons, W, are required to remove the quantity of earth dug out by two men in one hour the following formula will have to be used:

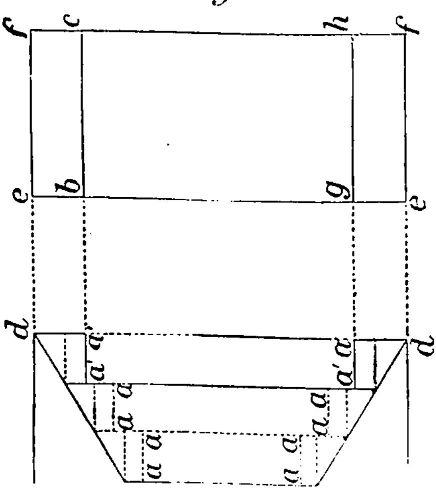
$$W = \frac{(6w + 4900)}{7000}.$$

We now have to speak of

THE CONSTRUCTION OF THE EARTH-WORKS.

In constructing large ditches, such as the main ditches and those for letting the water in and out, it will be found a great aid in constructing their walls or sides to dig out perpendicular steps 30, 60, and 90 centimeters high. These steps should vary in breadth from 15 to 60 centimeters; their breadth, however, will greatly depend on their height and on the angle of the slope. Only those on which laborers are to stand must at least be 90 centimeters broad. The Perpendicular sides *a a* of these steps (see the figure) should be distant about 15 centimeters from the proposed walls of the ditch, so that these may not be damaged. The breadth of the first step, carried inward from the terraced level edge of one of the sides of the ditch, supplies the end points for the line *b c*, along which the laborers are to be placed, and the same principle applied to the other side of the ditch supplies the line *g h*, the limits of the first prism *a′ a′ a′ a′* to be dug out. In order to accelerate the work it will be advisable to mark with pegs the piece assigned to each squad of laborers. The laborers are placed, according to the direction (either right or left) of the lines of work from the ditch towards the dike, in such a manner as to place one squad on the line *b c*, and the next on the line *g h*. Before the shovelers can be employed to move the earth farther,

Fig. 8.



every squad along the ditch should have piled enough earth at a distance of 3.6 meters, to give work to one shoveler, and as soon as it has been moved another 3.6 meters to another shoveler, and so on till the earth is brought to the edge of the sole of the dike on the land side. In constructing small ponds the piling up of the earth and the consequent placing of the shovelers will progress so rapidly that there will be no need of temporarily finding other employment for these shovelers. In large ponds they may, unless employed in digging the foundation of the dike, temporarily engage in some other work, *e. g.*, the digging of another ditch, and whenever needed they may be called on to aid in the construction of the dike. But even in the case of large ponds the time till the shovelers are needed at the dike will be very short; if, however, the number of these shovelers is large, an unnecessary expense would be incurred by letting them stand idle, even for a short time. After all the shovelers have been set to work in removing the earth towards the dike, and every squad is, therefore, complete, it will be found (if the calculation has been correct as to the nature of the soil, the outlines of the piece of ground to be worked, and the distances for which the earth has to be carried) that one shoveler, seconded by a proportionate number of men with pickaxes, will dig out and throw the earth the distance assigned him, one man will level it and pound it, and the other shovelers will be engaged in moving it from one point to the other.

As regards the pounders, it will be best to place several in a row, because if each one pounds at some distance from the other the earth will escape on all sides. If there is any scarcity of rammers, the different layers may be trodden down by the laborers; but as in that case one man would not be sufficient to attend both to the leveling and pounding, it will be found advantageous to supply the necessary number of rammers, one to each man. After the first prism has been dug out, work is commenced on the second, and so on till the sole of the ditch is reached. The deeper one goes the slower will the work progress, because the earth will have to be thrown not only in a horizontal but also in a vertical direction.

In case the scarfs of the dike are not to be covered, as much good earth as possible should be used for the outer coating. This earth should be piled up beyond the outer edges of the boards indicating the outlines, and should here be particularly well pounded and beaten together with broad and heavy pieces of wood. During this whole process the earth should be sprinkled a little. When this has been done the scarfs are, with the shovel, made as smooth and exact as possible, which adds greatly to their firmness, as the water is not apt to do as much damage to a smooth wall of earth as to one intersected by large and small furrows. If the dike is to remain uncovered, it should under all circumstances be planted with willows. If the sides are to be covered, one leaves a distance of 45 to 60 centimeters between the earth-work and the ropes indicating the outline, and does not begin to cover the dike until it has reached one-half or three-fourths of its height, so that during the rapid progress of the work of covering it there may always be sufficient earth for filling out. We shall below give directions as to the various methods to be followed in covering a dike. After the ditch has been dug out in its rough outline, furrows are cut in the steps in those places where the profiles of the ditch, lengthened upwards, have been drawn, in the same direction as these profiles. Thereupon the boards are lengthened downward, the wedge-shaped pieces of earth are removed with a spade, and finally the walls of the ditch are made as smooth and accurate as possible. The earth obtained by this process is used for completing the dike; if it should not prove sufficient it may be advisable to enlarge the ditches and the fish-pit. If even then the quantity of earth should not be sufficient it should be obtained from other places.

If the dike is to be built of a soil which consists only of one layer of good earth, and for the rest is composed of sand and stones, this layer should be taken off and piled up along the edge of the foot of the scarp on the water side, so as to serve as an outer coating, while the stones, &c., may be used for the inside. In this case it will always be necessary to obtain some earth from another locality. If the dike is to be placed on sloping ground it should have a very firm foundation, so that it cannot easily slide down. If the slope is very steep a sort of step should be dug out for the foundation, and if the slope is gentle, only a hole 20 to 40 centimeters deep; but, even in the latter case, the step referred to may answer the purpose. In the former case, trenches 50 to 60 centimeters broad are dug along the entire length of the proposed dike at intervals also of 50 to 60 centimeters, so that a small piece of the original soil remains between the different trenches, and the earth of the dike may, so to speak, be dovetailed with the original soil. No special laborers need be employed for preparing the foundation of the dike; this should be done by the shovelers and pounders during the intervals of their labor until they can be employed in removing the earth, and until a sufficient quantity of earth is piled up near the dike to begin with the leveling and pounding.

B.—*Covering the dike.*

In order to give the greatest possible firmness to the dike, the earthwork is surrounded with a coating of more solid material. This coating is particularly needed on the water side, and, if it is in any way possible, it should not be omitted on that side, which should also be planted with willows. If good earth has been employed this coating may be omitted on the land side, but even here it will prove an advantage. The land side should also, under all circumstances, be planted with willows.

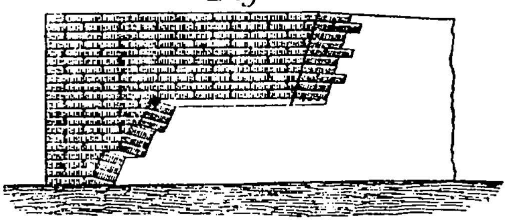
The dikes are covered either with 1, sod; 2, fascines; 3, wickerwork; 4, earth; or 5, wood.

1. *Sod.*—For this purpose there will be needed pieces of sod 30 centimeters broad, 30 to 45 centimeters long, and 10 to 15 centimeters thick,

For the corners, pieces of sod 45 centimeters broad and long are used. These pieces are obtained by the simple process of cutting or digging. In order to work dry sod advantageously it is sprinkled for several days before it is cut. It will be still better, however, to leave this work to nature, and not to begin digging until rain has sufficiently moistened the sod. The best sod is that which has a dense growth of short fine grass on a dark soil, while sod from a very moist or sandy soil is not good. Sod removed from a very moist soil will, when deprived of its natural moisture, soon wither and die; and sod from a sandy soil will fall to pieces when it is handled. Sod taken from a damp soil would thrive, when used on the water side, if the pond was filled with water immediately upon the completion of the dike, which, however, cannot be done, as one generally gives the dike a year's time to settle and become solid. After the place where the sod is to be cut has been marked off in suitable squares it will, if the sod is easy to cut, take three and, if difficult, five men to cut 2,000 pieces in twelve hours. This work had best be done in the following manner: One man inserts the spade to a depth of 10 to 15 centimeters, while two assistants, by a vigorous pull, strip off the sod, whereupon the first man lifts it out entirely and lays it on the ground with the grassy side downward. It is true that this work might be done by one man without any assistants, but in that case he will be able to supply in twelve hours only about one-fifth or one-sixth of the number of pieces which 3 men can supply. If possible no more pieces should be cut at a time than can be used up in one day, so that they may not dry out. If the supply on hand cannot be used up in one day, the remainder should be piled up to the height of 60 to 100 centimeters, and, if the weather is dry, be thoroughly sprinkled in the evening. The pieces of sod are carried in hods, similar to those employed for bricks. Such a hod will hold eight to ten pieces, while a common wheelbarrow will at most hold six.

The covering of the dike is done in the following manner:

Fig. 9



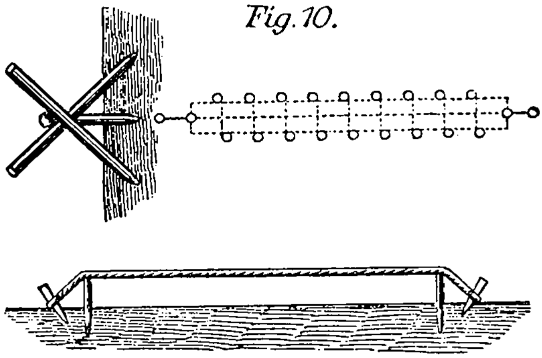
All the pieces, with the exception of the topmost layer, are laid down with the grassy side downward, so that their broad sides stand perpendicularly on the wall formed by them, and no seam comes to be over another one. The pieces composing the lowest layer are placed entirely in the ground. The pieces should join closely, and if the wall is to be scarped, extend to the outermost edges of the boards forming the profile, otherwise only to the inner edges of the same. In order to give greater firmness to the corners it will be advantageous to use for them larger pieces, about 45 centimeters square, by laying them alternating, with the ordinary pieces (30 centimeters square). Each layer is carefully smoothed down and the empty space in front of it filled with earth, which is rammed down. The uppermost layer is laid with the grassy side upward, and every layer is fastened with one or two pegs 30 centimeters long and 4 centimeters thick. After this has been done the wall is scarped and smoothed down, which, however, will not be necessary if the pieces of sod have been carefully laid. In order to make the connection between the covering and the earth-work of the dike stronger every third layer may be double, when the front pieces should be cut 10 centimeters (as shown in the figure), or larger pieces should be employed. A squad of three men, one of whom carries the pieces of sod, while the second lays and fastens them, and the third fills the spaces between the earth-work and the covering with earth and rams it down, can use 2,000 pieces in twelve hours.

The dimensions of the walls which are to be covered, and those of the pieces of sod, whose thickness will be only 7 to 10 centimeters even if they have been dug out from a depth of 10 to 15 centimeters, will determine the entire amount of pieces of sod required, to which should be added 10 per cent for those which cannot be used. The length of wall which can be covered in one hour is calculated by dividing the number of layers required for the entire wall by the number of pieces of sod (160) which can be laid in one hour, and the quotient is multiplied by the length of that side of the piece of sod which comes nearest the wall. This way of covering a dike with sod is called the head-sod covering. One may also, but only in case of very gentle slopes and wherever very solid soil can be obtained, cover the walls, after they have been scarped, with pieces of sod in such a manner that every piece lies with the grassy side upward, and in order to make this covering still more solid every piece may be pinned down with two pegs. It will be easily understood, however, that this mode of covering will not be near as solid as the one described above. The first-mentioned method should be employed in all cases where there is no solid earth for the outer sides of the earth-work and where it is impossible to obtain material for wicker-work. If instead of the pegs referred to shoots of willows can be used, the willow plantation will have been provided at the same time. Most of these shoots will thrive. If there are not enough of them to supply both the land and water side of the dike, they should only be used for the latter. Willows should likewise be planted along the foot of the dike.

2. *Fascine covering.*—The most solid covering, and that which can be made in a comparatively short time, is that by fascines. By fascines we understand cylinder-shaped bundles of dry sticks, tied very firmly, measuring at most 5.4 and at least 3 meters in length and 25 to 30 centimeters in thickness. If there is a sufficient quantity of material in the

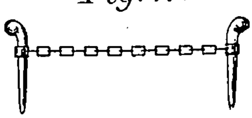
neighborhood these fascines can be prepared rapidly, and if there are enough willows near by, they are to be preferred to any other kind of covering. If there are not enough willows, the branches of poplars, alders, hazel bushes, birches, &c., may be used. If the number of willows is not sufficient to supply all, or at least one-half, of the fascines, one may alternately place one row of willow fascines and a row of those made of other material, or in making the fascines the willow branches may be put on the outside and the others inside. If the willows will not suffice for this, it will be advisable to use wicker-work for the covering of the dike. The branches or sticks used for fascines should be as long as possible and not more than 5 centimeters thick. For tying the bundles thin willow branches will be best, and if these cannot be obtained, thin branches of wild grape-vines, birches, and hazel bushes. It will in every respect be found advantageous, if possible, to manufacture the fascines in the place where the material is found. For making fascines, so-called fascine benches will be needed. For making these benches, which, as shown in the figure, should first be marked off by pegs, there will be required 18 pegs, measuring 6 to 8 centimeters in thickness and 175 centimeters in length, and 18 bands to tie the fascines.

Fig. 10.



In arranging the pegs, which cross each other, they should, especially if the ground is soft in the beginning, be placed almost perpendicularly, and be gradually inclined till they reach the rope stretched at a distance of 30 centimeters above the ground. At the place where the pegs cross each other they should be very firmly tied with willow branches or fastened with nails. Six men can make at least 30 pegs in twelve hours, if they are to be cut from solid wood, and a great many more if thin branches are used. For making fascines a squad of five men needs one pair of fascine pinchers (see the figure), one fascine knife, one stick of the same length as the fascines are to be (one will be sufficient for three squads of laborers), one short and thin stick 30 centimeters long, for measuring the distances between the bands, a thin switch, easily bent, for ascertaining the thickness (25 centimeters) of the fascines,

Fig. 11.



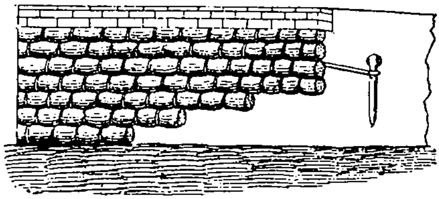
and a piece of wood, shaped like a two-pronged fork, for putting on the bands. The necessary quantity of sticks should, of course, be on hand, and 18 bands per fascine. Of these bands an extra supply should, however, be kept on hand, as many of them will tear; and if the work is to progress rapidly, a large quantity of bands should be on hand when the work commences. With the exception of those made of wild grape-vines and willows, they should all be heated before the fire and twisted a little, so as to make them tough. At their thin end they should have a loop. In order to make the fascines of equal thickness, *i. e.*, in the shape of cylinders, a bundle of sticks, with all the thick ends together towards the outside, is placed on the fascine bench; and thus one continues to lay bundles of sticks along the entire length of the bench in such a manner that the thick ends of one bundle are always over the thin ends of the next. Sticks are piled on until, by measuring the circumference with the above-mentioned pliable switch (for which purpose the fascine pinchers should also be used), one finds that the necessary diameter has been reached. In tying the fascines, two men press the sticks outside of the first cross together (with the fascine pinchers) in such a manner that the ends of the measuring switch, applied close to the place where the pegs are tied, lap over a little; a third man thereupon catches the bundles with the band in the same place, and in such a manner that he can draw its thick end downward through the loop, places the fork-shaped piece of wood on the loop, presses it with one foot, draws the band downward (when drawn upward it generally tears), twists it, thereby forms a sort of screw, and finally sticks the thick end of the band among the branches of the fascine. The fascine pinchers should be drawn off gently, because otherwise the band might easily be broken by the rebounding of the sticks of the fascine. In this manner all the 18 bands are put on, at intervals of 30 centimeters, all the screw-like portions (see above) being in a straight line, so that when the fascines are fastened to the earth-work of the dike they all may be on the inside. The next thing to do is to cut the fascine vertically 15 centimeters from the first band; from this point one measures 540 centimeters and cuts the fascine again, the fascine pinchers being put on the fascine outside of the saw with which the cutting is done, and finally the fascine is trimmed and cleaned of all protruding branches. If the bands are good, a laboring squad can easily finish a fascine 540 centimeters long in one hour. For transporting such fascines two men will be needed for short and three for long distances. If the roads are in good condition, a two-horse wagon can carry eight such fascines.

For the purpose of covering the earth-work of a dike with fascines, there will be needed for pinning them down thick pegs measuring 60 to 90 centimeters in length, and 7 to 10 centimeters in thickness. Six men can easily make 1,000 such pegs in one hour. There are also needed pegs with hooks, measuring 1 meter in length and 5 to 7 meters in thickness; of these the same number of men can make only 500 per hour.

The bands which are to serve for fastening the fascines must be very strong and long, and have a loop at each end. To every hooked peg one should count two such bands.

The fascines, which are close to the ground, should be entirely inserted in it, and all the screw-like pieces of the bands should be on the inside. This bottom layer of fascines is, at intervals of 30 centimeters, fastened to the ground by pegs measuring 60 to 90 centimeters in length. The other layers are pinned to the earth-work of the dike at intervals of 60 centimeters, with pegs 1 meter long (by the aid of these figures the whole number of pegs needed may be calculated). No succeeding layer of fascines should be pinned to the earth-work, until the empty space between the preceding one and the wall of the dike has been filled with earth well rammed down, nor should any of the places where one fascine joins the other be above another such place. Every third layer should be firmly anchored by means of pegs and bands at intervals of 2 meters. It will, therefore, be easy to ascertain the entire number of pegs and bands to be used for this purpose.

Fig. 12.



The fascine covering should be carried only to such a height as to leave room for from 25 to 30 centimeters of earth, which should be well rammed down. If there are any pieces of sod, at least two layers of these should be placed on the topmost fascine before the earth is put on. This is necessary in order that the cover may not project over the edge of the crest, when the earth begins to settle after awhile.

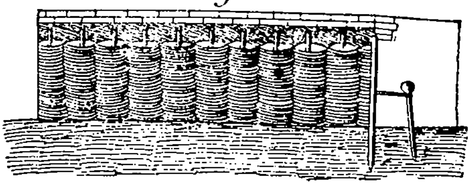
A squad of five men, with one mallet, one spade, and one rammer, can easily lay, pin, and anchor 21.6 meters, *i. e.*, 4 fascines measuring 5.4 meters each, in one hour. Some men should be ready with saws, for sawing off the fascines, if necessary. In a dike running in a straight line this will, however, be necessary only at the ends. By pinning, the fascines lose at least 25 millimeters of their diameter, which circumstance should be taken into consideration if the length of wall is to be calculated which a laboring squad can cover with fascines in one hour. L standing for this length of wall, and *a* for the necessary number of layers of fascines for a given height of wall, the thickness of the fascines being 22.5 meters, and the consecutive meters of fascines to be laid in one hour being 21.6, the following will be the formula:

$$L = \frac{21.6}{a\ 0.225}.$$

3. *Covering of wicker-work.*—To cover dikes with wicker-work involves but little trouble. This method, however, can be employed only in small

dikes with a height of wall of 1 to 2 meters, as with a greater height the mass of earth would exercise too great a pressure on the weak wicker-work. Whenever this method is employed in higher dikes their height should be broken by several terraces. The material for wicker-work is, of course, branches, those of the willow tree, whenever obtainable, to be preferred, because they will save the special planting of trees, as such wicker-work will soon grow and have numerous shoots. If willow branches cannot be obtained, the branches of poplars, alders, birches, &c., may be used. The branches should be long and slender, and 2, at most 3, centimeters thick, so that they can be twisted round the sticks without any trouble. Very thin branches would have to be plaited like the wicker-work of baskets, which would delay the work and make it more expensive. One man with a hatchet can in twelve hours cut enough branches to form 17 square meters of wicker-work covering. The sticks for the wicker-work should be 5 to 8 centimeters thick and project 60 centimeters above the wicker-work, and should, if possible, be taken from willow trees. If these sticks are to be cut from the solid wood, six men with the necessary tools can make 300 of them in twelve hours; if, however, young stems or branches of sufficient thickness can be used, this will be a great saving of time and labor.

Fig. 13.



Hints as to the manufacturing of the hooked sticks and bands have already been given above under the heading of the fascine covering. Laths or poles will be required for connecting the sticks, about 2.15 meters to every 2 consecutive meters of wall.

The covering of the dike with wicker-work is done in the following manner: The sticks are driven into the ground, at intervals of 30 centimeters, to a depth of 45 centimeters, and to prevent their being pulled out of position during the plaiting of the wicker-work they are at their tops connected by poles or laths. The wicker-work should enter at least 10 centimeters deep into the natural soil. As in fascine-covering, the wicker-work is made about 25 to 30 centimeters lower than the dike. In order to accomplish the work in the shortest possible time one should proceed in the following manner: The branches are laid down along the entire line of the dike at a distance of one pace. One man commences to plait at one end by laying the individual branches alternating inside and outside the sticks. If the branches are too thin several should be formed into a bundle. After the first man has proceeded 5 to 6 paces, a second one commences to plait, to be followed at a similar distance by the third and last man. In this way the work will progress rapidly, one man driving the other. The anchoring may, in dikes measuring 1 meter in height, be done in the middle; and in dikes measuring

2 meters at one-third and two-thirds of the entire height, at intervals of 1.8 meters. Double anchoring is done somewhat on the model of a chess-board. If, *e. g.*, at one-third of the height the 1st, 6th (or 7th), and 12th (or 13th) sticks have been anchored, this is done at two-thirds of the height with the 3d (or 4th), 9th (or 10th), and 15th (or 16th), &c. After the wicker-work has been carried to the necessary height the last three or four branches are, at intervals of 1.8 meters, tied to the sticks with bands, and finally earth is piled up over the wicker-work to the height of 25 to 30 centimeters and rammed down; or, as shown in the figure, two or three layers of pieces of sod are fastened to the dike. A squad of three men, supplied with the necessary tools, can ram in 300 sticks in twelve hours. A squad of five plaiters needs a fascine knife, a spade, and a mallet; and after the sticks have been driven in the ground they can finish 2.5 square meters of wicker-work in one hour, three men doing the plaiting, while one man fills the space between the wicker-work and the dike with earth, and another one carries the branches.

4. *Earth-covering.*—This consists of a cover of earth 45 to 90 centimeters thick, which serves as a coating for a dike composed of loose soil. Clayey or loamy soil will be best suited for this purpose. This covering is made by piling up layers 15 to 20 centimeters high of soil carefully freed from all stones. Every layer is well rammed down, and, if the weather is dry, it is sprinkled. In order to have the earth-work connect thoroughly with the covering, it will be well to ram down the covering in the shape of steps. For a length of dike of 1 meter, one man with a rammer will be needed, and to every 24 rammers, one man with a sprinkler. In this manner the earth-covering will progress at the rate of about 30 centimeters per hour. Earth-covering can be used only when the slope of the dike is very gentle, the base of the slope being equal to the entire height of the dike; and if one is compelled to employ this method of covering, the slope of the dike should be made to accord with it. This covering should be sowed with grass seed or planted with willows, by simply planting young shoots. Horak says in regard to this: "Among the willows the common basket-willow is the best, as it will thrive in a loose, moist soil, and is well adapted to wicker-work and fascines. One-year-old shoots, 20 to 30 centimeters long, should be used, putting seven-eighths of their entire length in loose soil and only allowing one-eighth to protrude. The beds where these shoots are to be planted should be hoed in a breadth of 20 to 30 centimeters and to a similar depth, and the shoots should be planted just as one plants young vegetables. If these shoots are well watered during dry seasons they will grow to the height of 50 to 70 centimeters during the first year. If the shoots are simply stuck in a hard soil the bark and the germ are destroyed, and the plantation will prove a failure."*

If the earth-covering is planted with willows immediately after its completion it will, of course, not be necessary to hoe the soil, as it will

* *Deutsche Fischerei-Zeitung*, 1878, No. 21.

be sufficiently loose, and all that is necessary will be to make holes in the ground for receiving the shoots In old dikes and wherever the earth has settled and become hard the hoeing should never be omitted.

5. *Wood-covering.*—This method consists in ramming in piles about 10 centimeters thick at intervals of 1 meter along the water side of the dike. These piles should be square, and back of them strong boards are placed, whose edges must fit closely together. They may also lap over a little, but in that case more boards will be needed. The places where the boards join should not be one over the other. These boards are nailed to the posts, which, in order to render them more durable, are generally made of oak wood. Both the posts and the boards should be covered with tar or creosote. Such wooden dikes, as they are called, should not rise perpendicularly on the water side, but must likewise slope somewhat, the base of the slope to be at least one-sixth of the height of the dike. Wood-covering, however, should be employed only in case of urgent necessity, *i. e.*, when no other material for covering the dike can be obtained, for it is not only very expensive, but it is also the least durable kind of covering, and requiring constant repairs.

C.—*Stone dikes.*

Unless constructed of square pieces of stone fitting closely together, stone dikes are the least practical of all dikes; but if constructed in this manner they will be so expensive as to prevent the laying out of the pond altogether. Dikes composed of earth and stones mixed will have the least firmness, because the water will easily work a way for itself between the stones. Such dikes must have a covering. Dikes composed of a large number of irregularly shaped stones, placed closely one upon the other, will still let the water pass through. The walls of the dike, at any rate on the water side, should therefore be well built with mortar and cement. Large stones, however, may well be used for filling out the dike, if there is enough binding earth to cover it, especially on the water side. But, wherever a firm dike is needed, and where it is impossible to construct an earth dike with any of the coverings described above, it will be safest to build along the water side a strong wall with a slope towards the water, and supported on the back by stone pillars. Back of this wall the dike is constructed of stones and sand as firmly as possible. Such a dike should be very broad, so as not to be pushed back by the wall (against which danger the pillars afford some, but not absolute, protection), and of corresponding height, so that during freshets the water may not overflow it and carry away the back part, *i. e.*, the dike proper. To make such an occurrence absolutely impossible, it will be necessary to build a similar wall also on the land side. In cases where the ditches furnish only gravel and sand for the construction of the dike it will not be advisable to lay out a pond, for the bottom of such a pond would not supply sufficient and suitable food to the finer kinds of fish, especially the carp, and would not hold water. The case will be different if the bottom of the pond has a layer of good earth on the top, then sand below this good earth, and below this sand good earth again. Neither wood nor stone dikes will then be necessary, but a dike made partly of earth and partly of sand and gravel, covered with one of the coverings described above, will answer the purpose.

D.—*Fascine dikes.*

These dikes are made of fascines in the following manner: A layer of fascines is placed along the entire breadth of the sole in the natural soil, and fastened in the ground at intervals of 30 centimeters, with sticks or pegs measuring 60 to 70 centimeters in length. The next layer of fascines is placed crosswise over the first, the next lengthwise, the next again crosswise, and so on until the dike has reached a proper height and shape. Great care should be taken that the seams of the fascines are not one above the other. Every layer is anchored, like the fascine covering, at intervals of 2 meters, and each individual fascine is pinned to the one below with pegs measuring 1 meter in length at intervals of 60 centimeters. Each layer is well filled with sand or gravel before the next layer is put on. Such a dike should have a gentle slope, and the walls, as well as the crest, should be covered with good earth (if possible) to the depth of 25 centimeters and well rammed down. If the outer fascines are made of willow branches there will soon be a growth of young willow shoots. Fascine dikes are very durable, but they require an enormous quantity of branches, and if there is a lack of binding earth, the covering will also have to be fascines or wicker-work.

No rules can be laid down as to the material for building the wall and constructing the covering, as this will have to be determined in each case by the local circumstances, especially by the degree of firmness which the dike needs in proportion to the size of the pond and the mass of water rushing against it; and, in the second place, by the building material at one's disposal. In a work like the present we can only point out the advantages of one method over the other, leaving to the pond culturist the choice of the methods, according to his peculiar circumstances; and it is not supposed that, in a case where wicker-work answers all purposes, he will choose the more expensive fascine covering, even if he should possess all the necessary material therefor.

2. THE MAIN DITCH.

This ditch should cross the entire pond in a straight line from the place where the water enters to its outflow. As it will be found advantageous to have all ponds so constructed as to allow the wintering of fish, the main ditch should, wherever the given quantity of water permits it, be at least 1.5 meters deep. The width of the ditch at the top will be determined by the base line of the slope; if the slope is gentle, it will be wide, and if steep, narrow. The question whether the slope is to be more or less gentle will depend on the quality of the soil from which the ditch is dug, whether it is firm or loose. The grade should also be taken into consideration. The steeper the grade the gentler should be the slopes of the walls of the ditch. In very loose soil the base line of the slope should be twice the depth of the ditch, in medium soil 1.5 of the depth, and in clayey soil equal to the depth. The breadth of the sole may be made to correspond with the quantity of water and the size of the pond; it will be advisible, however, in case the quantity of water in the ditch is as a rule moderate, but rises considerably at times, to make the sole very broad, and dig out from it a small ditch corresponding to the average depth of water. In small ponds, where it is not intended to winter fish, the main ditch may be less than 1.5 meters deep, and its other dimensions should be made to correspond with this depth. If there is a sufficient supply of water, a depth of 1.5 meters will be ample for wintering fish, and if the grade of the pond is very steep, and the greatest height of the water above the bottom of the pond is more than one meter, it will be well to diminish the depth of the ditch by this excess of height over 1 meter. The main ditch, as well as all the other ditches, should be carefully constructed, so that along the entire length the upper width and the breadth of the sole remain the same, and the slope is even and smooth throughout, as otherwise there is danger of their being washed out.

3. THE SIDE DITCHES.

In order to drain the pond and lay it dry, small side ditches will be needed, which end at the banks. Their number will depend on the size, location, and nature of the pond. Muddy and mossy ponds, containing many reeds, will require more such ditches than ponds with a firm bottom, which are free from such obstructions. They should invariably fall towards the main ditch, for they are not only intended, whenever the pond is drained for fishing, to compel the fish, as the water recedes, to fly to them, and thus to carry them to the main ditch and ultimately to the fish-pit, but they should also lead the water by the shortest possible way to the main ditch, and through this to the outflow. When the ponds have been laid dry and planted, they are to serve as receptacles for the rain-water, and as channels through which it can flow off quickly. During the fisheries they are also intended to enable the fishermen to penetrate into the thickets of reeds, and drive into them all fish which may have remained in these thickets, so that they may ultimately be carried to the fish-pit. In large ponds the main ditch and some of the side ditches should be broad enough for a boat to pass through them. The grade of these ditches should be the same, so that the fish do not remain scattered throughout the side ditches, thus making fishing difficult.

If there are many depressions in the bottom of the pond, ditches should be constructed from these to the main ditch, in order to cause the fish to enter them, and allow the fishermen to approach these depressions for catching the fish hiding in them. In ponds containing a great many reeds the side ditches are also to serve as roads by which the fish may easily reach their feeding-places near the banks, and as places of refuge in all parts of the pond, where they may find safety from birds of prey and other enemies of fish. Their construction and maintenance should therefore keep all these purposes in view, and they should be kept clean at all times. After the ponds have been laid dry, and the fisheries are over, special attention should be given to the cleaning out of mud from these ditches.

4. THE FISH-PIT.

In order to drain a pond completely and catch all the fish contained in it, the fish must be gathered within a narrow space, where they have water enough to prevent any suffering during the fisheries. For this purpose it is necessary to have a depression near the place where the water flows off into which the fish may gather when the pond is drained, and from which they can easily be taken with nets. This depression is called the fish-pit. When the pond is being drained, the fish, as the water recedes, seek the deep water of the ditches, and through these they enter the fish-pit. The fish-pit will best be formed by widening the main ditch either on one side of the ditch, as we generally find it in old ponds, or extending it equally on both sides, which will probably be the more practical way.

The fish-pit should be kept as clean as possible of mud, and it will therefore be advisable to line it with wood. This should only be omitted in ponds which have a very firm bottom and but little mud. The fish-pit of those ponds, however, which are to serve as spawning ponds should be lined with wood, unless the bottom is very clayey and firm, so that it may be possible to take out all the young fry. The fish-pit should be entirely free from stones, bushes, reeds, &c., so that the fish may not hurt themselves during the fisheries and during wintering, and likewise to prevent any tearing of the nets. After every fishing season the fish-pit should, therefore, be carefully cleaned. If the fish-pit is only to serve for fishing purposes, its depth need not be very great, but in order that the water may be let off entirely, and the pond may be cleared of fish, its bottom should be higher than the outlet pipes. If the fish-pit is intended also for wintering fish, its depth should be great enough to prevent the freezing of the pond in winter, and it should be at least 2 meters deeper than the greatest depth of water elsewhere in the pond.

In order to gain some means of determining the approximate size of the fish-pit, we will state that one generally counts 800 cubic decimeters of water to 100 pounds of carp; but it will in all cases be advisable to count double this quantity, especially when the fish-pit is to serve as a wintering place, or when there is a possible lack of water during the fisheries. Fish of prey, like pike, &c., need a still greater quantity of water and consequently a still larger fish-pit. As not only the success of the fisheries, but also the safety and well-being of the fish during winter, depends on the proper construction of the fish-pit, it should be carefully constructed and kept scrupulously clean.

5. THE OUTSIDE PIT.

In order to catch those fish, which, in spite of all precautionary measures, such as grates, nets, &c., escape through the outlet pipes, a depression corresponding to the fish-pit should be constructed on the land side of the dam, where the water leaves the outlet pipes, so that the fish may be gathered and caught in it. This depression is called the outside pit. It should be closed against the outer outlet ditch by a narrow grating. This will be all the more necessary if below the main pond there are spawning or growing ponds which are fed from it, so as to prevent fish of prey from entering them. The grating is not only intended to prevent the food-fish from escaping, but also to retain small fish which are used for feeding the fish of prey in the main ponds or tanks. The outside pit should always have a depth of water sufficient to keep the pipes under water, as only thus will they last for centuries, while, laid dry and exposed to the air, they will soon decay. The size of the outside pit will be regulated by the size and location of the pond, as well as by the quantity of fish it is expected to hold. With large ponds the outside pit is generally a square hole in the ground lined with wood.

6. DITCHES FOR THE SUPERFLUOUS WATER.

Whenever streams or brooks pass through a pond, it will be necessary to place a weir with locks in these streams or brooks, so that the necessary quantity of water may at any time be let into the pond, while the superfluous water must be carried away through ditches. This will be necessary particularly in mountain streams, as during heavy rains they will carry a great deal of gravel, small stones, and mud, which would soon obstruct the pond. Such waters should be caught outside the pond, or the weir, in the ditches which carry it round the pond, so as to join the stream again below the pond. The ditches for the superfluous water should be of sufficient breadth and depth to receive the quantity of water which may be expected, They should be carefully constructed, as irregular sides are much more exposed to the destructive force of the water than smooth ones. For better protection it will be well to plant the sides with willows. Wherever the tap system is employed, the outlet pipes are, after the water in the pond has been raised to its normal height, closed by a tap, which is not drawn till the fisheries commence, unless special circumstances should require it. In small ponds, whose supply of water is, as a general rule, small, and at times interrupted—as is specially the case with sky ponds—it will be necessary, in order to keep the water at its normal height, that a suitable means of escape should be furnished to the water, somewhere along the bank, usually near the point of the dike. This is likewise done by ditches which receive and carry away all the superfluous water from the pond and the surrounding cultivated land. These ditches, of which a large pond should have several, must at their starting point near the bank be closed with grates, so that no fish can escape through them. Such ditches also become necessary, where, after violent rain storms, or by the melting of the snow in spring, there is danger of inundations. To receive and carry away the water from such inundations, ditches should likewise be constructed in suitable places.

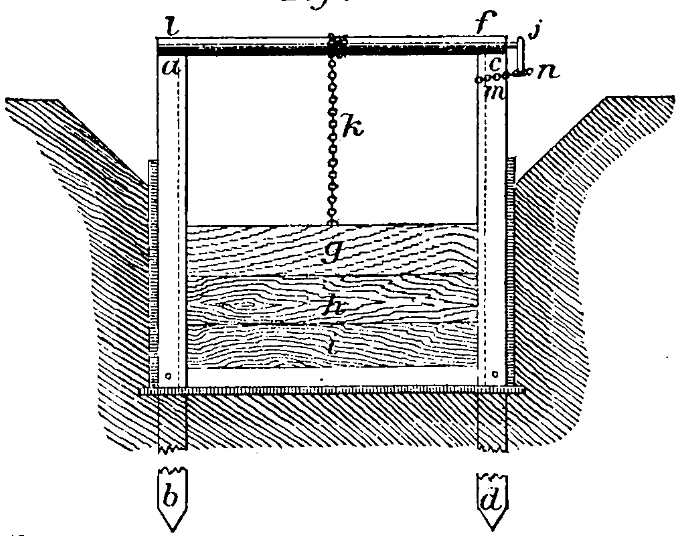
7. ARRANGEMENTS FOR LETTING THE WATER IN AND OUT.

A.—Weirs with locks (sluices).

The feeding ditch receives its water either, *a*, from a river or brook; *b*, from one or several springs; *c*, from rain or snow water (as in sky ponds); *d*, from other ponds.

a. A pond may be fed by a river or brook, either by having a portion of its waters led into it through channels, or by causing the entire stream to pass through the pond. In both cases it will be necessary to put a weir, with locks, at the place where the water enters, so that the supply of water may be properly regulated. In the first case, the water pursues its natural course in the bed of the river; and, in the second case, *i. e.*, where the weir is placed in the stream itself, the water has to be led in ditches round the pond to rejoin its original stream below the same. In both cases a narrow grate should be put at the place where the water enters the pond, so as to keep out intruders, especially fish of prey. Such weirs are constructed in the following manner:

Fig. 14.



Along the banks of the river, or at the opening of the dam (when the brook or river passes through the pond), strong wooden posts, *a b* and *c d*, are rammed in, and connected by a cross-beam of equal strength, *l f*. The opening should be tolerably wide, especially where much water flows into the pond. The bottom should be covered with strong pieces of wood, or with masonry, up to a level with the average height of the water. On this foundation rest strong movable boards, *g*, *h*, *i*, which should fit so exactly in grooves in the posts that no water can pass through. The two posts *a b* and *c d* must be so firmly connected with the dike, or with the banks of the stream, that the water cannot possibly force a passage between the posts and the sides of the dike. Instead of making grooves in the two posts *a b* and *c d* two posts may be placed on each side so close together that the spaces between them form grooves for the boards. In that case the posts should be so close together that no water can pass between them and the boards. The lowest board should fit exactly in a groove in the strong beam on which it rests. It will, of course, depend on the accuracy with which all this work is done whether the flow of the water can be properly regulated. The foundation beam, with its groove, should always be secured by iron clamps, so as to resist any pressure of the water. If one board is not sufficient, another one, or several, one above the other, should be used. Suitable contrivances should be connected with the cross-beam *l f* for raising and lowering the boards. The easiest way to do this is to make the cross-beam in the shape of a roller, as shown in the figure, or to place a roller immediately below the cross-beam. The roller and the boards are connected by a chain, *k*, so that by turning the roller by means of the lever *j* the boards can be raised or lowered. When the boards have been raised to the desired height, the lever is fastened to the post *c d* by the chain *m*, and secured in its position by a padlock, *n*, so that the arrangement cannot be tampered with. If the weir is very broad, it may be well to ram down in the center one or two posts of equal strength with the side posts, and use only short boards, which run in the grooves formed by these center posts. These short boards are easily raised and lowered and may be recommended because the water can be more easily regulated by them, as it will not be necessary to open the entire weir. In order to give firmness to the whole, strong posts should be laid close together at the bottom of the weir, and reach up to the first board. In order to prevent the water from washing out the holes underneath the weir, and thereby forcing a passage (which might easily happen if the weir was placed directly upon the ground), the ground below the weir should be covered for a length of 2 to 2.5 meters, or more, with strong posts and boards forming a firm floor, so that the superfluous water may easily flow off along this floor. Such weirs are, especially in large ponds, the safest and simplest means of regulating the water.

If it is impossible to carry off the superfluous water of a brook or stream passing through a pond by means of outside ditches, it should be allowed to flow in over a weir, so as to direct it towards the exit by the shortest road, so that the fish may not be disturbed or carried away by it. It will always be found advantageous to have smaller or larger weirs, according to the size of the pond and the quantity of water which flows into it, as they are, after all, the best means of regulating the supply of water. It will, under all circumstances, be advisable to keep the sluice-gate under lock and key, so that it cannot be opened by mischievous persons. This can be done in a very simple manner by a lever which holds the boards in position, and which is locked to one of the side-posts.

In large ponds it may become necessary to construct canals through the banks and dikes for the supply and exit of the water, generally in very steep places. Such canals should be very carefully constructed, so that no damage may be done to the bank or dike, and experts should be engaged for the purpose. Such canals may also be needed in ponds which have weirs, so as to supply still more outlets for the water, to decrease the force of the stream passing through a pond, or to carry off the water from remote portions of the pond, for which purposes weirs will not always suffice. For draining the pond for the purpose of fishing, there are conduits or pipes underneath the dam, through which the water may flow out. They fully answer this purpose, for weirs or sluices are not so practical in this case, as their management is always connected with some difficulty.

b and *c*. The supply of water from springs and, in sky ponds, from the atmosphere, will never be so large as to make it a matter of indifference whether this supply is constant, or whether there is, in sky ponds, anything to prevent the free entrance of rain or snow water; but as a general rule these means of supplying water need no special regulation. Weirs are therefore not needed, and all that is necessary will be to put a grate at the place where the water enters freely, but which prevents the fish from escaping. Any superfluous water may be carried off through outside ditches or be led to the lower pond or ponds.

d. A lower pond (or ponds) is filled from a higher pond by simply letting the water flow to its destination through pipes, until the desired height of water has been obtained, when the tap is driven in again. The supply of water coming in during the course of the year reaches the lower ponds through the outside ditches of the upper ponds, until a full supply is obtained, and the superfluous water is carried off through other outside ditches. All that is needed to regulate the water flowing through these various ditches will be to put grates in them at suitable places.

B.—Water-pipes.

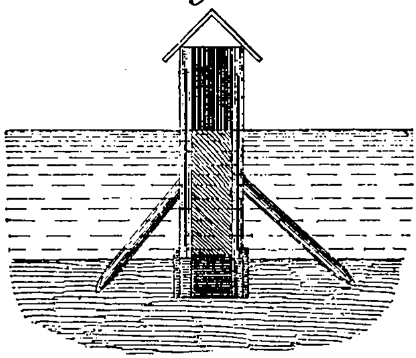
To drain a pond for the purpose of fishing two means may be employed, viz., taps and stand-pipes. For both these methods pipes are needed. These pipes are laid horizontally through the dike. They should lie 15 to 20 centimeters deeper than the bottom of the pond, or rather of the fish-pit, in which they open, so that they can receive all the water. To prevent the water from flowing out too near the dike, whereby it might be damaged, the pipes should extend 2 or 3 meters into the pond, and project about 1 meter on the land side. When laid, the pipes should be well enveloped in clay on all sides, so that the water may not force a passage by the side of them; for this will always be the place where there is danger that the water may escape from the pond. These pipes are made of the trunks of trees which are split in half and hollowed out; another half trunk, likewise hollowed out, is used for the upper portion, or lid; as soon as the lower one has been laid, the upper one is placed on the top of it. They should, of course, fit accurately. For this purpose a layer of fine moss is made, carefully cleaned of roots, branches, stones, &c. Such pipes can hold a good deal of water, and are, especially in large ponds, the safest means of supplying an exit for the water. If made of sound pines felled during winter, they will last for centuries, provided that they are constantly kept under water. As the laying of the pipes always necessitates the digging up of the dike, durability should of course be the first consideration; for this labor involves many inconveniences and considerable expense. The width of bore of these pipes should be regulated by the size of the pond, so as to allow the water to flow off in a suitable period of time. As a rule, however, the bore should not be wider than 30 centimeters, particularly as the water is apt to widen it in course of time. In large ponds there should be two, three, or more of these pipes, which should be laid at such distances from each other that for the purposes of repairs one of them can be dug up without interfering with the others.

In small, remote ponds, which are apt to be visited by fish-thieves, the openings of the pipes should be narrow, so that the water cannot flow off quickly, and requires more time than fish-thieves generally have at their disposal; for it will of course be easier to steal fish from a pond which can be drained in four to six hours, therefore in one night, than from one which takes from twelve to twenty-four hours.

C.—THE STAND-PIPE.

This consists of a second pipe placed vertically on the exit-pipe. This pipe is likewise made of a hollow trunk which is open on one side, where grooves run along its edges in which small boards can be inserted, and easily removed. The vertical pipe should project somewhat over the dike, so that the pond may be filled to any desired height. According to Jokisch, vertical pipes are also employed which are only as high as the average height of water in the pond (especially in ponds which have a constant supply of water). Such pipes are left open at the top, so that the small boards reach as far as the other sides of the pipe. The upper square opening is covered with a grate, so that the water when it rises above its normal height may flow off without carrying any fish with it. The same author says that a better contrivance of a similar character may also be connected with the common vertical pipes. They are allowed to rise as complete pipes (not halved), and only a little above the high-water mark they are cut down, so as to form a point resembling a roof, and small boards or pieces of tin are nailed to the top, so as to prevent it from rotting. The small boards should fit accurately so that as little water as possible may ooze through; and all cracks should be well closed with a mixture of clay and fine-cut straw, and covered with tar and sand. Where there is danger that ice may press against the vertical pipe, it will be well to drive some piles in front of the pipe, so as to prevent the ice from loosening the small boards.*

Fig. 15.



Delius says: "The exit-grate needs some arrangement to raise the water which flows through it, to any desired height, and cause it to flow out, for on this depends the regulating of the height of water in the ponds. In large ponds only one vertical pipe can be used. With grates having projecting sides, the vertical pipe is placed on the foundation-beam and firmly connected with it, as well as with the top of the grate. The open side is turned towards the pond, and each side has a groove in which are inserted small close-fitting boards corresponding to the height of the water. Only above these boards can the water of the pond flow off, and by inserting them, or taking them out, the height of the water can easily be regulated. The space between the sides of the pipe and the corner posts is closed by pieces of wood. At the back the pipe has an opening in which is inserted a small pipe intended to carry farther the water coming from above. The space round this small pipe is filled up with clay well rammed down. A still simpler arrangement, but only suitable for small ponds, is the so-called monk. Instead of the foundation-beam a long pipe is laid through the dike, so as to project on both sides; with this pipe is connected a vertical pipe, also with grooves and small boards inserted in these. If this monk is allowed to project far enough into the pond to make it difficult to reach it from the shore, it will not be easy to damage it, especially if the water is deep."†

According to Horak, vertical pipes are employed to advantage where small brooks pass through a pond, and where it is desirable to keep the water at an even height. The topmost little board is, so to speak, the indicator of the normal height, and all the superfluous water will easily pass over it. The pond may be drained gradually by removing one little board after the other till the bottom is reached.‡

I am inclined to prefer the stand-pipe, both in large and small ponds,

*Jokisch, *Handbuch der Fischerei*, 1804. (Manual of Fisheries.)

†Delius, *Teichwirthschaft*, pp. 87, 88.

‡Horak, *Teichwirthschaft*, 1869.

to all other methods of carrying off the water, not only because it is self-acting in keeping the water at a level even at times when the supply of water is superabundant, thus rendering outside ditches unnecessary, and because the draining of the pond can thereby be easily managed and regulated, but also because the change in the height of the water, when the supply is scanty, can readily be recognized by it. When the water falls one can, so to speak, read its height on the stand-pipe, for which purpose it will be well to make the little boards all of one and the same height and number them; and as it is important for the pond culturist to be able to find the different causes of the varying productiveness of his ponds, he will be aided in this by the stand-pipe which will enable him to ascertain at once the height of the water. Stand-pipes will, therefore, be of special importance in sky ponds.

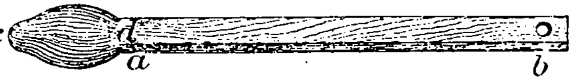
D.—The tap-exit.

This consists simply in placing a suitable piece of wood, called the tap, in the opening where the stand-pipe, described in the preceding chapter, joins the exit-pipe. In small ponds short, and in large ponds long, taps are used. Tscheiner says regarding short taps: "The short tap, which does not protrude above the surface of the water, will prevent thieving, and deserves special mention. It is about 60 to 70 centimeters long and shaped exactly like the lower portion of a common tap. After it has been firmly inserted in the hole, some centimeters, both in depth and breadth, of the wood are removed from the top, which is covered with a broad piece of iron having a long and narrow hole in the center. For drawing the tap a so-called key is necessary, consisting of a cross-shaped piece of iron, which must fit in the hole. To the other end of the key a pole is fastened. If several small ponds are to be closed by a short tap, the holes in the taps should be all of the same size, so that they can all be opened with one key. To open a pond closed in this manner, seek the hole with your key; as soon as found, insert the key; turn it half around, and thus lift the tap from the water. This can, of course, only be done in small ponds, when the taps are not large, and consequently not very heavy. In very small ponds, where diminutive taps are used, it will be sufficient to make at the top of the tap a small notch, in which, when it is to be drawn, the so-called pond-hook is inserted."

It should be observed that these contrivances for drawing a short tap will not suffice for drawing it out entirely, as it has to be driven in very firmly in order to keep the arrangement water-tight. It will therefore be necessary in all cases to loosen the tap by knocking it several times, when it can be taken out without the aid of any special contrivance. If the method described above is to be employed, it should not be forgotten to give the iron on the top a coat of paint to keep it from rusting. At the moment when the tap is drawn, a piece of wire-work is inserted in the hole. A grate should be put in front of the exit, or it should be surrounded by a standing net.

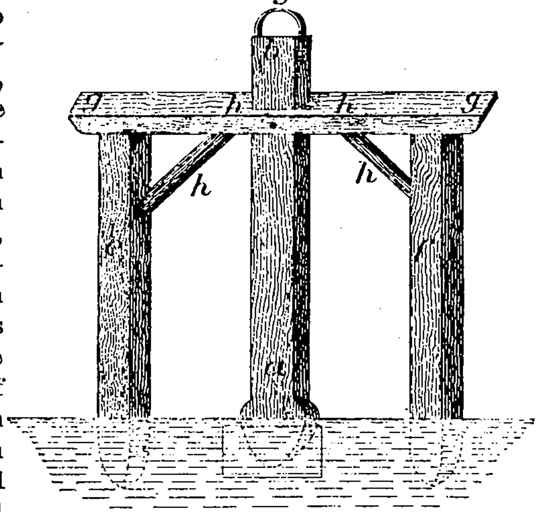
In great ponds where the pipes are large, and where the tap closing them is correspondingly large and heavy, it consists of a piece of solid

Fig. 16



wood, about 3 meters long (if the pond is very deep, still longer), the lower part of which is formed by the tap. In order to insert and draw this tap, the following contrivance will be necessary:

Fig. 17.



On both sides of the exit opening strong posts, *e f*, are driven in, which at the top are connected by an equally strong cross-beam, *g g*, and, in order to make the structure still stronger, are further connected by two braces, *h h*. In the center of the cross-beam there is an opening, *h h*, through which runs the tap-pole, *a b*,* and which when the tap is inserted projects about 30 centimeters above the cross-beam. The head of the tap-pole is covered with iron, in which a strong iron ring is firmly inserted and fastened with screws. All the iron-work is painted, to prevent it from rusting. Where the tap-pole passes through the cross-beam a strong screw is driven in, so as to prevent mischievous persons from drawing the tap. If there are several such tap contrivances, it will be well to have all these screws of the same size, so that they can be drawn by one and the same screw-driver. Whenever the tap is to be drawn, a strong pole is passed through the ring, and by moving this pole up and down (which operation requires three and sometimes more men), the tap is loosened and finally pulled out. In large ponds such contrivances are, on two sides, surrounded by a stone or wooden wall, so as to protect them against waves and ice. This wall is not continued on the side towards the pond, but is here replaced by a grate to prevent the fish

* These figures, with their explanations, are often obscure or in error. For instance, in Fig. 17, *h* means two different things.—EDITOR.

from escaping through the exit-pipes into the outside pit, whenever the tap has been drawn and the pond is being drained. In small ponds it will be sufficient to surround these contrivances on three, and sometimes on four, sides with grates; or even omitting these, to place simply a standing net in front of them during the fishing season. This, however, will be advisable only when a very short tap is used. Formerly the entire contrivance was sheltered by a roof, and has from this circumstance retained its name, "tap-house." If this tap-house is placed far out in the pond, it is connected with the dike by long boards which answer the purpose of a bridge. Of late years the tap-houses in large ponds have been built of stone and masonry. Horak says, regarding the advantages and disadvantages of such tap-houses, as compared with wooden ones:

"On the Wittingau estate a beginning with stone tap-houses was made in 1831; and since that time the old wooden tap-houses are, instead of being repaired after the spring floods at a great expense, replaced by new and solid ones built of stone. They are not only to be preferred because there is a saving of lumber, but also because they offer many other advantages. In the first place they are better able to resist the winter storms, and the floods and ice of spring, and they very seldom need repairs; the outlet pipes are not placed upright, but inclined at an angle of 40 degrees, and are protected by a solid stone covering. In the old wooden tap-houses the front was occupied by a grate; that portion of it which was under the water could, of course, easily resist any hurtful influences, while the portion above the surface, owing to the changes in the weather, would soon decay, and frequently be destroyed by the waves and by masses of ice pressing against it, which of course would cause the fish to escape into the tap-houses, and thence into the outside pit. It is now customary in stone tap-houses to have the grates entirely under the water; these grates resemble square cages, which, back of the scarf of the wall, are inserted in the bottom of the pond, and can be seen only when the pond is entirely drained. It cannot be denied, however, that stone tap-houses also have their disadvantages. As these stone tap-houses require the tap-pole to be in a vertical position, it will be necessary, in building a tap-house, to drive a shaft in the scarp of the dike down to the pipes and there make an opening to admit the tap. The entire structure becomes more erect, is moved closer to the terrace of the dam, and is connected with it in such a manner that the new tap-house only forms a sort of projection on this terrace.

"Among the disadvantages of stone tap-houses we must also mention the following: During very cold weather the tap-poles will freeze in the water, and as there is no possibility, as in the old wooden tap-houses, to get at the opening of the pipe, it will be necessary, whenever water is to be drained off during the winter, to heat the lower wall near the opening in the pipe, until the ice melts and the tap can be drawn. Iron grates are not practical. It has happened that through oxidation iron grates became so obstructed that openings had to be forced with strong poles, during which operation some of the bars of the grate were generally broken, and, to prevent the fish from escaping, the holes in the grates had to be stopped with fascines. Wherever iron grates have been employed they are gradually being replaced by wooden ones. When stone tap-houses were first built iron taps were fastened to wooden poles, which, however, did not prove a practical arrangement, because it frequently happened that the iron taps remained in the pipe, and only the poles were drawn, which, of course, necessitated laborious and expensive repairs. Although the stone tap-houses are liable to cause peculiar difficulties, the pond culturist should not thereby be discouraged, but he should endeavor to improve these tap-houses in every possible way, because, on the whole, they are far preferable to the old and cumbersome wooden boxes."*

E.—The grates.

All the exits of a pond must be so arranged that the water can flow off easily, without giving the fish any chance to escape. For this purpose grates are placed not only at all the exits, but also at the places where the water enters the pond, for it is well-known that fish like to go against the stream.

Delius gives the following description of the grate:

"It is a wooden grating, the bars of which are placed vertically, and which is close enough to keep the fish from passing through, while it

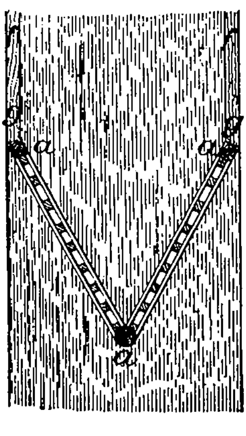
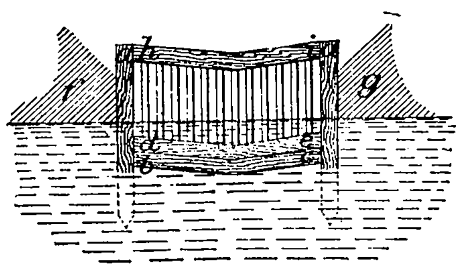


Fig. 18.



offers an unobstructed passage to the water. The size of the spaces between the bars depends upon the size of the fish which are in the pond. The following is the construction of the grate: On both sides of the ditch strong posts, *a a*, are driven in; between these posts another ditch is dug, across which beams, *b c*, are firmly laid; on the top of this

* Horak, *Teichwirthschaft*, 1869.

wooden foundation another cross-beam is laid, *d e*, in which the bars are inserted. The upper one of these two cross-beams is firmly joined to the side posts. The space in front and back of the foundation is filled with clay, which is rammed down firmly and smoothed on the top. On both sides of the posts a wooden wall, *f g*, is placed. The beams forming the foundation are on a level with the bottom of the ditch, while the wooden wall has about the same height as the average level of the water. Several feet above the surface of the water a cross-beam, *h i*, connects the two posts. The space between the foundation and this cross-beam is occupied by vertical bars which are inserted in holes in the cross-beam and in the foundation."* It will be found exceedingly practical to have two such grates meet at an angle, so that they can better resist the pressure of the water, and let more water pass through. Wherever the pressure of the water is not very strong a simple grate will suffice.

III.—Filling the pond with water.

After the pond has been constructed in the manner described above, and after the dike has been allowed to dry and become firm, the pond can be filled with water. In filling a pond two questions have to be considered, viz.: 1. How is it to be filled? and 2. At what time?

1. How filled.—When the pond is to be filled, all the exits have to be closed up, the taps are firmly driven into their places, and the tap-pole is screwed to the cross-beam. All crevices round the tap are carefully stopped up with moss or clay, so that there is no possibility that the water can enter the pipes. Earth may also be piled up round the tap, and rammed down firmly, but if the tap is short, the place should be marked, so that it can easily be found when the pond is to be drained. At the stand-pipes the little boards are placed in their grooves and screwed to them. If it is noticed that, in spite of all precautions, water oozes through in some place, it will be necessary to construct a dam of earth and sod round the place; for even if the quantity of water which oozes out is very small in the beginning, such places will gradually widen and do great damage to the dike and the pond, by decreasing the water at a time perhaps when every drop is needed. This case is particularly liable to happen in carp ponds which remain stocked for two or three years. All these precautionary measures should be taken before the pond is filled, and some little time should be allowed to pass, so the work may become firm. After all this has been done, the places where the water enters are thrown open, and the desired quantity of water is let in.

2. When filled.—The usual times for filling ponds are spring and autumn. It will depend on the use to which the pond is to be put after the fisheries have come to an end, which of these two seasons is to be selected. If the pond is to be stocked with fish before winter sets in,

* Delius, *Teichwirthschaft*, p. 87.

it should be filled in autumn. If it takes a long time to fill a pond, which is the case with large ponds, especially those whose supply of water is scanty, and still more with sky ponds, which are entirely dependent on rain and snow water, it will become imperative to fill the pond soon after the autumn fisheries. The necessity for filling a pond in autumn, which might have been allowed to lie dry during winter, may sometimes arise from the circumstance that the water is needed for other purposes besides the fisheries, *e. g.*, to drive mills or to form a supply in case of fire. The time for filling a pond will, of course, also depend on the quantity of water which can be disposed of.

If none of the above-mentioned circumstances render it advisable to fill the pond in autumn it will, as a general rule, be well to let it lie dry during winter, and not fill it till spring. Thereby it will become possible to make necessary improvements in the pond, to repair the dikes, clean the ditches, level rough places on the bottom of the pond, remove injurious plants and superfluous mud, and to hoe the bottom, so as to expose all its parts to the influences of the atmosphere, which makes it healthier for the fish and better calculated to produce worms, other fish-food, and useful aquatic plants. Young fry of fish of prey found in the spawning and raising ponds may be destroyed, the number of frogs may be diminished, &c. It will be seen that the advantages connected with letting a pond lie dry during winter are so great that no pond which is not to be stocked with fish in autumn, nor a pond whose supply of water allows it to be filled at any time, or which can easily be filled in spring before it is stocked with fish, should be filled in autumn. This is all the more necessary if the pond has been stocked for two or more consecutive years, as owing to the lack of atmospheric influences the bottom will cease to yield the necessary supply of fish-food. This will make itself particularly felt in those ponds which have to produce their own supply of fish-food; and less in those ponds which receive much water from cultivated fields and meadows, or are entirely dependent on this mode of supply; as, for example, the sky ponds. On the other hand, such ponds are more liable to accumulate an excessive and injurious quantity of mud.

As regards those ponds which remain filled for two years, Teichmann says that his experience has taught him that it will be advantageous not to give them their full supply of water during the first year. He states that during summer one entire side of these ponds was used as pasture close to the water's edge. On these dry places the cattle deposited their excrements, and it was certainly beneficial for the fish to expose these places to the fresh air during an entire summer. After more water was let into the pond in the second year, the fish undoubtedly found an abundant supply of food in those places which had remained dry during the preceding year. This experience appears to make it desirable, under certain circumstances, especially in large ponds which remain filled for more than one year, which are shallow and have no high banks, not to admit the full supply of water at once. If the circumstances are such as to allow the water to be admitted and let out at any desirable time, and if it is not intended to fill the ponds immediately to their full height, stand-pipes are to be preferred to tap-houses. Taps cannot be drawn until it is desired to drain the pond entirely, because, in ponds of any size, it will be difficult again to drive them in firmly and make them water-tight. With stand-pipes it is possible to fill a pond to a certain desired height, and to let the superfluous water flow off through the stand-pipe.* A pond which is not entirely filled during the first year should receive a quantity of fish corresponding to the filled portion, and not to its whole area, and it will be doubtful whether the relative increase in the weight of fish will be the same as if the pond had received its full stock of fish. More will be said on this subject under the head of stocking the ponds.

IV.—FISH-CULTURE.

As has been said above, pond culture comprises both the raising of fish (fish-culture) and the keeping of fish. Local circumstances, such as the number and size of the ponds, their location, the nature of their soil and water, &c., will determine the manner in which pond culture is to be carried on. In some places, therefore, fish-culture and the keeping of fish will have to be combined, while in others these two branches of pond culture will have to be carried on separately, in order to derive the greatest possible income from a certain given area of water. Without fish-culture, however, pond culture will always remain incomplete. The keeping of fish, without fish-culture, means only to use a pond according to its locality, nature, and local circumstances.

A.—*Carp-culture.*

Fish-culture may extend to several kinds of fish, but, as a general rule, pond culture relates exclusively to the culture of the carp. From an economical point of view the carp must be considered as one of the most important food-producers, as it destroys no valuable food-matter, its food principally consisting of products of nature which could not find any other use, and of the refuse from the human household; as it is easily satisfied as regards the nature of the soil and water; as it is a very hardy fish, which can easily be raised almost anywhere; and as it grows rapidly, has a fine flavor, and everywhere finds a large and ready sale.

Systematic pond culture requires at least four ponds: 1, a spawning pond; 2, a raising pond; 3, a stock pond; and 4, a winter pond. These four kinds of ponds are absolutely necessary for systematic fish-culture.

The *spawning pond* is needed because the spawn and young fry, if placed in ponds with larger fish, could not be sufficiently protected against numerous dangers. The young fry should, therefore, be in

* Teichmann, *Ueber Teichfischerei*, 1812, p. 40.

small ponds by themselves, so that the proper care and supervision can be exercised. It would, of course, be possibly to carry on carp-culture in a large pond in such a manner as to let the carp spawn there and grow up there until they become marketable. In this case the full-grown fish would be caught every year, but their number would not be very large, nor could they always be obtained at the right time. This method, therefore, is only excusable when a person possesses only one pond. In that case it would hardly be proper to speak of regular systematic pond culture, and it would be advisable to confine himself to the keeping of fish. In cases where only one pond can be cultivated all that will be obtained will be the leavings of the pike. By keeping the young fry in ponds especially adapted to their needs (spawning ponds) the greatest possible quantity of young fry may be looked for with absolute certainty, and when these young fish have grown sufficiently to be transferred to larger ponds there is reasonable hope that they will thrive, because they have become strong enough to avoid dangers, and are moreover not exposed to as many dangers as the young fry.

Young fry of one summer cannot immediately be placed in the large main or stock ponds, as these, in order to answer their full purpose, have to be stocked with other fish besides carp, especially with fish of prey, *e. g.*, pike; and even if this was not done intentionally, it would be exceedingly difficult to keep such ponds entirely clear of fish of prey. It is, therefore, necessary to have other ponds, in which the young fry can be raised and grow strong enough to be transferred to the stock ponds; and these ponds are the *raising ponds.* But since, as a general rule, the young fry have, during the second summer, not yet become strong enough to escape the dangers which threaten them in the stock ponds, another raising pond, No. 2, will be needed. If it is impossible to have this second pond, nothing remains but to place the young fry of two summers at once in the stock ponds, and let them remain there three, or at least two, years, which, as will be shown later, is not advantageous.

After the third year has been completed—I always count in the spawning year—the young fry have grown large and strong enough to share a pond with other fish, and they can, therefore, be transferred to the *stock ponds.* In the stock pond the fish are allowed to remain one or two years, *i. e.*, until they have reached a weight of at least 2 pounds apiece, and have thus become marketable.

As only in very rare cases the spawning and raising ponds are of sufficient depth and of a character to permit the wintering of the fry and young fish, a fourth pond will be needed, which is of sufficient depth and has the requisite supply of water to prevent the fish from freezing during winter. In this pond the fry and young fish can be put in autumn, so that they can pass the winter with absolute safety. Such ponds are called *winter ponds.*

These are the most necessary ponds for carrying on systematic fish-culture, more especially carp-culture. It will be self-evident, however, that fish-culture and the keeping of fish can be carried on more successfully if one has a larger number of ponds. The smaller the number of ponds—even if they are of large size—the more unreliable will fish-culture be, as it will be impossible to guarantee to the fish that degree of safety which they require at different ages. A complete pond culture, therefore, requires a large number of ponds, which will not only make it possible to raise carp systematically, but will also offer an opportunity to raise other fish, as trout, pike, &c. Not only every kind of fish, but every age, needs different circumstances and surroundings to insure success. Not all ponds have the same soil, the same natural conditions, the same water, depth, size, &c., but they differ in these respects, and fish-culture must take into account these differences, if it is to be carried on systematically and successfully. It will, therefore, be necessary to know which ponds are best adapted to certain purposes, and we shall have to examine what experience teaches relative to the selection of ponds for the various purposes of carp-culture.

1. SPAWNING PONDS.

The spawning pond is the most important of all the ponds, for it forms the basis of the entire pond culture. On the production of a suitable quantity of young fry of the proper quality the success of pond culture will principally depend, and great care should, therefore, be exercised in selecting the spawning pond.

The following are the requisites of a good spawning pond: A spawning pond should not be very large; it should lie on a level, and be exposed to the sun the whole day; for water sufficiently heated by the rays of the sun is the main condition not only of beginning the spawning process in due season, but also of its ultimate success, as well as of the hatching of the eggs. Ponds fed by springs should therefore be avoided. Spawning ponds should not be shaded by trees; but on the side which is most exposed to the wind they should be protected by woods or hills, because strong waves occasioned by wind are injurious to the spawn, and are apt to throw the young fry on the banks, where they will perish. It must be considered as particularly favorable if on the north and east side there are hills or buildings which reflect the rays of the sun on the pond. Spawning ponds should be shallow, because this favors the heating of the water, and their depth should decrease towards the shore. They should be crossed by a suitable number of ditches, so as also to afford to the fish deep and cool places. Their depth of water should never be less than one meter, so that there is no danger of their drying out in summer. Spawning ponds should not only be drained during winter, but they should also be planted the year previous, not only to remove acids from the soil, but also to make sure that there are no pike in it. This method also drives away the frogs, which destroy much spawn. In order to make sure that there are no pike in the spawning pond it should in spring be filled by rain or snow water, *i. e.*, if possible, be a sky pond. It should not connect with brooks and rivers, as in this way other fish, especially pike, may get into the pond. For the same reason spawning ponds should not draw their supply of water from other ponds. If it is impossible to fulfil any of these conditions, the grates should be very narrow, and, if possible, double. It is under all circumstances advisable to substitute in spawning ponds for the grates sieves of copper wire or perforated boards. The fish-pit of spawning ponds should be of sufficient depth to allow the young fry to winter in it. If during the summer the fish-pit is covered with vegetation, this should be removed with a sickle attached to a long handle before the beginning of autumn, so that the young fry may find a clean resting-place during winter. Reimann insists that all spawning ponds should have a fish-pit, *i. e.*, a place deeper than the rest of the pond, where the fish may gather during winter, and where during summer they may find a cool place of refuge.*

Horak says: "The young fry of the current year should not be caught during autumn of the same year, because they are exposed to many dangers, and even to total destruction; only in the exceptional case that the fry cannot winter in the spawning pond, it may be justifiable to catch them. This should, however, be done with great care, before the fish reach sexual maturity."† In all cases, no matter whether the young fry remain in the pond during winter or not, the fish-pit should be lined with wood, so to prevent any loss of young fish while they are being caught.

The following should also be observed: The spawning pond must contain some stones, and in some places aquatic plants, because the female fish like to rub against stones for the purpose of ridding themselves of the roe, and besides the roe readily attaches itself to aquatic plants. As a general rule, however, it is best for the young fry if the pond is tolerably free from reeds and aquatic plants. It is useful, however, if such plants grow along the edges, especially *Festuca fluitans*, as its leaves, blossoms, and seeds form excellent food for the young fish. If there are in a pond no aquatic plants to which the fish can attach their spawn, birch or juniper branches should be thrown into the pond, which may prove of still further advantage, as the naturally impregnated spawn of the carp attached to these branches can be transported a considerable distance. Special attention should be given to the quiet and safety of the young fry. Spawning ponds should therefore not be near villages or pastures; on the other hand, it will not be advisable to have these ponds in very remote places, over which constant supervision cannot be exercised, as there are many two-handed lovers of young carp. All animals which are injurious to the spawn and the young fish should be kept away from the pond as much as possible; birds of prey

* Reimann, *Praktischer Abriss des Fischereiwesens*, 1804.

† Horak, *Teichwirthschaft*, 1869.

should be chased away or caught, and neither ducks nor geese should be allowed on the pond. The frogs should, if possible, all be removed, and in selecting a spawning pond, ponds containing many frogs should be avoided. If the ponds have but few or no aquatic plants, and are not surrounded by bushes or shaded by trees, few injurious animals will be found in or near them; and even if there should be some, they can easily be discovered and rendered harmless.

Spawning ponds need not contain a very large quantity of fish-food, for the quantity required by the young fry and the parent fish will not be great. On the contrary, ponds containing a scanty supply of food are to be preferred for spawning ponds, because a superabundance of food hinders the propagating process. Young fish which have been raised in ponds containing a great deal of food are, as a general rule, retarded in their growth when placed in poor raising ponds, while, on the other hand, fish which have lived on short rations will grow rapidly when placed in good raising ponds. If it is thought that a pond contains too much fish-food it will be well to place in it some more spawning carp, for a superabundance of young fry will never do any harm. Teichmann says on this subject: "The soil does not influence the production of fish as much as many people seem to believe. It is certain, however, that rich soil is rather injurious than otherwise, for in the spawning ponds the fish are to be produced, and not to be fattened."* Horak says: "The bottom of spawning ponds should not be composed of peat or sand, nor should it be rich enough to produce grain, because in the first case the young fish would be retarded in their growth by want of food, while in the second case they would be spoiled in their early age by too rich a food, and when transferred to the raising ponds would grow but slowly. The bottom of a spawning pond should, therefore, not be principally composed of humus, but be a medium, mild, clayey soil."†

My views on this subject coincide with those expressed in the last sentence quoted from Horak, and are that, as the nature of the carp requires good soil (among which I class medium clayey soil), the young fry should have the same kind of soil. But, apart from this, it cannot be said when a spawning pond is selected whether it will offer much or little food for the young fish, as the number of young ones produced by one spawner varies greatly. As a general rule, 1,000 to 1,500 may be counted to one spawner. Sometimes, however, there are less, and often twice as many. For a smaller number the pond may possibly offer sufficient food, while a larger number would suffer want. It is a common experience that young fish which, in poor or overstocked raising ponds, have been retarded in their growth, when placed during the following year in better ponds will make up for lost time. Thus I can state from my own experience that in an overstocked pond the young of

* Teichmann, *Der erfahrene Fischmeister*, 1821.

† Horak, *Teichwirthschaft*, 1869.

two summers reached only a weight of 5 pounds for 60 fish, but that in the following year they reached the same weight as those which when placed in the pond had weighed 26 pounds per 60 fish. Such experiences, which are not reliable in all cases, should not induce any one to overstock the raising ponds during the first year, or to select poor ponds for raising ponds; much less should this be done with regard to spawning ponds. It may be laid down as a principle in fish-culture that as the fish develop during the raising years they should, if possible, be transferred from poorer to better ponds.

2. RAISING PONDS.

The young fry which have been produced in the spawning ponds are too small to be transferred at once to the stock ponds, where they would become the prey of larger fish before they could be raised to a marketable size. Before being transferred to the stock ponds the young fish should grow still more in size, and also grow stronger; and for this purpose they are, for a year or two, placed in other ponds which are called raising ponds. Good raising ponds are no less important than good spawning ponds; for the rapid production of marketable fish will greatly depend on this. Horak characterizes good raising ponds as follows: "They should be located in low lands, open towards the south, and sheltered towards the north; their water supply should, during thaw and rainy weather, come from the neighborhood of villages and from cultivated fields; their banks should not be sandy, steep, full of reeds, or shaded by trees; their soil should be favorable to the cultivation of grain, and it should be possible to supply them with the necessary water whenever it is deemed desirable. Under favorable circumstances a very large number of fish may be placed in them; if the weather is favorable the young fry may, during one summer, reach a weight of 60 to 90 pounds per 60 fish; although the result may be considered satisfactory, if in one summer they reach a weight of 30 to 40 pounds per 60 fish, and if the average weight, per 60 fish, of the fish from all the raising ponds reaches 18 to 20 pounds. Raising ponds lose much of their value, if there is no way of supplying them with water artificially, and if, for fear that they cannot be sufficiently filled in spring, they have to be filled immediately after the autumn fisheries; and likewise if, during dry seasons, their water becomes so low that their food-producing edges are laid bare. In ponds which are located below villages, and are used for watering cattle, the young fish are often seriously injured, and in many cases entirely destroyed."*

In my opinion, however, the watering of cattle does not necessarily injure the young fish, but will rather prove a benefit, as experience has shown that the growth of the young fish was favorable in raising ponds where cattle were watered, as they would generally drop their excrements. I even do not deem it dangerous to the fish, if the cattle go

* Horak, *Teichwirthschaft*, 1869.

far into the pond, as at their approach the fish immediately seek the ditches and the fish-pit, and when the cattle have left the pond, at once return to their feeding grounds to devour the excrements. I have, in my whole experience, never found the watering of cattle to be injurious to fish, but, on the contrary, favorable, and I have therefore gladly seen it, if cattle were watered in raising or stock ponds. Injury or danger can arise only if during very hot summers the water becomes too hot, and the fish consequently grow sick, which, of course, would be made worse by the watering of cattle. During very hot weather it should therefore not be permitted, at least in small ponds.

After the spawning ponds have been selected, there will hardly be any choice of raising ponds. In most cases it will be necessary to use the largest ponds as stock ponds, which of course would leave only the medium-sized ponds for raising ponds. In large establishments, however, in which there are two classes of raising ponds, there will be some chance to make a selection, in such a way as to select for those of the 1st class (which are to receive the young fry upon their arrival from the spawning-ponds), small, shallow ponds with warm water, avoiding especially ponds fed by spring water, leaving the remainder for raising ponds of the 2d class. When the selection is limited it should be the object of the pond culturist to improve his raising ponds as much as possible, which can generally be attained by sowing them systematically. The number of raising ponds should be large enough to supply all the fish needed for stocking the stock ponds. This also applies in cases where the stock ponds are not touched for two or three years, as on a properly regulated pond farm the same area of stock ponds should be stocked every year.

3. STOCK PONDS.

The stock pond is intended to develop the young fish which have been raised in the raising ponds, so as to make them marketable in the shortest possible time. Carp become marketable when they have reached a weight of 2¼ pounds. Most buyers, however, will prefer a weight of 2½ pounds, although a good many carp are sold which weigh only 2 pounds. To answer their purpose stock ponds should possess all the requisites of a good carp pond, which are in most respects the same as those of a good raising pond. Above everything else they should have an ample supply of good fish-food. For stock ponds those large ponds should be selected which are not needed for raising ponds. As the fish must, as a general rule, remain in them two and sometimes three years, they should be of sufficient depth to afford comfortable and safe winter-quarters for the fish.

The experience of old-established pond farms has demonstrated the importance of having deep stock ponds; and in the construction of new ponds this should not be lost sight of. But even if the greatest care is exercised in the selection of the stock and other ponds, it will be impossible to reach absolute perfection and meet every demand, as the area and the nature of the soil have to be taken as they are. To reach his object the pond culturist will have to improve his ponds gradually, following the hints given in previous chapters. An intelligent and energetic man will find ways and means to obtain the best possible results, no matter how he is situated.

4. WINTER PONDS.

In most cases a pond farm will only have few ponds in which the safe wintering of fish can be guaranteed; it will, moreover, hardly be possible to place all the fish from the raising ponds at once in the stock ponds in autumn; and finally, even if it was possible to leave the young fish in the raising ponds during winter, the supervision and management of these ponds, especially in an extensive pond farm, during the winter season would be exceedingly difficult, and it will therefore be absolutely necessary to have a few ponds in which a large number of fish can be safely wintered. Such ponds are called winter ponds. "To them," as Horak truthfully remarks, "is entrusted the entire hope of the fisheries; on their success depends the stocking of the stock ponds and of other ponds; in other words, the final success of the fisheries; and their failure will have the most serious consequences for the entire pond farm."* They should therefore be adapted to their purpose in every respect. Winter ponds should be on low ground, sheltered by woods, have high banks rising 1 to 1.5 meters above the surface of the water, be of considerable depth—not less than 2 to 2.5 meters—have the same depth at all times, and be capable of being supplied with fresh water at any time. They should be free from mud and aquatic plants, especially in their fish-pit, which should occupy about one-third of their entire area. If winter ponds can receive a constant supply of spring water, this will prove a great advantage, as it is warmer than brook and river water, and very rarely freezes in winter. A supply of water from higher ponds is to be preferred to brook and spring water, as its temperature will better agree with that of the winter ponds.

Considering that only in rare cases will all the above-mentioned qualities be combined in one and the same pond, winter ponds, which have been tried and found to answer their purpose, will rarely be used for other objects. Separate winter ponds are needed, not only for every kind of fish, such as carp, tench, pike, &c., but every age should also have its special winter pond. The number of winter ponds, and also their size—which need not be very great—will depend on the extent of the pond farm. If it is large, a comparatively greater number of ponds and larger ponds will be required.

In order not to render the necessary supervision and management of the fish during winter difficult on account of too great a number of winter ponds, large winter ponds are to be preferred to small ones, also for

* Horak, *Teichwirthschaft*, 1869.

the reason that these latter are more apt to freeze throughout during particularly severe weather than large ones. In small ponds, moreover, the snow-water, during a thaw, increases the quantity of water so suddenly that the fish are scared away from their resting-place, leave it, and suffer injury during succeeding frosts.

According to Horak, a large pond farm, intended to keep 60,000 to 90,000 fish, needs a pond area of 23 to 34 hectares, and a fish-pit, free from mud, of 8.6 to 11.4 hectares.* Jokisch characterizes a good and safe winter pond as follows: "It should be of sufficient depth so that, even during the most severe frost, it does not freeze to the bottom, but always retains an ample quantity of water. Winter ponds should not be exposed to floods occasioned by sudden thaws, for as soon as the fish notice an unusual motion in the water, they become excited and rise towards the surface, where they freeze to the ice and die. This is particularly dangerous in spring when a thaw is often succeeded by a severe frost. Winter ponds should be in a quiet locality, and during winter there should be no walking, sleighing, or skating on them, nor any knocking on the ice. Winter ponds ought, therefore, never be used for furnishing ice for ice-houses, because the cutting of the ice would seriously disturb the fish. The fish need a little air, especially when the snow is very deep, and to supply this a hole should be made in the ice, in which are stuck some bundles of reeds or straw, which reach down into the water and protrude above the ice. Whenever a pond has a good many reeds, air will naturally be supplied, and it will not be necessary to make a hole in the ice. Nothing, however, contributes so much to the success of a winter pond as springs, or a supply of spring water."† Horak also insists that the winter ponds should be near to the stock ponds, so as to make the transportation of fish easy, and that prior to being filled they should be sowed at least in part.* As regards the proximity of the stock ponds, it is of course desirable, but in selecting winter ponds this consideration should not be decisive.

5. THE RELATIVE SIZE OF THE DIFFERENT CLASSES OF PONDS.

In a well-regulated pond farm the size of the spawning and raising ponds should be proportionate to that of the stock ponds, *i. e.*, the former should always be ready to supply the necessary stock of fish of the required quality. To make this proportion correct is the first condition of successfully cultivating a given pond area, and of deriving from it the greatest possible income. If the proportion between the raising and stock ponds is not correct, this may give rise to difficulties, if there are in the raising ponds more young fish than can in two or three years be developed to marketable fish in the stock ponds; and, on the other hand, if the raising ponds cannot furnish the number of fish

* Horak, *Teichwirthschaft*, 1869.

† Jokisch, *Handbuch der Fischerei*, 1804.

which in the given time can in the stock ponds be developed to marketable fish, it would be impossible to derive the greatest possible income from the pond farm. Still more serious difficulties would arise if the number and size of the winter ponds were not in due proportion to the number of fish which are to be wintered; and to avoid entire failure, a sufficient area of winter ponds would have to be obtained at any price, or if this is impossible, the raising ponds should be so arranged that fish can be wintered in them. This latter measure, however, would always have to be considered as a mere make-shift, and the lack of winter ponds would still make itself felt. A pond farm without winter ponds does not deserve to be called well regulated, and will never yield the profit which otherwise might justly have been expected from the given pond area.

An undue proportion of the spawning ponds to the other ponds will prove of serious consequences to pond culture, as it might be impossible to raise the required quantity of young fry; while a surplus of young fry will not occasion any difficulty, as in most cases they can be sold to advantage or prove useful by supplying food for the fish of prey in the stock ponds. It will, therefore, be better under all circumstances to produce an excess of young fry than run the risk of having too small a supply. In the latter case, it is true, the necessary supply of young fry may be obtained by buying some from other pond farms, but these bought fish may frequently not answer the purpose in every respect, and possibly they cannot be obtained in the neighborhood, and would have to be brought from a distance at a considerable expense; all of which would again result in causing the pond farm to yield much less income than might otherwise have been expected. If the spawning pond should be too small to hold the quantity of young fry to be expected from the spawners and milters placed in them, this difficulty may be obviated to some extent by using one or the other of the raising ponds occasionally as a spawning pond, but even at best this is a somewhat irregular proceeding, and its consequences will be more or less injurious to pond culture. The usefulness of an excess of young fry, however, also has its limits, and it would not contribute to the success of a pond farm, if one should be compelled to use a disproportionately large pond as a spawning pond; for, if it was to be stocked with spawners according to its area, a large portion of the young fry to be looked for could not be put to any use. In order to derive the greatest possible benefit from such a pond it will have to be used both as a spawning and as a raising pond, which again would be more or less injurious to the spawn and young fry. It will therefore be evident that wherever the relations as to size of the different kinds of ponds are not as they should be, a greater or less injury to the pond farm and a diminished income will be the consequence. This injury will grow from year to year, and finally become serious enough to ruin the entire pond farm.

Although it is impossible to lay down strictly binding rules as to the relative size of the different ponds, as this will to a great extent depend on local circumstances and frequently on the experience of many years, it will be safe to say that in a pond farm whose ponds do not differ much from each other as to their supply of food, a total pond area of 100 hectares should—at least approximately—be divided among the different classes of ponds as follows:

	Hectares.
Spawning ponds	4
Raising ponds of the first class	12
Raising ponds of the second class	18
Stock ponds (of which in a two years' course 30 hectares should be stocked per annum)	60
Winter ponds	6
Total	100

The above figures not only give valuable hints, but they will serve as a safe guide in organizing a pond farm, where a two years' course in the stock ponds is contemplated. Later we shall, on the same principle, give the relative size of the ponds for a one year's course. In organizing a new pond farm it will, therefore, be well, in the beginning at least, to follow these figures, and only to deviate from them gradually as the circumstances require. Pond culturists will find no difficulty in following these figures by varying the number of fish in the different raising ponds according to their character, provided, of course, that the average number per pond is not placed too high. If, as is frequently the case in large pond farms, the character of the ponds varies considerably, the above figures may in course of time be somewhat different. Thus in the pond farm of Peitz, near Kottbus (Prussia), the total pond area of 4,600 acres is divided as follows:*

250 acres spawning ponds	= 5.42, in round figures	5 per cent.
500 acres raising ponds of the first class	=10.84, in round figures	11 per cent.
860 acres raising ponds of the second class	=18.65, in round figures	19 per cent.
3,000 acres stock ponds (one year's course)	=65.09, in round figures	65 per cent.
Total	100	100

This, however, does not include the winter ponds. According to the above proportion, and assuming the spawning pond to be equal to 1, the raising ponds of the first class are equal to 2, of the second class to 3.4, the stock ponds to 12, while on the basis of the figures given above the spawning ponds of the first class would be equal to 3, of the second class to 4.5, and the stock ponds (one year's course) to 7.5. In finding the most suitable system for a newly organized pond farm, or in correcting mistakes in the management of an old pond farm with a view to reorganizing it, it will under all circumstances be advisable to make the beginning on the basis of the figures first given above.

* Delius, *Teichwirthschaft*, p. 62.

6. GENERAL RULES AS TO THE STOCKING OF PONDS.

What kinds of fish are to be raised, and consequently with what kinds of fish the ponds are to be stocked, depends on the following:

1. On the character of the ponds, *i. e.*, the nature of the soil of each pond, on the quality of its water, and its supply of food; as the different nature of the various kinds of fish will cause a difference in the conditions necessary for success. Thus carp and tench want a muddy bottom and stagnant, warm water; while pike and perch want deep and running water, or water which at any rate is not stagnant; and trout need a stony bottom, with clear, cold, running water, with some places where the water is not in constant motion.

2. If ponds are to be stocked with several kinds of fish, the food necessary for each kind should be found in the pond, *i. e.*, fish of prey should, either in a natural or artificial way, be supplied with the necessary food-fish; care should also be taken to place only those kinds of fish in one and the same pond which are able to agree with each other; thus fish of prey with prickly fins will not agree with other fish; and if they are to be kept in carp ponds, their number should be reduced as much as possible.

3. It should be ascertained what kinds of fish are most sought after in the neighborhood, and will therefore have a ready and profitable sale.

All the above considerations should be carefully weighed, for to disregard them may cause serious losses.

Among all the different kinds of German fish the carp has for centuries occupied the first rank as a pond fish, and still holds its own. For reasons given in previous chapters, the carp certainly deserves this prominent place; and it is therefore the fish to which pond culture principally relates, the keeping of other fish being a mere secondary consideration. It is true that under special circumstances, particularly if the necessary food can easily be procured, trout-culture will pay better than carp-culture; and as matters stand at the present time in Germany, greater attention should probably be given to the raising and keeping of finer kinds of fish. The great progress made in artificial fish-culture, and the remarkable successes achieved on this new field of industry, will render this easier than it would have been in former times. It is nevertheless hardly probable that trout-culture will ever be carried on to such an extent as carp-culture.

In the following we shall occupy ourselves principally with the carp and those fish whose culture has for centuries gone hand in hand with that of the carp. The number of fish to be placed in a pond will depend: 1, on its size and the quantity of its water supply; 2, on the character of its water, and the quantity of food contained in it; 3, on the size and weight of the carp to be placed in it; and 4, on the length of time during which the ponds are to remain stocked with fish.

It will be impossible to lay down rules which will apply to every pond. Experience must gradually teach the proper rules in this respect, and a carefully arranged and punctually kept system of records will prove invaluable—in fact, be absolutely necessary. As a fundamental principle, however, we must state that a pond should never be overstocked. Horak says: "It is not the area of the pond, but the quality of the soil, the quality and quantity of the water, and the flat and easily warmed banks of the pond, which determine the success of the fish. It may, therefore, happen that small ponds can sustain a comparatively larger number of fish than large ponds, even if the quality of the soil is the same. In large ponds the pasture-grounds of the fish are comparatively smaller than in small ponds with shallow water and a grassy bottom, these latter furnishing more and better food and a more suitable place of sojourn for fish. The water of large ponds is seldom calm, and the waves are apt to disturb the fish. Large ponds, moreover, have generally sandy banks, while small ponds have a more evenly good soil, and are therefore more conducive to the well-being of the fish. The case frequently occurs that ponds having the same soil differ greatly from each other in other respects, and that ponds with poor soil are in reality better for the fish than those with good soil. The reason for these anomalies must be found in the difference of location. The heat of the sun can often replace the lack of good soil, and the cold water of a pond surrounded by woods can make even a pond with the best soil a poor one for purposes of fish-culture. To place fish of different kinds in one and the same pond is not to be recommended, because the larger fish will deprive the smaller ones of their food, although there are cases where a mixed stock of fish in one pond may be deemed advisable."*

As has already been stated, the number of fish to be placed in one pond will depend on their size and weight. On a well-regulated pond farm the fish are, before they are placed in the ponds, separated not only according to age, but also according to weight. My own experience has shown the following figures to be reliable:

Weight per 100 fish.

	Pounds.
One year's fish	1 to 1.7
One year's fish	1.7 to 2.5
Two years' fish, small	15 to 30
Two years' fish, medium	31 to 70
Two years' fish, large	71 to 100
Three years' fish	101 to 130
Four years' fish	131 to 160

All these subdivisions according to weight, however, will be needed only in large pond farms with a great many ponds, and even then only if the ponds differ greatly in their character; the difference, especially between the small and medium fish, will be very inconsiderable; the one year's fish will generally vary in weight between 1.6 and 2.5

* Horak, *Teichwirthschaft*, 1869.

pounds per 100 fish, the two years' fish between 35 and 70 per 100, the three years' fish between 100 and 130 per 100, and the four years' fish may sometimes reach the weight of 200 pounds and more per 100 fish, so as often to become marketable at that age. The above gradations of weight will suffice for all cases. Different names are employed for fish of different weight and age in the various parts of Germany, which is to be regretted, as it often leads to errors; and it would be advantageous if certain technical terms for fish of different ages were universally adopted.

In former times the fish were sorted according to their length, which, however, was not always a safe guide, for fish of the same length may differ greatly in breadth and volume. An experienced pond culturist should be able to judge of the weight of fish, and sort them accordingly, merely by looking at them. The stock pond is stocked, not only with carp, but also, to prevent the spawning of the carp or the production of young fish, with other fish, principally fish of prey. Although experience will be the principal guide in the matter of determining the number of fish to be placed in each pond, persons about to establish a pond farm, or those who take in hand an old pond farm, where no books have been kept—persons, in short, who lack experience—should have certain data on which they can base their plan, adapting it, of course, to the local circumstances. Such data will aid in determining what approximate number of fish should be placed in each pond, for it will not be sufficient to know and carry out the principle not to overstock a pond. A person should be able to determine, as nearly as possible, the proper number of fish which a pond, according to its location and character, can sustain, so as to avoid the understocking of ponds, which may also prove injurious.

The following should be considered as an attempt to aid in furnishing such data. On the pond farm at Wittingau, in Bohemia, which possesses the enormous pond area of 5,755 hectares, and whose circumstances will, therefore, not apply in all respects to medium-sized or small pond farms, the various classes of ponds are stocked in the following ratios:

A. *Spawning ponds:* 5 spawners and 3 milters per hectare.
B. *Raising ponds:*

Ponds.	Class of fish.	Weight per 100 fish.	Number of fish.			
			Very good.	Good.	Medium.	Poor.
Raising pond of the—		*Pounds.*				
First class	One year's fish	0.9 to 2.6	729	625	520	312
Second class	Two years' fish, small	18.6 to 37.8	520	487	312	156
Second class	Two years' fish, medium	37.4 to 59.0	487	312	208	104
Second class	Two years' fish, large	57.0 to 112.0	312	208	156	78
Stock pond—						
First year	Three years' fish	113.0 to 149.0	208	156	104	52
Second year	Four years' fish	150.0 to 202.0	156	104	78	52

The number of fish per pond, therefore, varies: In raising ponds of the first class, from 312 to 729 fish per hectare; second class, from 78 to 520; in stock ponds, from 52 to 208.

For the better understanding of these figures, we would state that under ordinary circumstances the one year's fish are placed in the raising ponds of the first, and the two years' fish in those of the second class. The carp which, in the raising ponds of the second class, have grown to be three years' fish are placed in the stock ponds for two years, during which time they will reach a weight varying, according to the character of the pond, from 2.5 to 5 pounds. If it should happen that the small or medium two years' fish in the raising ponds of the second class do not reach a sufficient size for placing them in the stock pond, they should be allowed to remain in these ponds for another year, or the course of the stock ponds should be extended to three years. It should be the object of the pond culturist to make the fish in the stock ponds marketable in one year, which, in good or medium ponds, is entirely within the reach of possibility.

C. *Stock-ponds.*—According to Horak,* stock ponds should have from 47 to 118 fish per hectare. It should be borne in mind, however, that this ratio refers to ponds having an area of 100 to 400 hectares, and that smaller ponds will often sustain two and three times that number of fish. Delius† does not state the number of fish to be placed in the stock ponds; for spawning ponds he counts 4 milters and 8 spawners—at most, twice that number—per hectare; and for raising ponds of the first class, 960 to 1,440, and for those of the second class, 480 to 720 fish.

These figures are very much like those of the Peitz estate, near Kottbus, the largest pond farm in Prussia, concerning which Delius has published the following statistics:

Ponds.	Area.	Stock.	Result.*	Loss.
	Hectares.			*Per cent.*
40 spawning ponds	6,250	450	210,000	80
21 raising ponds for the second year	12,500	210,000	150,000	28
5 raising ponds for the third year	21,500	150,000	108,000	12
6 stock ponds (one year)	75,000	108,000	93,000	
Total	115,250			

* Total result=200,000 pounds.

The losses on this farm are comparatively heavy, probably owing to the large number of herons and pike. The ratio of stocking these ponds per hectare is, therefore, as follows: Raising ponds of the first class, 1,680 fish; second class, 1,008; stock ponds, 264.

The above figures, however, can hardly be considered as standard, for they really seem enormous, as regards the raising ponds, and it is probable that they have been adopted for the Peitz farm with a view

* Horak, *Teichwirthschaft*, 1869.
† Delius, *Teichwirthschaft*.

to reach a somewhat favorable result, in spite of the very anomalous local conditions. If there were no large losses, it would be sufficient to raise in the raising ponds only that number of fish which remain for the market. In that case, the ratio of stocking would be about as follows: For the raising ponds of the first class, 768 fish per hectare; second class, 446; for the stock ponds, 130.

Even these figures must be considered rather high, especially as regards the raising ponds, and show the excellent quality of the Peitz ponds, in which young fry are, in a period of four years, developed to marketable fish.

Von dem Borne* who does not make the distinction of raising ponds of the first and second class, gives the following figures as the proper ratio per hectare: For spawning ponds, 9.6 spawners, 6.4 milters, 3.2 drivers; and for raising ponds, good, 600 to 800 fish; medium, 400 to 600; poor, 100 to 400.

G. Kraft† gives the following figures: Spawning ponds per hectare, 6 to 12 spawners, 4 to 8 milters, and to every 3 milters 1 driver; raising ponds of the first class, 300 to 600 fish, average 450; raising ponds of the second class, 180 to 420 fish, average 300; stock ponds, 120 to 180 fish, average 150.

As they are, these figures cannot serve as a general guide if we take the relative size of the various kinds of ponds as given above, because they do not meet the first demand of a well-regulated pond farm, viz., that the number of fish needed for the stock ponds shall be raised in the raising ponds. If we calculate the ratio of stocking on the basis of the relative size of the different classes of ponds, as given above, which on the whole seems to be correct, we obtain the following result:

Ponds.	Area.	Number of fish.		
		Minimum.	Average.	Maximum.
	Hectares.			
Raising ponds of the first class	12	3,600	5,400	7,200
Raising ponds of the second class	18	3,240	5,400	7,560
Stock ponds (one year's course)	60	7,200	9,000	10,800
Stock ponds (two years' course)	30	3,600	4,500	5,400
Stock ponds (three years' course)	30	3,600	4,500	5,400

It will be seen at a glance that in a one year's course the raising ponds cannot produce the necessary number of fish for the stock ponds, and that if the two years' course is adopted, more fish are produced in the raising

* Von dem Borne, *Fischzucht.*
†G. Kraft, *Landwirthschaft.*

ponds than they can accommodate to any advantage. In order to correct this, the ratio of fish per hectare will have to be as follows:

Ponds.	Number of fish.		
	Minimum.	Average.	Maximum.
Raising ponds of the first class	300	450	600
Raising ponds of the second class	200	300	400
Stock ponds (one years' course)	120	180	240
Stock ponds (two years' course)	60	90	120

Which would give for a total pond area of 100 hectares, reserving 6 hectares for winter ponds, the following ratio:

Hectares.	Ponds.	Number of fish.		
		Minimum.	Average.	Maximum.
12	Raising ponds of the first class	3,600	5,400	7,200
18	Raising ponds of the second class	3,600	5,400	7,200
30	Stock ponds (two year's course)	3,600	5,400	7,200
30	......do	3,600	5,400	7,200
60	Stock ponds (one year's course)	3,600	5,400	7,200

The above figures must be considered the best and most rational. To these should be added the so-called "excess," which, however, need not be calculated here, as it will generally be destroyed during summer, and will therefore not burden the ponds. In order to neutralize the unavoidable losses by transportation, wintering, fish of prey, birds of prey, &c., as well as the cases of death which will necessarily occur even on the best-regulated farms, a larger number of fish than the ponds are entitled to are placed in them, and this excess over the normal figures is generally determined by the known or estimated loss in former years, or on other pond farms.

According to Krafft* the average losses are: In spawning ponds, 12 to 14 per cent; in raising ponds of the first class, 10 per cent; of the second class, 7 per cent; in stock ponds, 2 to 8 per cent.

That these losses will in many cases be much greater may be seen from the statistics of the Peitz farm given above. According to Horak,† the average losses are: Of small two years' fish, 13 to 14 per cent; medium two years' fish, 13 to 14 per cent; large two years' fish, 10 per cent; three years' fish, 6 to 7 per cent; four years' fish, 3 to 4 per cent.

With a view to expedite matters, and also to avoid any unnecessary handling of the fish, the young fry are not counted, but measured, for which purpose a measure holding 60 to 100 is used. Different measures should be used for the different kinds of young fish, and on large pond farms it will generally be found necessary to use three different meas-

* Dr. Krafft, *Landwirthschaft.*

† Horak, *Teichwirthschaft,* 1869.

ures. One may, of course, employ any measure he chooses, after its capacity has been ascertained. In this latter case the measure—generally a small net or a perforated tin ladle—ought to hold a little more than 60 young fish, while in the former case a larger measure should be employed, allowing for the excess referred to above.

If these rules are observed the fisheries will, under favorable circumstances, yield a moderate surplus, because the excess is not entered on the books; but it may also happen during an unfavorable year that, in spite of the excess, there are actual losses, generally owing to the circumstance that the excess had not been calculated according to the greatest loss during a period embracing several years. As such losses may seriously disturb the systematic management of the farm, it will be well to make the excess rather high than otherwise. A moderate surplus—say about one-half of the excess—will be considered very desirable by every pond culturist, while a large surplus, which can be gained only by interfering with the normal growth of the fish, will not be considered profitable.

As regards the excess, care should be taken to make it, for the one year's fish, equal to the estimated total loss during the four or five years' period of raising, so that finally the stock pond may yield its normal product during the fisheries. If there is danger that by a great excess (necessitated possibly by local circumstances) the growth of the fish is retarded, nothing remains but to be contented with a comparatively small normal product of the stock ponds.

Taking as a basis the losses as given by Krafft, the excess should be: For two years' fish 25 per cent, in the raising ponds of the first class; for three years' fish 15 per cent, in the raising ponds of the second class; for four years' fish 8 per cent, in the stock ponds.

If we compare the ratio of fish per pond, given last, with the data furnished by Horak and Delius, and with the experience of the Peitz farm, we find that it may justly be considered as standard in most cases.

We must expressly state, however, that this does not imply that the relative size of the ponds, as given by us, should in practice be exact, even down to an are or square meter; this would be impossible, and will only be approximately attained in a pond farm containing a great many different ponds. Nor do we mean to say that the stocking of the ponds should only be carried out on the basis of three classes of ponds—good, medium, and poor. It will, on the contrary, vary as much as the endlessly varying character of the ponds; but, under all circumstances, it will be necessary that the proportion between the classification of the ponds and the quantities of fish placed in them should be made to harmonize, for otherwise there is danger that the raising ponds will not furnish the necessary number of fish for the stock ponds. To obtain this necessary number, at least approximately, it will be advisable, in large pond farms, to form the ponds into groups, according to their character, give each group a separate stock pond, and manage each group by itself. Even in small or medium-sized pond farms which possess a great number of ponds this method will be found profitable. As the increase in the weight of the fish per annum in the stock pond will indicate the number of fish with which it is to be stocked, if this increase is to reach a certain height within a given period of time, and as the relative proportion of the ponds should be such as to enable them to produce the number of fish required for the stock ponds, we should be able, on the basis of the relative size of the ponds as given by us, to fix the proper number of fish for the raising ponds of the first and second classes. To do this it will be necessary only to regulate this number on the following principle: Stock pond = 1; raising pond of the first class = 2.5; raising pond of the second class = 1.66 (or 1.67) per hectare.

The relative size of the ponds, as given by us, will, however, only be advantageous if it is intended to work the stock ponds in a two years' course. The number of fish which we gave for a one year's course in the stock ponds is rather low; and if we wish to apply this number to a two years' course—which may be done in good ponds—and thus make the fish marketable in the fourth year, the proportion of the different classes of ponds will have to be changed, and would in a total pond area of 100 hectares be as follows:

	Hectares.
Spawning ponds	6
Raising ponds of the first class	17
Raising ponds of the second class	25.1
Stock ponds	42.5
Winter ponds	9
Total	100

Supposing the stock pond could stand only 100 fish per hectare, we get the following number of fish per hectare: Raising ponds of the first class, 100×2.5=250 fish; of the second class, 100×1.66=166 or 167 fish; and the entire number of fish would be distributed as follows: 17 hectares raising ponds of the first class at 250=4,250 fish; 25.5 hectares raising ponds of the second class at 166 to 167=4,233 to 4,250 fish; 42.5 hectares stock ponds at 100=4,250 fish. The difference between the raising pond of the second class and the stock pond (17 fish) is caused by the repeating decimal fraction (1.6+), and is very insignificant, and we place in the raising pond of the second class 4,250 fish, because if we were to stock the raising pond of the first class in exact proportion to the stock pond, we would at any rate have these 17 fish on hand. If we had regulated the stocking of the raising pond of the first class according to that of the stock pond, that of the raising pond of the second class will regulate itself naturally, according to the stocking of that of the first class, and small differences need not at all be taken into consideration. All that can be done in laying out the plan for managing a pond farm, will be to get approximate figures, so as to have some sort of a basis of operations and not to work entirely in the dark until experience will show after years which are the figures that are most likely to insure success.

As regards the spawning ponds, there is—if the relative size of these ponds should not be quite up to the standard—less danger that they could not produce the number of fish necessary for the stock ponds, because too small an area can, in case of necessity, support two and three times the standard number of spawners.

The proportion of the area of the winter ponds to the entire pond area is not so important as the proper proportion between the raising ponds and the stock ponds, for if necessary raising ponds can easily be transformed into winter ponds, and if these ponds are properly arranged, double the number of fish per hectare can be wintered in them. The case may frequently occur that the given pond area is such as to make it impossible to maintain the standard relation of size of the different classes of ponds. In whatever way we may make our calculation, we shall in that case always arrive at the result that it will be impossible to stock sufficiently one or the other of our ponds, and that consequently we must suffer more or less loss, which but rarely will be prevented by accidental circumstances.

The greatest possible profit which can be derived from an entire pond area will be diminished in proportion as one is compelled to make changes in the standard relative size of the different classes of ponds.

The correctness of this assertion will at once become apparent if we, for instance, compare the management of a pond farm having an entire pond area of 100 hectares divided among 4 ponds of 25, or 5 ponds of 20 hectares, with that required by a pond farm likewise embracing a pond area of 100 hectares but divided among 5 ponds of 4, 12, 15, 60, and 9 hectares. After the various ponds have been assigned, some for spawning, others for raising, and others for stock ponds, it must be ascertained whether the individual ponds of one and the same class differ very considerably from each other in regard to their nature, whether they resemble each other or have the same character in all respects. In the last-mentioned case it will be best to place an equal number of fish per hectare in each of these ponds. If, however, one has a number of ponds whose soil and other qualities differ very considerably from each other they should be subdivided into different categories according to their quality, and the same number of fish per hectare should be placed in all the ponds of one and the same category.

The result of the first year during which this method of stocking has been employed—making the number of fish rather too low than too high—will enable the pond culturist to form a tolerably correct idea of the quality of each individual pond, if compared with the other ponds and the entire pond area. In this way the overstocking of the entire pond area will be avoided. The possible overstocking of one or the other of the ponds will only aid in arriving at some definite opinion as regards their relative productivity; and if the proper ratio of stocking has not been ascertained in the beginning, a few years of experience will be sufficient to find the proper standard. If, however, the plan of managing a pond farm does not appear to be absolutely erroneous during the first year, one should be slow in introducing changes; and if they seem unavoidable, the outlines of the system once adopted should be preserved as much as possible, so as to prevent injury to the entire farm from a failure of such changes. If among the ponds there are some which are not adapted to carp-culture, it should be considered whether they could not be more profitably employed for raising or keeping other fish, as trout, eels, &c. As the largest ponds should be used for stock ponds, and as consequently one will have to deal with a given area which possibly is still too large, if compared with the area remaining for spawning and raising ponds, it will be necessary either to overstock these ponds and supply the lack of area, and consequently of natural food, by artificial feeding, or to buy fish for stocking the stock pond to its full capacity, or prolong its course for another year; in which case, however, no fish of prey should be placed in it at least during the first year, as the carp would have to enter it when only two years old.

In order to derive the full profit from a pond, *i. e.*, to stock it in such a manner as to cause it to yield the best possible result, one should know how many pounds of fish can be raised in it per annum, and from this it can be calculated how many fish will have to be placed in a pond to raise within a given time a certain weight of fish. This should be known especially as regards the stock pond or ponds, for, being the largest ponds, they should yield the largest income, and in proportion as this object can be reached, one should regulate the stocking of the spawning ponds and raising ponds. From autumn till spring—generally from October till April—there is a pause in the growth of cultivated fish; and not till vegetation begins to revive do they again commence to grow. Frequently half of the month of May is included in this period of rest, as the weather is often cool enough to cause the fish to seek the deep water. In September the weather again grows cooler, the number of insects, worms, and plants on which fish live begins to diminish, and it is therefore a rare case if carp, or any other cultivated fish, increase in weight during the second half of September. Fish of prey, as a general rule, grow more rapidly than tame (cultivated) fish, provided there is a sufficient quantity of food; but they rest only for a short time during winter, and pursue their warfare against other fish during the remaining portion of that season. Horak remarks relative to the growth of carp: "During average years the increase in weight will generally be as follows: in May, 10 per cent; in June, 30 per cent; in July, 35 per cent; in August, 20 per cent; in September, 5 per cent. Total, 100 per cent.

"If the weather throughout the entire month of May is warm and calm the increase in weight during that month may be twice as great as that given above. During summer the carp resort to the edges of the ponds about 9 o'clock in the morning, and remain there till midnight, when they return to the deep water, where they appear to rest, to commence their daily routine again about 9 o'clock the next morning. The age of fish exercises a great influence on their increase in weight. The younger a fish the more rapidly will it grow, while the growth of an old fish is slow. The pond culturist, therefore, should aim at having only young fry and young fish, which form the backbone of a good pond farm."*

The growth of the carp will be specially favored by not placing too many fish in a pond in proportion to its quantity of food and water. Besides suitable food a fish also needs for its proper development sufficient space, so as to allow freedom of movement. The goldfish, which are closely related to the carp, furnish a proof of this. In ponds they will reach a length of 30 to 45 centimeters, while in glass globes they only reach 6 to 12 centimeters, during an age of two years. I have even known goldfish to reach the age of eight years without growing any longer than about 12 centimeters. In good ponds young carp can reach a weight of 10 grams † apiece during the year of their birth, 256 grams during the second, 650 during the third, and 2½ pounds to 5 pounds during the fourth year; and in exceptionally good ponds the ratio of increase is even greater.

7. STOCKING OF THE SPAWNING PONDS AND PRODUCTION OF YOUNG FRY.

After the spawning ponds have been selected and filled, the spawning carp are placed in them. As there are different kinds of carp, such as the common carp, the mirror carp, and the leather carp, it will be necessary to state which of these different kinds should be recommended. The only suitable fish for pond culture is the common carp. It is true that the mirror carp has its admirers, and sometimes sells at a higher price than the common carp, but in spite of this, it cannot be recommended for cultivation in ponds. It is not protected by scales, and is therefore more liable to be injured; and even in good ponds it never reaches the size and weight of the common carp. As a general rule the common carp is the variety most sought after. What has been said of the mirror carp also applies to the leather carp. If, however, there should be many admirers of the mirror carp in some locality, so that it would fetch a higher price than the common carp, it may be recommended to raise it in special spawning, raising, and stock ponds.

It is an old adage, "Like parents, like children;" and it will, therefore, behoove the pond culturist to be exceedingly careful in selecting his spawning carp. As a general rule they should be fully matured, the milter should be long and narrow and the spawner round and plump.

* Horak, *Teichwirthschaft*, 1869.

† There are about 453.6 grams in 1 pound (avoirdupois); hence in 2½ pounds there are 1,134 grams.

The spawning carp are selected in autumn during the fisheries in the stock ponds, and are, during winter, kept in special tanks, where they receive little or no food, for they should not be fat, but only fully matured; and they are, therefore, generally taken from poor ponds. It is not very difficult to distinguish the male from the female carp, still it may require a little practice.

Horak says: "Fishermen who are not able to determine the sex of a fish at once are in the habit of squeezing the genital parts until they yield either milt or roe. This method is very injurious to the production of young fish. An experienced pond culturist will, at the first glance, distinguish a male from a female carp, even when they are only one year old. The milter, or male fish, has a depression or concave place in its genital parts, while the spawner, or female fish, has a protuberance or convex place."*

The aperture of the navel also seems to be somewhat larger and redder in the female than in the male.

Reimann characterizes good spawning carp as follows: "They should have a long-stretched shape, have a bright, shining, yellow color, and be entirely free from bluish or reddish spots; nor should they have lost any of their scales. The best age is between five and seven years, and the proper weight four to five pounds."† Horak says: "Spawning carp should be raised in medium ponds, weight not less than four and not more than six pounds, and not be younger than four and not older than six years. Their shape should be long-stretched, and they should be well grown and built, the head small and the body long. The spawner should be well rounded, but not too plump; the milter should have a bright, shining belly, hard to the touch. All the scales should be perfect. Every year the scales grow thicker, a new leaflet or layer being added, which may be easily distinguished through a magnifying glass. Fish with thick scales are old."*

In making the selection, care should also be taken that all the spawning carp are of the same age, so that young should not pair with old fish, as a great deal will depend on this. If fish of unequal age are paired one may look for delay in the production of the young fry, or for young fish of very unequal growth. On a systematic pond farm where fish of every age are raised in separate ponds and are developed into marketable fish in certain regular and well-defined periods, and where books are kept for every pond, there will be no difficulty in making the proper selection of spawning carp. As, nevertheless, the growth of carp will be unequal, especially on large pond farms, those fish which have been retarded in their growth will either have to stay another year in separate ponds or they will have to be placed in stock ponds and stay there two, and perhaps three, years. No experienced pond culturist

* Horak, *Teichwirthschaft*, 1869.

† Reimann, *Praktischer Abriss des Fischereiwesens*, 1804.

will place in one and the same pond fish greatly differing in age or weight. A difference of one year in the age of the spawning carp may possibly not do much harm; but if greater, this difference will surely make itself felt by a diminished quantity of young fry. It should, therefore, be considered an inviolable rule to place in one and the same spawning pond only milters and spawners of the same age, and if possible of the same weight.

Spawning carp should not be used for propagating purposes more than once, but should be sold, after they have fulfilled their mission; for old spawning carp become indolent, remain too long in deep water, and spawn too late, thus preventing the young fry from reaching their proper development during the short remaining part of summer.

There is great difference of opinion as to what number of spawning-parties (each composed of three fish) should be placed in a pond, or rather what relation that number should hold to its area. The same difference of opinion prevails as to the relative number of milters and spawners. The number of spawning-parties does not appear of great importance as long as a certain limit has not been exceeded; the relative number of milters and spawners, however, may to a great extent influence the result of spawning. Delius counts one milter and two spawners to every 25 ares.* These three carp compose what is technically termed a "spawning-party." Horak says: "It is important to fix the relative number of male and female fish. Pond culturists differ in their opinion on this point, and the proportion of female and male fish varies considerably in the different countries. Many years ago it was the practice in Southern Bohemia to count one milter to every two spawners; and it is alleged that among the young fry the female predominated, so much so that buyers began to grumble at the excessive number of female fish. Since that time it has been the custom to count two milters to three spawners, to which was generally added one 'driver,' or 'enticer'—always one 'enticer' to three milters. These so-called 'drivers' are three-year-old fish (weighing about 70 to 80 pounds per hundred), which are not used for spawning, but simply to drive or entice the other fish to that process, and which should always be milters."†

As regards the number of milters for a given pond area there is likewise great difference of opinion and practice. Von dem Borne counts, per hectare, 9.6 spawners, 6.4 milters, 3.2 "drivers." Dr. Krafft counts, per hectare, 6.12 spawners, 4.8 milters, and to every three milters one "driver"; Horak, 5.21 spawners, 3.47 milters; Von Reider, per 34.07 ares, two spawning-parties, each composed of one milter and two spawners, or per hectare, about 6 milters and 12 spawners.‡

As long as there is so much difference of opinion, it will be best to take the average of these figures, and therefore place in poor spawning

* Delius, *Teichwirthschaft*, p. 58.
† Von Reider, *Das Ganze der Fischerei*, 1825
‡ Horak, *Teichwirthschaft*, 1860.

ponds 6 spawners, 4 milters, 1 "driver" per hectare; in medium spawning ponds, 9 spawners, 6 milters, 2 "drivers" per hectare; in good spawning ponds, 12 spawners, 8 milters, 3 "drivers" per hectare.

To avoid any trouble from lack of young fry, it will be well to have several spawning ponds, so that if the spawning should prove a failure in one pond the other ponds can make up for the loss. In cold, windy summers fish do not spawn much, and many female fish do not spawn at all; and at best the spawn, after having been deposited, is only hatched in part; or fish of prey, especially pike, enter the pond, which even happens sometimes in sky ponds; or other enemies of the spawn and the young fry are more numerous in one year, or in one particular pond, thus making the quantity of spawn uncertain.

Delius says: "One milter and 2 spawners—at most double that number—are generally considered sufficient per 25 ares, from which 300 to 1,500 young fish may be looked for, according to the way in which the fish spawn and the degree to which the pond is protected against enemies. This method I must consider as wrong, for it is most decidedly one of the causes of a small production of spawn. It is feared that by placing too many spawning fish in one pond the production of young fish would be so great as to cause lack of food, and keep the fish small and weak. This fear is well founded; but this should never prevent any one from placing ten times as many spawning fish in one pond, as the young fish can easily and at a trifling expense be fed artificially. If it should be found that there are, nevertheless, too many young fish, they may easily be caught near the entrance grate or in their feeding-place and placed in other ponds, or used as food for pike. This, of course, implies that a careful examination as to the quantity of young fry should be made after the spawning season. For this purpose some bran should be scattered along the edge of the pond, and by visiting the place about noon one will soon get an idea as to the quantity of young fry in the pond. About that time the little fish leave the deep water and seek the shallow places near the edges of the pond, for the purpose of playing and seeking food. Bran, meat chopped very fine, or boiled potatoes crushed into small pieces, may serve as food. If the number of young fish is very great they endeavor to escape from their pond, and generally go towards the place where the water flows into it. If there is a slight depression in the bottom in front of the entrance grate the young fish will there gather in large numbers about midday and jump up against the grate. If it is possible to fence off this depression by some boards and dip the water from it, a great many little fish can easily be caught. I have in this way dipped 24,000 young fish from a pond having an area of 16 acres, in a few days."*

In another place Delius says: "The first condition of successful carp fisheries is the certain production of young fish, either by propagation or by buying them, if possible, when still young fry, so as to make sure

* Delius, *Teichwirthschaft*, p. 59.

of a good stock of young fish. The result of propagation can never be calculated with absolute certainty; and it is, therefore, advisable to stock the pond with a large number of spawning fish. Formerly it was considered a misfortune if young fry occurred in the stock ponds, for they will diminish the quantity of food in the ponds. But times have changed, new objects have arisen, and the methods have consequently been compelled to undergo a change. It will certainly do no harm to place a few spawning fish in every pond, if one only takes care to watch and ascertain the quantity of young fry, so as to be sure to make the supply of food ample. Even if occasionally there should be a surplus of young fry, this will always find buyers; and by supplying it with the necessary food it may be retained and sold when the young fish have reached the age of three years."*

Although I agree with Delius in his first remarks, I must consider it something of a venture to place spawning fish in all the ponds, by which he can mean only the raising and spawning ponds, as in the stock ponds the young fry would become the prey of the pike, and I would not advise this, except in case of absolute necessity. I cannot share the fear that the quantity of food would be diminished by the young fry, but I rather fear that the young fish will get too little food, as experience teaches that the large fish drive the little ones away from the feeding-places and rob them of their food. Moreover the young fry would not find that rest which is so necessary for their proper development, if there are many other fish in the same pond. Although rarely, it nevertheless occurs sometimes that three-year or four-year old fish spawn in the raising ponds. In that case the young of these immature fish would mingle with those of the spawning fish. No young fry produced outside of the spawning ponds, even if ever so fine, should be used for raising. In order, therefore, to make sure of a sufficient quantity of young fry, it should be distributed over a number of small spawning ponds, which should be stocked with a comparatively large number of spawning fish. Whenever young fry occur in stock ponds, this will in all cases have to be considered as a misfortune, as the food necessary for the other fish will be diminished, and because the spawning of the fish decreases their weight. To remedy these evils fish of prey should be placed in the stock ponds so as to prevent the tame fish from spawning, and at any rate to decrease the quantity of young fry. Although in our times spawn and young fish will find a readier sale than formerly, it can hardly be deemed advisable to deviate from the above principles. The favorable results which have accompanied the artificial hatching of various kinds of salmonoids have led people to think that the same method might be employed with the carp; but the attempts in that direction have proved successful only in rare cases, the main difficulty being the adhesive quality of the eggs. As it is not our object to treat of artificial hatching, it will not be necessary to enter further into this matter. It will

* Delius, *Teichwirthschaft*, p. 93.

be best in all respects to avoid everything artificial in carp-culture. All that can be done to aid in producing a favorable result of the spawning process, is to make a suitable selection of the spawning ponds and the spawning fish, to place the fish in the ponds at the proper time and to put some stones and branches in the water, so the fish may rub against these and deposit their spawn. In this way, Von Reider says, spawn may easily be transferred from one pond to the other: "Take the root of a willow growing on the bank of the pond, which has a great many fibers and small roots, tie it to a stone and throw it into the water where the fish gather. The fish will soon approach this root, especially if there are no aquatic plants near by, and deposit their spawn on the root. If this root has been thrown into the water during calm, warm weather, it can be taken out after a few days, and thrown into the pond which is to be stocked with spawn, in a place where the water will cover it to the depth of 8 to 12 centimeters."*

The above method may be applicable in rivers and brooks, but cannot be recommended in pond culture, for all that would be gained would be a saving in the number of spawning carp to be placed in the ponds, which would be a doubtful advantage. This method may, however, possibly be used with profit in carp-culture in the following manner: Although, like many other pond culturists, I am, on general principles, opposed to everything artificial in carp-culture, the artificial protection of the eggs seems to deserve some attention and be worth a trial. Molin says on this subject: "If eggs adhering to different objects, *e. g.*, carp eggs or tench eggs, are to be hatched in summer and in stagnant water, take a shallow wooden tub, place in it the aquatic plants to which the eggs adhere, fill it with water, and place it in the sun. If the temperature during the day rises above 20 or 25 degrees, cover the tub with a piece of linen or with some green branches; and if during the night the temperature falls below 16 degrees cover it with a straw mat or a wooden lid."†

The time when the spawning carp are to be placed in the spawning ponds cannot be accurately fixed as to the month and day. The best time is in the beginning of spring when the weather, and consequently the water, begins to get warmer. This time may be in March, April, or May. It should be laid down as a rule not to place the spawning fish in the spawning ponds before warm spring weather sets in. To do it too early in the season will always be injurious, and nothing can possibly be gained thereby. Even if the spawning carp should spawn sooner, the spawn will remain unhatched until the sun is strong enough to do this; and the longer it remains in that condition the more will it decrease, owing to its many enemies. The quicker the spawn is hatched the more numerous will be the young fry. Teichmann says: "Spawning carp should not be placed in the ponds too early in the season, when

* Von Reider, *Das Ganze der Fischerei*, 1825.
† Molin, *Rationelle Zucht der Süsswasserfische*.

the water is still cold. Many people hold a different opinion, but I think they are mistaken, and I shall state the reasons why I think so: The water of the winter ponds is warmer than that of the other ponds; (1) because during the very coldest months many fish have been gathered there; (2) because most winter ponds have so-called warm springs. It is a remarkable fact that even during the most severe cold it will not be safe to venture on the ice of such ponds; (3) because, owing to their location, they are not so much exposed to the cold winds as the raising ponds, which are often entirely frozen, while the winter ponds are still free from ice.

"It must also be remembered that during winter the fish keep close together, and probably communicate warmth to each other. If one or the other of the above causes exercises an influence on the spawning of the carp, which cannot be denied, it must be considered a great mistake to transfer the spawning carp too early in the season from the winter ponds to the spawning ponds. Even allowing that spawning is not entirely prevented thereby, it may be retarded. If the young fry are, as the saying is, as small as plum-stones—an experience which every pond culturist will have to make at some time or other—the cause of this will probably have to be sought in the circumstance that the spawning fish were placed in the spawning ponds too early in the season."*

It is an undoubted fact that, owing to the causes given above, the water of the winter ponds is warmer than that of the other ponds; but I am inclined to doubt that the fish communicate warmth to each other, like warm-blooded animals, because they always have the temperature of the element in which they live, and can therefore only communicate to each other the temperature of the water which surrounds them. When the spawning carp are taken from the winter ponds in order to be placed in the spawning ponds, they should be once more carefully examined, and taken to the ponds and placed in them by thoroughly reliable persons.

In transporting these fish great care should be exercised. The kegs in which they are conveyed should be entirely filled with water, so that during the journey the fish cannot be knocked about and hurt. The fish should be placed in the kegs with the greatest possible care, one by one, head foremost; and a keg having a capacity of five hectoliters should not hold more than 20 or 25 fish. The fish should be taken from the kegs with the same care, and one by one. The person who attends to this should stay near the pond, until he has convinced himself that all the fish have left the edges; as it has often happened that, as soon as he turns his back to the pond, thieves come and easily catch the spawning carp which have remained near the edges. Even with the most favorable weather the spawning carp will not spawn immediately after they have been placed in the pond, but have first to become

*Teichmann, *Fischerei*, 1831.

acquainted with each other. This is another reason why (especially if but few spawning-parties are placed in a pond) small ponds should be selected for spawning ponds. As soon as the fish have became acquainted with each other, and the water has grown warm, the spawning carp may be seen to seek the shallow spawning places near the edges of the ponds. Then the spawning process takes place. Horak describes this process as follows: "The female fish, or spawners, accompanied by the male fish, or milters, move rapidly along the edges of the pond, or near the calm surface of the water. The actual process of spawning generally takes place during the early part of the forenoon. I have taken careful observations of this process, and have invariably noticed that several milters always accompanied one female fish, and deposit their spawn, for not all females spawn at the same time. Sometimes this accompanying degenerates into a regular chase which lasts until the act of propagation has been consummated. At the beginning of the spawning season the fish therefore gather in large shoals and move so close together as actually to touch each other. During warm, calm weather the spawning process is carried on at so lively a rate, that the water is squirted 50 to 85 centimeters above the surface."*

The best time for carp to spawn is the end of May or the beginning of June. At that season the pond culturist should pay frequent visits to his spawning ponds and watch the spawning and everything which may be helpful or hurtful to this process. This becomes all the more necessary, as during the spawning season the fish are so little shy that they can easily be caught by the hand near the edges of the ponds. If the weather is favorable the spawning season does not last long. Fourteen days to three weeks after having been deposited the eggs are hatched. The small being contained within the shell bursts it, and soon develops into a lively little fish. The deeper the eggs are in the water, and the lower its temperature, as well as that of the air, the later will they be hatched. Spawning ponds should always be kept under careful supervision, and everything calculated to disturb the propagation of the fish should be promptly removed. No cattle should ever be allowed to graze on the banks of the spawning ponds. Birds of prey and other dangerous animals should either be driven away or caught or killed. Great care should be exercised to prevent any fish of prey from entering the spawning ponds, and if, in spite of every care, they nevertheless get in, they should be caught as quickly as possible. Tench should not be suffered in the spawning ponds, because they will also spawn there; and after their young fry have mingled with those of the carp, it will, if not absolutely impossible, still be exceedingly difficult to separate them. Spawning ponds should always have the same depth of water, and wherever it is possible be freely supplied with fresh water. If sky ponds are employed as spawning ponds, the opportunity to do this will of course offer itself but rarely. The spawning

*Horak, *Teichwirthschaft*, 1869.

ponds should be protected against inundations, and regard should be had to this matter when the ponds are selected. During winter, when the young fry is wintered in the spawning ponds, they need special supervision; and all the hints regarding the management of winter ponds given in another chapter should be carefully observed.

We have already referred to the quantity of young fry which may be looked for. The cause of variations in this quantity must be found in the fact that not all carp spawn at one and the same time, and in the circumstance that there are sometimes two spawning seasons. When taken from the ponds the young fry should be sorted, and if the quantity is sufficiently large, only the larger ones should be used for raising. The remainder should, if possible, be sold; and if this is impossible, they should be placed in the stock ponds to serve as food for the pike. If the selection of spawning ponds is not too much limited, these ponds should never be used as raising ponds, but, after the young fry have been taken out, they should be allowed to lie dry until they are again used for spawning. Von Reider recommends not to take all the young fry from the spawning ponds in autumn, but only to select the larger ones, and leave the remainder in the ponds to risk the coming winter. If there is a superabundance of young fry this is of course quite unobjectionable, as the very small young fry are not exposed to possible injuries during the fishing, the transportation, and the placing in the winter ponds, and are therefore likely to endure the severity of the winter. As a general rule, however, it will be impossible to avoid the catching of the very small young fry together with the larger ones, and all that can be done is to return the former to the waters of the pond. If this is done the pond should of course be filled with water immediately after the fisheries; and even during the fisheries sufficient water should be left in the fish-pits to prevent the young fry from perishing during the interval between the end of the fisheries and the filling of the pond. This method may be employed for ascertaining the capacity of a pond for wintering fish.

8. STOCKING THE RAISING PONDS.

The aim and nature of raising ponds has been described in a previous chapter, and it will, therefore, not be necessary to refer to it again.

The rapid development of the young fish into marketable fish will depend entirely on the character of the fish which are placed in the raising ponds and on the care bestowed upon the fish during the period of raising. The raising ponds are stocked with young fry, and with small or medium two years' fish, which have not grown large enough to be placed in the stock ponds. The successful development of the fish depends: (*a*) On healthy, strong, and perfect fish being placed in the raising ponds; (*b*) on the quality of the soil, the favorable location, and general character of the pond; (*c*) on the weather during the summer; and (*d*) on the proper number of fish for each pond.

To be able to stock properly the raising ponds, one should be thoroughly acquainted with their capacity of furnishing the necessary quantity of suitable food, taking proper regard to the location of the ponds and the temperature of the water. The first step will be to divide one's ponds into spawning, raising, and stock ponds; next the raising ponds will have to be divided into medium, good, and poor ponds, and these again should be classed according to their size. On well-regulated pond farms, which possess a sufficient number of ponds, the raising ponds will be divided into two classes; and in those of the first class the young fry, and in those of the second class the two years' fish will be placed. Wherever this is impossible, a three years', or at least a two years' course in the stock ponds will become necessary. For raising ponds of the first class it will be best to select small ponds, as they are more likely to supply the conditions upon which depends the rapid growth of the young fry, viz., quiet, the greatest possible degree of warmth of the water, and shallow, and extensive margins. Ponds, fed from rivers, brooks, or larger ponds, should be avoided as much as possible, so that the young fry may not be injured or entirely destroyed by fish of prey, which enter the pond from the above-mentioned sources. Although both the young fry and the two years' fish need good ponds for their successful development, it will nevertheless be advisable, whenever one has the choice between good and medium ponds, to place the young fry in the medium ponds, because experience has shown that it is injurious if young fry, which have come from spawning ponds having an abundance of good food, are placed in ponds where they find less and inferior food. This will retard their growth, because, unaccustomed to privations, they are unable to bear them. It is, therefore, necessary, if possible, to assign good ponds for the young fry, so as to afford them quiet, warmth, and ample food.

From the above it may be implied what kind of ponds should be selected as raising ponds of the first class for the two years' fish. As these fish are larger, they should also be assigned to larger ponds; or if this is impossible, the smaller ponds should not be stocked too heavily. From this it follows that the entire pond area for the second raising year should, in extent, exceed that of the first year, if the two-year-old fish are to reach their proper development. But there is another reason why the smaller ponds should be selected for the young fry, viz., because these little fish can move about with greater ease in their shallow grassy edges and thus make it possible to find food, in places where the two-year-old fish, owing to their greater size, could hardly go. In cases where it becomes necessary to stock such ponds with larger fish, it will be well, with a view to deriving the fullest possible benefit from these ponds, to place in them also some young fry. This should not, however, become the rule, but only be a rare exception, and on a well-regulated pond farm it will always be best to stock each pond only with one and the same kind of fish.

It will be as impossible with the raising ponds as with the spawning ponds to lay down definite rules as to the number of fish to be placed in them, and experience will prove the best guide in this respect. As a general rule one counts per hectare, in good raising ponds of the first class, 600 fry; in medium, 450; in poor, 300; in good raising ponds of the second class, 400 two-year-old fish; in medium, 300; in poor, 200. Regard should also be had to the weight of the fish, as even fish of the same age will but rarely have the same size and weight; for, apart from the influence of the varying nature of the ponds, fish, like plants, will not always thrive equally well if placed under the same conditions. If the ponds, however, have been carefully selected, this difference will make itself felt but slightly.

Horak* counts the following number of fry per hectare: In very good raising ponds, 622 to 833; in good, 519 to 622; in medium, 416 to 529; in poor, 210 to 313; in very poor, 103 to 154. Von Reider † places in ponds, which in case of necessity can be used as stock ponds, 1,500 to 3,000 per hectare, and in poor raising ponds only half that number; and Teichmann,‡ in medium ponds, 2,350 to 2,830 per hectare. Reimann§ says: "If a pond does not contain much food, I place in it 1,880 young fry per hectare; if it contains a medium quantity of food, 2,350; and if an abundance of food, 2,820."

We here miss the data as to the age of the fish, but considering the high figures, there is no doubt that young fry, or one-year-old fish, are meant. But even for young fry these are very high figures, and it may be stated as a fact that all the above-mentioned pond cultivators have, as a rule, raised marketable fish during a one year's course in the stock ponds. From this it may be inferred that in giving the above data they had no reference whatever to poor ponds. Raising ponds which have been sowed the year before can stand a comparatively larger number of fish than those where this is not the case. By arranging it so that every raising pond is sowed once in six years, the growth of the fish will be furthered considerably, and the main object, viz., to fit the young fish in the shortest possible time for the stock ponds, will be attained. If possible, the raising ponds should lie dry at least during winter. It is not always possible, however, to introduce a regular system of rotation in sowing the ponds or to let the ponds lie during the winter, for sheer necessity will compel many a pond cultivator to select for raising ponds ponds which consist of marshes and peat-bogs, and can, therefore, never be laid entirely dry, or which are used for industrial purposes, mills, &c., and can, for that reason, never be drained entirely. A system of rotation in sowing the ponds can only be introduced on pond farms which possess a very large number of ponds.

* Horak, *Teichwirthschaft*, 1869.

† Von Reider, *Das Ganze der Fischerei*, 1825.

‡ Teichmann, *Teichfischerei*, Leipzig, 1831.

§ Reimann, *Praktischer Abriss der Fischerei*, 1804.

The stocking of the raising ponds should begin in spring, when the weather commences to get warm and no more frosts need be feared. The young fish used for the purpose are taken from the winter ponds, or from the spawning ponds which have not been fished in autumn. The fry are measured out into kegs, which are not filled to the brim, and are conveyed to the raising ponds by reliable persons, who must remain near the ponds until the fish have left the edges, and also to see how many of the little fish have become weak or have perished during transportation. These observations should be repeated for several days, so as to repair any losses. The two-year-old fish should not only be counted, but also weighed, and the same precautions should be exercised as with the fry; but if the kegs are not filled too much with fish, and have a sufficient quantity of water, no loss need be feared, as the fish are strong enough to stand the hardships of transportation. In raising ponds it will be well to add a few tench, which by rooting in the ground will make the food hidden in the mud accessible for the fry and two-year-old fish. In these ponds there should also be placed some three-year-old carp as "leaders," particularly in raising ponds of the first class. These so-called "leaders" are to draw the attention of the younger fish to threatening dangers by flying to the depths, whither the young fish will immediately follow them. If the raising pond contains winter quarters, these three-year-old fish will also lead the young fish there; and it will be necessary to add a few such leaders in winter ponds containing young fish.

The fisheries in the raising ponds generally begin in October, and somewhat earlier on large pond farms, so as to get through before frost sets in. Horak says that large and deep raising ponds which have an ample and constant supply of water may be omitted in the autumn fisheries and be fished in spring, thus saving time and money. From the raising ponds the fish are transferred direct to the stock ponds. The omission of large raising ponds from the fisheries is only advisable if these ponds afford absolutely safe winter-quarters for the fish, and only when the pond cultivator is overtaken by an unusually early winter.*

9. STOCKING THE MAIN OR STOCK PONDS.

In selecting the stock ponds two conditions will have to be considered, which are but rarely combined. In most cases large, even very large, ponds will have to be selected, principally because these large ponds, owing to their size, depth, the low temperature of the water, and the introduction of other fish—caused by their being generally fed direct by rivers and brooks—which rob the carp of their food, will not be suitable for young fish or fry. Stock ponds will need some fish of prey to destroy the intruding fish, and they should have an ample supply of the very best food, so that the fish may become marketable after one year. In large ponds, however, the supply of food will not be as ample

* Horak, *Teichwirthschaft*, 1869.

as in small ponds, even if the nature of the soil is the same. In fulfilling the first condition of a stock pond, viz., that it shall be large, it will become difficult to fulfil the second, viz., to have an ample supply of good food. It should therefore, be the aim of the pond cultivator to stock the stock pond in due proportion to the quantity of food contained in it, and thus make sure of sufficient food for the fish. The main points in the selection of stock ponds should always be sufficient depth and an ample and constant supply of water, so as to insure the safety of the fish during winter; and it will therefore, under all circumstances, become a matter of necessity to select large ponds for stock ponds.

We have already stated that the main object is to make the fish marketable in as short a time as possible. The shortest time in which this is possible is four years—not five or six, as is customary on most pond farms. If this object is attained, pond culture may be said to have been entirely successful. Delius says very truly: "We often meet with ponds in which the fish are left three years; but this is evidently an error. No pond can possess the necessary conditions of food for three years, and the total loss, if 10 per cent per year, will be very considerable. This loss may be avoided in a two years' course if the number is proportioned exactly to the conditions of food. It is exactly as in stock-raising, the quicker an animal is raised and fattened the greater will be the gain. A certain quantity of the food is needed for sustaining life, and everything above that quantity goes towards fattening the animals. Although with fish the quantity of food needed for sustaining life is smaller than with cattle, it will nevertheless make a great difference whether this quantity has to be counted for one or for three years. In a very good pond it will be easy to make suitable arrangements in this respect. To obtain favorable results, it should be ascertained what will be the annual increase of weight (in pounds) in a pond; and from this it can be calculated what number of fish should be placed in it to obtain the best possible results. The case will be different in poor ponds; if the supply of food is not very abundant, it will take several years to raise the carp to a certain size. In this case it will be found advantageous to stock the pond with three and four year old fish (mixed), and fish it every year, which will make it possible to place the proper number of fish in the ponds. If the pond requires a three years' course, three classes of fish (according to age) should be placed in it, and the oldest sold every year. The result will then be better than if one class of fish is allowed to remain in the pond for three years."*

I have given the above quotation verbatim, because I could not have expressed my own views better. I think, however, that even in a poor stock pond the three years' course may be avoided if the young fish have previously been properly raised and are not placed in the stock ponds unless they weigh 1 pound apiece, which weight carp can reach in three years in medium and even in poor raising ponds if these have

* Delius, *Teichwirthschaft*, p. 63.

been stocked in proportion to their capacity. It will rarely occur, especially in large pond farms, that all the ponds are poor. Even if the stock pond is poor, but the raising ponds good, the carp can in these acquire the necessary weight so as to become marketable after two years in the stock ponds. If placed in the stock ponds when weighing 1 pound apiece the carp will in one, and certainly in two years, reach the marketable weight of 2 or 2½ pounds. If the pond is stocked in due proportion to its capacity it may even reach a greater weight in two years. But, as Delius says,* there is no special advantage in raising carp to a greater weight than 2 to 2½ pounds, it being more profitable to sell the carp as soon as possible, even if they should weigh only 2 or 2½ pounds, than to raise them to a weight of 4 or 5 pounds, which would require five or six years. For to the carp cultivator, as to the stock raiser, applies the old adage: "Too long a period of raising, the total quantity of food being the same, will yield but small profits." It will, under all circumstances, be more profitable to produce a certain number of marketable fish in a few years than a larger number in a longer period. To obtain the desired result the ponds should rather be under than over stocked. The most profitable method will always be the one by which carp can be marketable in four and not in five or even six years. To attain this should be the aim of every rational pond cultivator. In endeavoring to reach this object he may meet with unavoidable difficulties, but if proceeding systematically he will always be able to raise marketable fish in five years, even in medium, and occasionally also in poor ponds. If he needs six years, he must have made mistakes in the selection, stocking, and management of his raising ponds.

I therefore repeat what I said under the head of raising ponds: It should be the principal aim of the pond cultivator to shun no trouble and care, to raise only healthy and strong fry and young fish; for a single mistake may frustrate all his plans, and disturb even the best system to a degree that it may take years to repair the damage. If the pond cultivator has done his duty by his raising ponds, he will in due time reap his reward in the stock ponds. Horak says: "Carp ponds with a one year's course are but rarely profitable; the aim should be, therefore, to have only ponds with a two years' course, and to avoid a three years' course." He endeavors to prove his assertion as follows: "The location of the pond, and the nature of its soil and water have a decided influence on the length of time which will be required to raise the fish to their proper weight. There are only a few ponds in which the young fish, which generally remain in medium ponds three summers, will become marketable fish in two or even one year. Such results can only be looked for in exceptional cases, in particularly favorable years, and after the pond has been sowed, for as a general rule the large three-year-old fish will need three summers, and the two-year-old fish one summer to become marketable fish. After having been sowed, only

* Delius, *Teichwirthschaft*, p. 64.

the best ponds are given a two years' or one year's course, by placing in them only three-year-old fish."*

The above may apply to very large pond farms like that of Wittingau, which has a total pond area of 6,000 hectares, raising ponds of 7 to 50 hectares, stock ponds of 100 to 500 hectares and more, and a total number of about 300 ponds, for not only will the conditions of soil vary much in the different ponds, but there may be great differences in this regard in one and the same pond, thus causing a difference in the growth of the various classes of fish. But the above may apply at Wittingau also on account of the great size of the individual ponds, as it is a rule—and exceptions only go to prove the rule—that large ponds do not seem as favorable to the raising of fish as small ponds; and it may, therefore, frequently happen at Wittingau that the one year's fry do not, in the second year, reach the minimum weight of half a pound apiece, and do not reach the minimum weight of 1¼ pounds in the third year, in which case all that can be hoped for is that the fish, during one year in the stock pond, will reach the weight of at least 2 pounds. It is therefore considered a satisfactory result at Wittingau if the average result of the raising ponds of the first class is 30 to 33 pounds per 100 fish. Under ordinary circumstances the fish will in the second raising year not reach the weight which would enable them to become marketable during one year spent in the stock pond. There is only the alternative to let them pass through another raising pond, or to let them remain two years in the stock pond. If this should on some pond farm occur very frequently, or even become the rule, it would have to be considered a miscalculation if the one year's course in stock ponds was introduced, and it will under all circumstances be the safest plan to have only stock ponds with a two years' course. On medium-sized pond farms there is no necessity whatever for stock ponds with a three years' course.

It is an old adage that what is good for big folks is not always good for little folks, and, as the vast majority of pond farms are small, we shall not deviate from our program, and take for our motto, "The highest aim of a pond cultivator is not to have two years' but one year's stock ponds." Von Reider advocates, as a rule, only stock ponds having a one year's course. He says: "Those stock ponds are the best which can be fished clean every year; but, in order to accomplish this, one should be able to raise every year the necessary number of fish for stocking them, and consequently have as many raising ponds as this requires. Such ponds should have a constant supply of fresh water, so that they can every year be filled as soon as needed, and there should be no cause for shunning the expense of the frequent fisheries. Only very large stock ponds are fished clean every two years, as it may be difficult to fill them; or, in case there is a lack of raising ponds, making it necessary to use some of the stock ponds for this purpose; or, finally, where it is desirable to avoid the expense of annual fisheries. To use

* Horak, *Teichwirthschaft*, 1869.

stock ponds partly as raising ponds is generally an indication of disproportion between the raising ponds and the stock ponds. It will therefore be well at the very start to classify the ponds, properly assigning enough of each class for the purpose which they are to serve, and make a point of having every year a full supply of two years' fish (not counting the year in the raising ponds) for stocking the stock ponds. Where local circumstances forbid this, the inferior stock ponds should also be partly used as raising ponds, or have stock ponds with a two years' course. The stock ponds are, therefore, stocked with fish which have spent one or two years in the raising ponds, but only in such a manner that those stock ponds which are fished clean every year are stocked with two years' fish, and those which have a two years' course with one year's fish. In exceptional cases, however, if the stock ponds are particularly good and there is a lack of fish, they may be stocked with one year's fish and fished clean in autumn, when, supposing that there is sufficient food and ample room for the fish, a satisfactory yield may be expected in every case. The largest fish must be selected for stocking the stock ponds, and, even if in these ponds they do not reach the largest possible size, there will nevertheless be some profit."*

There may be cases where circumstances not at all connected with the pond farm may necessitate a two years' course in a stock pond, *e. g.*, when the water has also to serve industrial purposes, mills, &c. In such a case the profits of annual fisheries would not compensate for the losses occasioned by the stoppage of a mill or factory, and all that can reasonably be looked for is to raise marketable carp weighing 3 or 4 pounds. Although it should be the aim of every rational pond cultivator to make his young fish marketable as rapidly as possible, it would be an erroneous and irrational proceeding to finish the course of development with the third year, and bring to market three-year-old carp weighing on an average only 1.5 pounds apiece. I feel compelled to call special attention to this matter, because experience has shown that there are pond farms where such irrational methods are followed, in the belief that a good business is being done. It does, therefore, not seem superfluous to show the unreasonableness of such a course by giving a brief sketch of an imaginary pond farm of small size, where, deluded by a ready market for carp weighing 1.4 to 1.6 pounds—it probably being impossible for the consumers to get carp weighing 2 pounds anywhere in the neighborhood—the proprietor follows the above system, and comparing therewith another brief sketch of a systematic pond farm selling three-year-old carp weighing 1.5 pounds apiece, and finally offering for further comparison the sketch of a farm selling four years' fish with a minimum weight of 2 pounds apiece.

We suppose the pond farm to have eleven ponds, with a total area of 700 ares, the largest pond covering 220 ares, and the smallest two 6.8 and 8.5 ares, the remainder varying from 35 to 92 ares. The ponds

* Von Reider, *Das Ganze der Fischerei*, 1825.

are all of the best kind. Managed without any system, they yield annually 300 pounds of carp, each fish weighing 1.4 and at most 1.6 pounds. By systematizing the management of this farm according to the principles laid down in previous chapters, the result will be about as follows: One-seventh part of the 700 ares, therefore 100 ares, are allowed to lie dry for sowing. The other 600 ares are to be utilized in the following manner:

Ponds.	No. of ares.	Number of fish.			
		Minimum per are.	Total.	Average per are.	Total.
10 per cent spawning ponds	60				
30 per cent raising ponds	180	1.8	324	2.7	486
45 per cent stock ponds	270	1.2	324	1.8	486
15 per cent winter ponds	*90				

*Of the area of winter ponds given here, a part may be used for raising purposes, but in the present scheme this need not be taken into consideration.

On the above basis of stocking, the yield in the third year will be: In poor ponds, 324 fish at 1.5 pounds=486 pounds; in good ponds, 486 fish at 1.5 pounds=729 pounds.

In managing and stocking the ponds on the basis that the fish are not to be sold till the fourth year, when they have reached a minimum weight of 2 pounds apiece, the scheme would be as follows:

Ponds.	Number of ares.	Number of fish.			
		Minimum per are.	Total.	Average per are.	Total.
6 per cent spawning pond	36				
15 per cent raising ponds of the first class	102	3.0	306	4.5	460
25.5 per cent raising ponds of the second class	153	2.0	306	3.0	460
42.5 per cent stock ponds	255	1.2	306	1.8	460
9 per cent winter ponds	54				

On this basis the yield in the fourth year will be: In poor ponds, 306 fish at 2 pounds=612 pounds; in good ponds, 460 fish at 2 pounds=920 pounds. But in the fourth year we may count on some pike, equal to at least 5 per cent of the stock of carp, in round figures 30 to 45 pike at 2 pounds; therefore, a total quantity of pike of 60 to 90 pounds. The grand total of the yield will therefore be: 612 pounds carp + 30 pounds pike=642 pounds, and 920 pounds carp + 45 pounds pike=965 pounds; consequently an excess over the sale of fish weighing 1.5 pounds apiece of 156 and 236 pounds, respectively; which excess, owing to the fact that in all probability the carp in the fourth year will have reached an average weight of 2.37 pounds apiece, will be increased to from 300 to 400 pounds.

It should of course be taken into consideration that this favorable result in the fourth year is attained one year later than the smaller yield of the third year, and that, therefore, in starting a pond farm three years instead of two are without result, and also that when the change is made from the three to the four years' period, one year will be without any profit; but by the surplus of the fourth and fifth year this difference is equalized; and from that time on the farm will annually yield a surplus, mainly caused by its reorganization. It further follows from this that the productiveness of a pond farm will greatly depend on using a rational method; for the same results as those given above have been attained in practice by reorganizing a large pond farm, where, without increasing the total stock of fish, the yield was doubled. It is therefore a great mistake to sell three years' carp weighing about 1.5 pounds apiece, while that method must be considered the most rational by which the pond cultivator succeeds in raising in two years carp weighing two pounds and finding a ready market for them. The fish which are to form the stock of the stock ponds are taken from the raising ponds.

The number of fish to be placed in the stock ponds depends on the nature of the soil, the quantity of food, the location, and water supply of the pond, and on the age and weight of the fish to be placed in it. Von Reider says: "The number of fish to be placed in a stock pond depends solely on its capacity for furnishing food; good ponds should be stocked at the rate of about 230, and poor ones of 150 fish per hectare. But if fish which have only spent one year in the raising pond are placed in stock ponds which are fished clean every year, only 230 fish should be counted per hectare. In order, however, to derive still greater benefit from large stock ponds, the number may be still lower; but if this is done no fish of prey should be allowed in the stock ponds. But this should only be done if one thinks that the losses would be greater if more fish were placed in the pond."*

Reimann says: "Every square rod of stock pond area should receive one carp from the raising ponds; the age of such carp should be three years; medium stock ponds should receive one carp per 1½ square rods (*i. e.*, per hectare, 470 and 310, respectively), and poor stock ponds should receive 1 three-year-old carp for from 2 to 3 square rods (*i. e.*, per hectare, 150 and 230, respectively)."

Reimann says in another place: "Some people take, as a general rule, for a one year's course in the stock ponds, carp weighing fully one-half pound apiece, and, if possible, those which have reached the age of three years, and for stock ponds which are fished clean every year carp weighing 1, 1¼ to 1½ pounds, also three years old. According to the greater or less size of the stock ponds, and their greater or less capacity for furnishing food, such people will stock a pond area of 120 square rods with 60, 50, 45, and sometimes with only 40 fish (*i. e.*, 240, 200, 180, 160, respectively, per hectare)." †

The proper time for stocking the stock ponds is autumn, immediately

* Von Reider, *Das Ganze der Fischerei*, 1825.

† Reimann, pp. 86, 87.

after the fisheries in the raising ponds have come to a close. If there is no trouble about filling the stock ponds in spring, and if there is a sufficient area of winter ponds, it may sometimes be advisable to let the stock ponds lie dry during winter, and to cart away the mud. If there are any stock ponds which, after the close of the autumn fisheries, cannot be filled immediately, or at least not to their full depth, they should not be fully stocked at once, but the number of fish placed in them in autumn should be in proportion to their quantity of water, and in the following spring they should receive their full stock of fish from the winter ponds. If there are stock ponds with a two years' course, which cannot be entirely filled in the time from autumn till spring, and which therefore do not receive their full supply of water till the second year after the fisheries—which often happens in large sky ponds—the number of fish should not be proportioned to the entire area of the pond, but to that portion which is filled during the first year; and this number of fish should not be increased during the second year, for at that time the pond, as a general rule, cannot supply the grown fish with the food which they need for their further development. It will therefore be an advantage if during the second year the fish get for their pasture-grounds the edges of the pond which hitherto have lain dry, but which are now filled with good food. If the number of fish was doubled, both the old inhabitants of the pond and the new-comers would suffer want, and therefore undoubtedly be retarded in their growth.

The transportation of the fish to the stock ponds should be intrusted to thoroughly reliable persons, so that the losses at the time of the fisheries may not be too large, and the hopes of the pond cultivator may not be too severely disappointed. In stock ponds which have a two years' course, regard should be taken to the age of the fish, because if three years' fish are placed in such ponds, they will spawn when they reach the age of 4 or 5 years, and the food will have to be shared by the old and young fish, in consequence of which the former are retarded in their growth. But if a suitable number of fish of prey is placed in the ponds, which do not let the young fish grow up and hinder the old ones from spawning, less harm will result from placing in the ponds fish which have reached too great an age. It may be laid down as a rule, however, that by spawning a carp is invariably retarded in its regular growth.

Horak enumerates the following reasons why carp spawn in stock ponds: (1) If old or crippled fish, or such as have not been hatched in spawning ponds, are placed in the stock ponds; (2) if the summer is particularly warm, and has much calm weather; (3) if there is too much food in the pond; and (4) if no pike are placed in the pond, or if those which were contained in it have perished from want of proper food or have destroyed each other. Horak thinks that the pike prevent the carp from spawning, because they constantly see before them the bitterest enemy of their young ones. According to my experience I am inclined to doubt this, although there may be a grain of truth in it, for on what should the pike live, especially in a sky pond, if not on the young of the carp. I had 10 per cent pike in four large stock ponds (sky ponds), which in two years grew to a very respectable size, although besides the carp there were in these ponds only a few tench, on whose young ones, in addition to the poor fry of carp from the raising ponds, the pike could not possibly live and reach, as they did, a weight of 4 to 6 pounds. It must, therefore, be supposed that if not all, at any rate the greater portion of the carp, had spawned, and thereby furnished ample food for the pike. If the carp had not spawned, no young fry could have been fished from the pond, and the quantity taken therefrom was very considerable.

The stock ponds are generally fished in October; but the fish may also be allowed to remain in them during winter, and the fisheries take place in spring or summer, if there is reasonable hope that at that season the fish will fetch a higher price than in autumn. The losses, however, which are unavoidably connected with summer fisheries, will in most cases neutralize any possible gain caused by the higher price of fish. Summer fisheries should always take place in the cool of the morning, and with as much expedition as possible. One should always be prepared for considerable losses in the stock pond fisheries. We have already, in a previous chapter, spoken of the average amount of the losses during the fisheries; but it may be useful to quote Von Reider on this subject. He says: "In the stock ponds one should always count on some losses, although it will be impossible to determine their extent beforehand; for a great deal will depend on the location of the stock ponds, whether they are surrounded by forests, in which case birds of prey will make havoc among the fish, whether there is much thieving going on in the neighborhood, whether there is danger of inundations, &c. According to these varying circumstances one should always count as loss one-tenth to one-twentieth of the number of fish placed in the ponds. Some people always count the loss as one-fifth, and therefore overstock the ponds very much, which, however, does more harm than good, as it deprives the fish of sufficient room and food, and keeps them small. It will be better to understock than overstock the stock ponds, and if there are too many fish on hand from the raising ponds, it will be better to sell those which are not needed."

As the largest ponds are generally selected for stock ponds, the food which they offer is, as a rule, of a more varied character than in small ponds; and with the view to derive the greatest possible profit from them, it will be advisable to stock them with some other fish besides carp. Large stock ponds not only offer a larger variety of worms and insects, thus providing the proper food for different kinds of fish, but also they generally receive their supply of water from rivers and brooks, when, in spite of the grates, fish of all kinds will get into the ponds. Such fish are of no direct value to the pond cultivator, and can be utilized only by feeding them to fish of prey, which are certain to find a ready market. As has already been stated, the older carp like to spawn in the stock ponds; their young ones will likewise decrease the quantity of food, and it will become necessary to destroy these young fish, which is easily done by placing in the pond a number of fish of prey. Among the fish of prey the pike deserves the preference on account of its voracity, its rapid growth, its hardy nature, and its ready sale; and from time immemorial it has been and is still the constant companion of the carp in the stock ponds. Care should be taken, however, that the pike do not exterminate the carp, and only pike of such a size as to make it impossible for them to outgrow the carp should be placed in the stock ponds. The pike is the most inveterate enemy of the carp, and will destroy it whenever possible. The number of pike, or other fish of prey, will depend on the quantity of food supplied for them, and on the number of carp in the pond. When ponds are fished which contain both carp and pike, great care should be exercised that no pike of any considerable size remains over till the following year, for a single large pike is capable of making sad havoc among a stock of carp. Carp weighing 1 pound should be accompanied by pike weighing at most one-quarter pound, and carp weighing 2 pounds by pike weighing at most one-half to three-quarters of a pound apiece. The same applies to other fish of prey, *e. g.*, perch, &c. To every 100 carp one generally counts 10 to 15 fish of prey.

Of other fish the tench are best suited for stock ponds, especially in a neighborhood where they find a ready market. The same price is often paid for them by dealers as for carp. If not placed in the ponds in excessive quantity the tench have the advantage that they can live on food hidden in the mud, which is not accessible for the carp, and that by their rooting in the mud they dig up food for the carp which these otherwise could never get at. A large quantity of the young fry of the tench serves as food for the pike. The *Idus melanotus* may also prove a valuable addition in carp ponds, as it often finds a ready sale as an ornamental fish. It will be well not to place too many other fish in the stock ponds, and their number should be deducted from the number of carp to be placed in the pond.

10. CARE OF THE FISH, ESPECIALLY THE CARP.

The care of the fish consists—

1. In keeping the pond in good order, which is done: (*a*) By keeping the dikes and banks in good repair, and by regulating the supply and outflow of the water; (*b*) by keeping the water always at a proper height.

2. In providing not only sufficient but good food for the fish, which may be done: (*a*) By artificially improving the capacity of the ponds for producing food; (*b*) by feeding the fish artificially.

3. By exercising careful supervision over the ponds, both in summer

and winter, so as to keep away from the fish all enemies and hurtful influences.

Keeping the dikes in repair.—The proper depth of water will principally depend on the character of the dike. It should therefore be one of the main objects of the pond cultivator to keep the dikes constantly in good repair. For this purpose they should be carefully examined from time to time, and any damage that is discovered should be repaired at once. The most suitable time for making repairs is after the autumn fisheries. When the water has been let off the dike should be carefully examined; any damage which is found should be repaired without delay, and if considerable the work should go on, as the weather permits, until it is completed. If it is impossible at the time to make thorough repairs, something should be done to prevent the spreading of the damage, and the thorough repairs should be made as soon as practicable. Small breaks in the dike are most quickly repaired by ramming in piles below the damaged place on the water side, by filling the space between the dike and these piles with small willow fascines, and by covering the whole closely and firmly with sod. Holes in the dikes and banks are filled with earth and clay mixed with stones. Teichmann says on this subject: "If water penetrates the dike in one or more places, this should be immediately remedied, for if there is great pressure the water will soon widen out the holes and break through the dike. In this case loamy or clayey soil should be piled upon the water side, wherever holes are found, and the evil thus be checked. Manure mixed with straw may sometimes answer the purpose. If by employing one or the other of these remedies the holes cannot be entirely stopped up, extensive repairs should be made as soon as the fisheries are over. Wherever the dike has suffered any damage it should be dug up, and if the soil has not much consistency it should be mixed with loam or clay and rammed down firmly. The mended place is covered with pieces of sod. If the pond is large, and the waves strike the covering of sod violently, it may be well to construct a fence of willow branches in front of the mended place and fill the space between it and the dike with earth."*

These hints for repairing dikes must suffice, as any one who has carefully studied the chapters treating of the construction of dikes will easily find ways and means for making all the necessary repairs.

After the fisheries are over, the outflow-pipes, taps, and stand-pipes should also be carefully examined, and repairs be made wherever needed. The weirs and grates should likewise be examined, and if necessary be repaired or renewed. The ditches should be cleaned of mud and aquatic plants.

Keeping the water at a proper height.—To do this it will be necessary to keep up a constant and even supply of water from the outside, and regulate the outflow after the pond has received its full supply. The best plan will be to introduce into the ponds clear running water from brooks

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*Teichmann, *Der erfahrene Fischmeister*, 1821.

and springs or from ponds which are fed from these sources. To obtain an even influx and outflow it is above everything else necessary that all the ditches should constantly be kept in good repair, and from time to time, especially after the fisheries, be cleaned of mud and aquatic plants. There is but little difficulty in keeping up a regular influx of water, if the ponds are fed from brooks and rivers, and by weirs and sluices this can easily be regulated. It is different in sky ponds, whose supply of water depends on the accidental gathering of rain and snow water in fields and meadows. Here it will become necessary to keep the ditches through which the water enters the pond in particularly good repair, to construct a large number of these ditches, and even, if necessary, to bring the water from a distance. If any roads or dikes are in the way, the water should be carried underneath them through pipes or conduits, while it may be led round small elevations. As the water in these ponds is apt to be stagnant, and as a slight agitation favors the absorption of oxygen from the air and thereby makes the water healthier for the carp, the desired object is attained by letting the water flow into the pond over a weir, so that by its rushing motion it keeps up that constant movement of the waters of the pond which is beneficial to the fish. To substitute weirs for grates may be recommended in all those ponds which are fed by small streams or springs. If ponds are fed by brooks or rivers, the pressure of the water on entering the pond is generally stronger than may appear desirable for the fish, and in this case, therefore, it will be preferable to let it flow in through grates. For keeping the water at an even height the stand-pipe may be recommended, of which we have spoken in a previous chapter.

Cleaning out the mud.—To insure an even height of water, and a regular supply and outflow, no mud or aquatic plants in the ditches should offer any hindrance to the water in its flow. After the fisheries, therefore, all the ditches should be carefully cleaned. It is true that the mud contains a great deal of nutritious matter, while the aquatic plants not only serve as food for fish but also sustain many insects which form a favorite article of fish-food; but it cannot be denied that too great an accumulation of mud and too rank a growth of plants will contract the water area very preceptibly, and thus prove injurious to the fish. To clean a pond of superfluous mud and aquatic plants, it will be necessary to drain it and dig ditches through the mud which should all open into a main ditch and carry the water towards the outflow. The mud taken from the ditches is piled up in heaps and allowed to dry in the sun and air. These mud piles are not carted away till winter when the ground is frozen, and should then remain exposed to the influence of the atmosphere for at least a year before they can be used as a fertilizer. This has also the advantage that the mud decreases at least one-half in volume and weight, and offers much less difficulty in carting it to the fields than if it had to be moved in its moist condition.

The mud is removed from the different parts of the pond to its banks in wheelbarrows, and in very large ponds one-horse carts may be used, from which the mud can easily be dumped. In removing mud from a pond, special care should be taken to do this evenly throughout the entire pond, so as to prevent the formation of holes in the bottom, which would seriously interfere with the fisheries. It would, however, be a mistake to remove every particle of mud from a pond, as this would diminish its food-producing capacity, but it should always be allowed to remain to the depth of 30 to 40 centimeters. If the mud is to be taken from very large ponds, it will be impossible to accomplish this by carting it away, as this would involve too much labor and expense; and it will become necessary, immediately after the fisheries, when the mud is still in a fluid condition, to have it carried away with the water. To do this, running water should be led to the deepest places; or special ditches should be dug, to which the mud is carried from all sides, and whence the water carries it farther, and finally out of the pond through the pipes, which process should be aided by rakes, shovels, and brooms. This process will of course, require rapidly running water, whose course may be accelerated by occasionally driving in the tap and quickly pulling it out again. This process should be continued until the pond has been sufficiently cleaned of mud. If possible, the bottom of a pond which has undergone this process should be plowed, and not be allowed to dry out, but should be immediately filled again with water.

Sickness among fish.—By cleaning the pond annually and by aiding the influx of water, the health and growth of the fish will be greatly promoted. If the water is very low, and if there is too great an accumulation of mud in the pond, the temperature of the water will, in hot summers, become too high, too much oxygen will be absorbed, the decay of vegetable and animal matter will be very great, the water will deteriorate, the fish will perish, unless either a timely supply of fresh water is introduced into the pond or the windows of the sky are opened and help comes from above. To this danger fish are particularly exposed in sky ponds in which it is difficult to keep up an even height of water, and among these the smaller and shallower ponds are apt to suffer more than the larger ones. This danger will be greatest during the months of June and July.

This condition of affairs is indicated by various signs; the fish swim about near the surface of the water endeavoring to get a breath of air, they become languid, lose their natural color, and finally perish. If at the first signs of such a catastrophe it is impossible to introduce fresh water into the pond, and if there is no hope of rain, nothing remains to be done but to commence the fisheries at once, and transfer the fish to fresh water. It is true that by the fisheries the mud is stirred up, and the water is consequently still more deteriorated, thus increasing the danger, but of two evils the smaller one must be chosen, and all the fish which can be saved should be saved. Such fisheries, however, should not take place during the heat of the day, but at night. In small ponds aid may be afforded, and the worst consequences averted, by throwing black soil, if it can be obtained in the neighborhood, into the pond, until it is covered to the height of 7 to 10 centimeters. Thereby the pond is again rendered healthy, and the fact that the water becomes turbid need not alarm any one, for no fish will perish from this cause. On no condition whatever should such a pond be drained, for thereby the mud is stirred up, and the evil is made worse.*

Horak is also of opinion that the stirring up of the mud makes matters worse, and considers fisheries as the only remedy. He says: "If animal refuse is carried into ponds located in the middle of or below villages, or if cattle are driven into them, the accumulated organic matter will, during hot summers, particularly during the months of June and July, begin to ferment, and will thereby cause the death of the fish."† A pond in which a large number of fish have died should be drained and sowed.

Unless the water sinks too low, an extraordinary supply of water should in no case be introduced into a pond, as this will invariably drive the fish away from their pasture-grounds, disturb them greatly, and cause them to go towards the fresh water which flows into the pond. If it is absolutely necessary to introduce a fresh supply of water, this should be done slowly and gradually. Wherever there is fear of inundations, which generally take place in spring, but also at other seasons, in consequence of violent or long-continued rains, there should be plenty of ditches for superfluous water, which should always be kept clean, so that they may receive the greatest possible quantity of water. If the danger of inundation is imminent, the pond must be constantly watched, the grates and weirs should frequently be examined, and persons should keep watch all through the night, especially if there is any fear of thieves approaching the pond, for inundations carry the fish towards the fresh current and offer them a chance of escape from the pond. Unless proper precautions have been taken, the fish will, during an inundation, scatter all over the neighboring country and will get lost or stolen, unless they are gathered as soon as the waters commence to recede and are returned to the pond. In gathering fish which have become scattered in the manner described above, search should be made for holes in the ground, where the fish will naturally go, for there are not unfrequently neighbors who, on such an occasion, will dig holes with a view to catch the fish.

Improving the food-producing capacity of the ponds by artificial means.—(1) The safest way to keep up an ample supply of good food, to introduce new food into the ponds, and thereby to improve them, is to drain and sow the ponds at certain stated periods; in other words, to use them for a time for raising grain or grass. After a pond has been fished clean and the water drained off, ditches should be constructed in it in every direction,

* Von dem Borne, *Fischzucht*, p. 74.
† Horak, *Teichwirthschaft*, 1869.

so that the water may be entirely taken out, and the bottom allowed to dry. In this condition the ponds are left till spring, say April or May, when they may be plowed and prepared for the seed. To insure a good harvest, the entire bottom of the pond should be divided into raised beds, separated from each other by water furrows. These beds may be sowed with oats, hemp, or poppies; other grains or plants will yield only poor harvests. After the harvest has been gathered, the soil should be hoed, and allowed to remain in this condition till the following spring, when the pond is again filled. If it is not intended to gather a harvest, but simply to supply the pond with plenty of fresh food, it is plowed in spring and allowed to lie fallow till summer, when it is sowed with turnips. Still better food will be introduced into the pond if it is sowed with peas, beans, and vetches, with a few turnips between. In this case there is no hurry about sowing the pond, and this may be deferred till June, or till July if only turnips are sowed. When the peas and turnips are nearly ripe, the pond is filled with water, and may be stocked with fish that same autumn, although it will be better to defer this till spring. In most cases, however, it will be best to gather the harvest, as the decay of vegetable matter easily assumes too great proportions and becomes injurious to the fish. This applies particularly to small ponds. Even if the harvest is gathered, the sowing of a pond will be of great benefit, and make its influence felt for years. For during the time of growing and during the harvest many seeds fall into the pond, and to favor this one may defer the harvest until the grain or plants are dead ripe. Even the stubbles in themselves form an addition to the food. By sowing a pond, food is also indirectly introduced into it by giving it a period of rest, during which worms, &c., will increase. In their decay the stubbles also furnish food; and the thorough freeing of the soil from acids caused by the draining and sowing of a pond has a most beneficial influence on the health and growth of the fish.

The object of sowing a pond is twofold; the acids are taken away from the mud by the draining and plowing of the pond, and new food is introduced in it, and, on the other hand, an additional income is derived from the sale of grain or vegetables. To sow a pond for one year will be beneficial, but to continue this process for several consecutive years is not advisable, as the pond is apt to dry out too much, and loses its mud, which is indispensable to the growth of the fish. The banks and dikes also dry out too much—the latter are undermined by mice, moles, &c.—the wood-work of the grates, &c., suffers, and repairs become necessary, the expense for which is not sufficiently made up by the income from the harvests. By using a pond for agricultural purposes for any considerable length of time its fish-food is reduced almost to nothing (this is less to be feared when the pond is used merely as a meadow, which, however, will yield only poor and sour grass) and the benefit to be derived from sowing a pond is completely lost.

If a pond yields constant and sure harvests, and can also be used for winter grain, it will pay better to transform it into a field. Teichmann is of the same opinion when he says: "One of the most efficient means for improving a pond is undoubtedly in all cases to let it lie dry for a year and to utilize it during that period by raising grain; for it has invariably been observed that after a year when the pond had been used for agricultural purposes the fish grew remarkably well, even if a much larger number was placed in the pond than it could otherwise support. If a pond which had been sowed for a longer period is to be filled with water, the number of fish must gradually be reduced, and even brought below the average, if they are to reach the desired size. The beneficial effects of sowing make themselves felt for six years, and in some cases even longer. The sowing of the ponds is, so to speak, a rejuvenating process. It will depend on the various localities how often ponds should be sowed. In some places the ponds, not even excepting very large ones, should be drained every sixth year and sowed with oats. Sowing is the most effective means for destroying frogs and other injurious animals. It is not advisable to use ponds for agricultural purposes several years in succession, for in that case mice and other animals are apt to undermine and injure the dikes, and the long dry period would also injure the tap-houses, grates, &c." *

Experience should gradually teach how often it will be necessary to sow a pond. Sowing repeated at considerable intervals can never be injurious, and will under all circumstances exercise a beneficial influence on fish-culture and the general condition of the ponds. These intervals should not be longer than ten and not shorter than five years. In drawing up a plan for the management of a pond farm, it will sometimes be found impossible to determine the length of these intervals. If they are not less than five and more than ten years, it will be better to adapt oneself to circumstances than to sow pond areas of greatly varying extent every year, as this will in most cases interfere with the regular management of the ponds. If the ponds are few and large, it will be difficult to introduce a regular system of sowing.

(2) Another way to introduce food into the ponds is to lead rain and snow water from cultivated fields, which always contain much fish-food, by means of ditches into ponds which are fed by brooks or springs. In sky ponds it will be absolutely necessary to do this.

(3) The accumulation of food is favored and the general condition of the ponds is improved if after the autumn fisheries they are allowed to lie dry till spring. If it is in any way possible this should be done. It will, of course, depend on the possibility of filling the pond in spring. Whenever a pond is allowed to lie dry one should not forget to remove the mud.

(4) The production of food is greatly promoted by the planting of various kinds of grass and aquatic plants, *e. g.*, *Acorus calamus*, *Festuca fluitans*, and other plants whose young shoots, seeds, &c., serve as food

* Teichmann, *Teichfischerei*, 1831.

for fish, and of such plants as are inhabited by aquatic insects, &c. The *Potamogeton*, *Glyceria*, *Spectabilis*, *Ranunculus aquatica*, *Trapa natans*, &c., are generally covered with these insects. The planting of reeds in bare places will also render the pond better suited for fish and improve its general condition.

Feeding carp artificially.—The sowing of the ponds may be considered as a means of providing artificial food, but in a narrower sense we understand by artificial feeding the introduction of food which the pond cannot produce. Artificial feeding will be difficult if the pond farm is very extensive; and if all the ponds are very large it will be impossible. There are, however, many medium and small pond farms which, besides large ponds, possess also a number of small ponds, in which the system of artificial feeding may be introduced. It is the object of artificial feeding to increase the weight of the entire stock of carp, or a portion of it, in the shortest possible time, or at any rate sooner than would be the case if the fish lived only on natural food. It may become possible by artificial feeding to determine beforehand what weight the carp will reach within a certain given time. A second object of artificial feeding is to enable the stocking of a pond with a larger number of fish than it could otherwise support.

By artificial feeding the carp cultivator may derive extraordinary advantages, as it will, to a certain degree, make him independent of the nature of his ponds, make the yield of poor ponds equal to that of the best, so that he can stock them with any number of fish; of course making this proportionate to the size of the pond and to the quantity of water. Even if only introduced in one or two ponds, artificial feeding will prove advantageous; and the same applies to periodical feeding, say during the months of May, September, and October, when the quantity of natural food is smallest. In spite of all these advantages, however, it will be a problem whether—and, if so, by what method of feeding—the pond cultivator will be repaid for his trouble. We intend to discuss this problem at some length.

The first question will be whether a system of artificial feeding will pay; that is, whether the undoubted increase of weight attained thereby will compensate for the expense and labor connected with it, so as not only to cover the expense, but also to leave a considerable net revenue. In order to answer this question we must first endeavor to get a satisfactory answer to the questions: What food is to be used, and in what quantity? Before endeavoring to answer these questions from the present stand-point regarding the general principles of sustaining animal life, we will hear what old and experienced pond cultivators have to say on the subject. I consider their experience as very important and in many respects of practical use, even in our days. Their methods of preparing fish-food may at any rate give valuable hints how to preserve the food from spoiling, in case it is not eaten by the carp as soon as it is thrown into the pond.

That the pond cultivators of bygone times have employed artificial feeding is proved by their own statements on the subject; and that they found it advantageous appears from the fact that they often employed expensive articles of food. Even if such food was not as expensive in those days as it is now, it should be remembered that the price of carp was much lower. Von Reider, for instance, recommends the following method of feeding carp in fish-tanks: "Perforate both the bottom and sides of light kegs, fill them with ground malt, and throw them into the fish-tanks. Others take good, fat clay, broken into small pieces, mix it with the malt, and put this mixture in a keg, which is closed firmly. By pushing the keg about, the carp cause the malt and clay to ooze out through the holes, and thereby the water is rendered sweet and nourishing. Others mix malt and wheat flour, make this mixture into loaves, which are baked in an oven. Others again bake loaves of ground malt and clay, well kneaded together, and throw the broken loaves into the fish-tank. Others take fat clay, the solid excrements of sheep, malt, and a little salt, kneed all this into a dough, which is rolled out thin and scattered along the banks. Others take fat clay, mix it with honey and barley flour, kneed it well, and form it into balls, which are thrown to the fish. The clay should be mixed with sand, to aid the fish in digesting it."

Jokisch recommends the following fish-food: "The so-called fish-bread, which is baked in an oven or dried in the sun, should be made of such ingredients that if baked in summer it will keep in a dry place till winter. Potatoes, peas, lentils, beans, &c., are cooked until they are tolerably soft, and thereto are added bran, a little refuse from breweries or spoiled malt, and dark flour, which serves to give consistency to the whole. With this mixture some brewer's yeast, poor milk, or water is incorporated, and allowed to work it thoroughly, when it is formed into loaves. If these loaves are baked in an oven, they should be made tolerably large, while they must be small if they are to be dried in the sun, so as to prevent their molding or rotting, of which there is danger in water which is not running at all times. Such loaves are broken and thrown into the ponds in quantities to suit the number of fish, and after a few days they are devoured by the fish. In ponds which do not receive much natural food from the outside, artificial food will be very useful. Husks of beans and various kinds of grain, and particularly the carcasses of horses, will here render excellent service. It will always be found that wherever the refuse from breweries, distilleries, starch factories, &c., is emptied into ponds, the fish will be particularly fat and of excellent quality. Potatoes boiled and cut up also form an excellent article of food for carp."

Tscheiner says: "The fish will get fat if fed on a mixture of hemp, beans, peas, and the solid excrements of sheep. Rest also favors the fattening of carp, and they are, therefore, fattened outside the water in the following manner: They are wrapped in moss, which is constantly kept moist, so tightly that they cannot stir, and if fed on the food described above they will grow fat in a very short time and acquire a most delicious flavor. Another means of fattening fish is to castrate them. This operation was first tried in England, not only on carp, but also on pike and other fish. It seems, however, that the great expectations entertained in regard to this method were not realized."*

Unfortunately, the above data do not contain the slightest hints as to the quantity of food, and also leave us entirely in the dark as to the results (in figures). They are, nevertheless, exceedingly valuable for making experiments, and because they show what articles of food were used successfully by former pond cultivators. In all probability it would pay even in our days to employ such food. We also learn that the food consisted principally of those products of the vegetable kingdom which contain a great deal of albumen. The articles of food described above were generally employed in small receptacles such as fish tanks, and the only one among the older authors on the subject who states that they may with as much advantage be employed in ponds is Jokisch. It may be presumed, however, that the articles of food mentioned by the other writers may be used in ponds as well as in tanks. We will cite the following interesting example, which shows how profitable the artificial feeding of carp may be. The papers contained an account of a German by the name of Poppe, residing in California, who imported carp from Germany and placed them in a pond containing warm springs. The carp were fed on blood, thick milk, refuse from slaughter-houses, &c., and grew marvelously. When placed in the pond they measured 15 centimeters in length; after nine months they commenced to spawn, and after twelve months they measured 50 centimeters in length and weighed from 12 to 15 pounds.† Delius, who gives an account of Mr. Poppe's experiments, says: "These results seem almost incredible, but, by taking into account all the local conditions, we must grant that they are within the reach of possibility. It should be remembered that the water all the year round‡ had the most favorable temperature of 18° Réaumur [72½° F.], and that the development of the fish was not retarded by a single cool day. In one year the original weight of the carp had increased sixty or seventy fold. A young pig at its birth weighs about 6 pounds, and there are instances where the weight of such a pig was in twelve months increased to 400 pounds, which would show about the same ratio of increase as that of the carp referred to above." We regret that we are not informed as to the quantity of food which Mr. Poppe gave to his carp; but it may be presumed that this development was reached by employing food which contained a great deal of nitrogen, from which it may be inferred that the carp, in order to grow

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* Tscheiner, p. 191.

† Delius, *Teichwirthschaft*, p. 28.

‡ The growth of the fish was, therefore, not interrupted during winter, and the twelve months are fully equal to two years under our conditions.

rapidly, should be fed on articles containing a great deal of nitrogen. After giving the above data, we shall now endeavor, proceeding by analogy, to ascertain, on the basis of the laws which regulate the feeding of various domestic animals, that proportion of nutritive substances which is most favorable to the development of carp, and the quantity in which the food should be administered.

The substances composing the various articles of food of the higher classes of animals are divided into those which contain nitrogen and those which are free from nitrogen. To the former belong the proteine or albuminous substances, to the latter the hydrates of carbon and fat. Vegetable food contains comparatively much less nitrogen than animal food. The most profitable method of feeding domestic animals is that which provides the quantity of nutritive matter which is best suited to the purpose these animals are to serve, and provides it in the proper proportion, *i. e.*, the right proportion between the digestible albuminous substances and the digestible hydrates of carbon, including fat. The substances containing nitrogen—in other words, the albuminous substances in the various changes which they undergo in the animal body—mainly serve to form flesh and fat, while those substances which contain but little nitrogen principally serve the purposes of respiration.

By comparing the different methods of feeding domestic animals, chiefly cattle, whose food belongs exclusively to the vegetable kingdom, and the different kinds of grass of good pasture-lands, in which the proportion of nutritive matter—*i. e.*, the proportion between the substances containing nitrogen and those which do not contain it, is as 1 to from 5 to 6—it has been ascertained that the most profitable proportion of nutritive substances is about 1 to 4 or 1 to 7. Professor Wolff says: "If the food contains less albumen than would correspond to the proportion 1 to from 6 to 7, a considerable portion is not properly digested and absorbed, and a part of the nutritive substances which do not contain nitrogen is passed with the excrements, without having been of any use to the body. If the proportion exceeds that of 1 to from 6 to 7, there is not sufficient albuminous matter to attain the desired production quickly and safely, it progresses slowly and without energy, so that in the end the profits are very small, even if the food has been very cheap. A proportion like that of 1 to 4 is never needed in feeding domestic animals, as it would tend to further the disintegration of matter in the body and cause losses in the end. But if the absolute quantities of the nutritive substances containing nitrogen and of those which are free from nitrogen are sufficiently large and do not exceed the proportion given above as the most suitable, all reasonable requirements have been met. No losses need then be feared by a relaxation of the digestive organs or too great a disintegration of matter; nor will there ever be a lack of material to favor quick and ample production. The most suitable proportion for purposes of production will, therefore, be somewhere between 1 to 4 and 1 to 7; although it may be laid down as a general rule that, within these limits the total quantity of effective nutritive matter being the same, production will increase as the proportion becomes smaller; but whether in the end it will yield greater profits will have to be decided according to local circumstances."*

The proportion between albumen and hydrates of carbon will be particularly influenced by the circumstance that in their food the animals should receive the quantity of hydrates of carbon which they absolutely need for purposes of respiration. From experiments made by Müller it appears that this quantity varies very much in the different animals. Per 100 pounds weight of the body the tench exhales 12 grams carbon =1; the frog, 43.5=3.5; man, 146.0=12; the pigeon, 1370.=114. It appears from these figures that fish—in this case the tench, which greatly resembles the carp in the quantity and quality of food it needs—use for the processes of life, more particularly of respiration, a very small portion of hydrates of carbon as compared with warm-blooded animals. These figures, therefore, may serve as a guide in finding the most suitable proportion of nutritive substances for fish. But as no experiments have been made to test the matter, and as at any rate nothing has been published on the subject, all that can be done is to draw conclusions from analogy and compare therewith the experiments in feeding warm-blooded animals. The exhalation of carbon holds a certain relation to the absorption of oxygen. The more oxygen is absorbed the more hydrates of carbon will be destroyed, the greater warmth is generated in the body, and the more carbonic acid is exhaled. But as fish have no warmth of their own, but always have the temperature of the water in which they live, they need only a small quantity of hydrates of carbon to keep up life, and the result of Mr. Müller's experiments is proved true.

Although it is impossible to find out from these experiments what is the proportion between the quantities of carbon inhaled and exhaled, it is safe to assume that the greater the quantity consumed in the respiratory process, all the more hydrates of carbon will have to be introduced into the body with the food, and *vice versa*. Baussingault's observations throw some light on the proportion between the quantity of carbon in the food and that consumed by the respiratory process in domestic animals. It appears that the milch-cow and the horse exhale 60 per cent, the hog 70 per cent, and the pigeon 80 per cent of the carbon absorbed with the food. These data, however, do not yet answer our purposes, and we have to look further. Experiments made at Wende with full-grown sheep have shown that these animals, while receiving 481.3 grams carbon with their food, exhaled 222.5 grams (*i. e.*, 60 per cent) per 100 pounds of live weight in twenty-four hours.† The

*Prof. E. Wolff, *Fütterungslehre*, 1874, p. 147.

†Prof. E. Wolff, *Fütterung der landwirthschaftlichen Nutzthiere*, 1874, p. 35.

food used in these experiments was hay of medium quality, and the proportion of nutritive substances was probably the following:

$$Nh : Nfr = 1 : 7.$$

As was stated above, the tench exhaled per 100 pounds weight in twenty-four hours, 12 grams carbon, while the sheep exhaled 222.5 grams, therefore 18.5 times as much. We now know the quantity of carbon consumed and exhaled by sheep per 100 pounds live weight, and when a certain kind of food is employed; we also know the quantity of carbon exhaled by an equal weight of tench, and we can therefrom easily calculate the quantity of carbon consumed by tench. We are, therefore, enabled, since we have three known quantities, to find the fourth one by the following proportion:

$$222.5 \text{ grams} : 12 \text{ grams} = 7 \text{ Nfr.} : x \text{ Nfr.}$$

$$x = \frac{12 \times 7}{222.5} = 0.38.$$

We get the same result if we say that the proportion between the absorption of carbon with the food of sheep and the absorption of carbon by the tench—which is found by the following proportion: $222.5 : 12 = 481.3 : x$, *i. e.*, $x = 25.9$—is as follows:

$$481.3 : 25.9 = 7 : x, \text{ whence } x = 0.38.$$

The proportion of nutritive substances in food, therefore is, for sheep, Nh : Nfr = 1 : 7; carp = 1 : 0.38.

As the absorption of nutritive substances in the different kinds of hay varies from 1 : 5.1 to 1 : 10.6, and as we do not know what kind of hay was used in the experiments made at Wende, the proportion of nutritive substances in the food of the carp will probably vary between 0.27 and 0.57. It can hardly be supposed, however, that the hay used in the experiments referred to was anything but hay of a medium quality, as first-class hay is but rarely met with in that locality. The difference will, therefore, be only between 1 : 7 and 1 : 8, and for the carp between 0.38 and 0.43.

Although this whole calculation is somewhat bold, and absolute correctness cannot be claimed for its results, it is probable that these are at any rate approximately correct. This proportion of nutritive substances is very close; but we will have to acknowledge its approximate correctness, if we take into consideration the following facts:

1. For generating and maintaining the normal degree of heat in the body of warm-blooded animals (with man, 37° Centigrade [$98\frac{3}{5}$° F.]) a certain quantity of carbon, and therefore of hydrates of carbon, is needed, which, in connection with the oxygen inhaled, causes the destruction (by a burning process) of fat in the animal body, by which heat is generated. Fish have no heat of their own, therefore need no

carbon for generating and maintaining heat, and require only a small quantity of carbon which is necessary for burning the substances which decay through the process of life.

2. Fish have an advantage over land animals in needing less force for their movements. While land animals need a considerable exertion of the muscles even when they stand perfectly still; fish can swim about, or rest at the bottom, without any special exertion; and even their movements in any direction whatever require less exertion than the movements of land animals, which have to propel their bodies by lifting the feet. The water moreover offers but little resistance to the movements of fish. This is easily explained if we remember what heavy pieces of lumber a man can propel in the water with comparatively little exertion, while he would not be able to move them on land. If swimming tires a man more than walking, this is not caused by the greater exertion required by the movement in the water, but because those muscles which are principally brought into play are those which otherwise are not accustomed to rapid and long-continued movements. Writing, for example, does not in itself require any great exertion, and still a person not accustomed to it will get more tired by an hour's writing than by the same time spent in manual labor. As great exertions of the muscles accelerate the disintegration of matter in the animal body and increase it to a degree which becomes injurious, this must be neutralized by introducing more food into the body; while, on the other hand, a steady and ample supply of suitable food will cause the body to grow more rapidly.* The small quantity of hydrates of carbon needed in the food is therefore easily explained by the fact that the exertion is less; for in strong exertion the loss is occasioned not so much by the wear and tear of the various organs of the body and the destruction of albumen, as by the increased burning of hydrates of carbon, in consequence of which a greater quantity of oxygen is absorbed by the process of respiration, and more heat is not only generated, but also exhaled.†

3. The small quantity of oxygen absorbed also necessitates a comparatively small absorption of hydrates of carbon.

4. The component parts of the carp, according to Dr. König, of Munster, are the following: 76.97 per cent water, 20.61 per cent substances containing nitrogen, 1.09 per cent fat, 0 per cent substances free from nitrogen, 1.33 per cent ashes.

According to the above figures—the quantity of substances free from nitrogen being=0—food which contains much nitrogen appears to be the most suitable food for carp.

Professor Wolff's analysis of the carp shows different results, viz.: 79.8 per cent water, 13.6 per cent albumen, 1.1 per cent fat, 4.5 per cent extractives free from nitrogen, 1 per cent ashes.

* Wolff, *Fütterungslehre*, p. 27.

† Wolff, *Fütterungslehre*, p. 64.

I am unable to decide which of these two naturalists is right, but I deem it proper to give both sets of figures.

From the above it appears that fish, compared with warm-blooded animals, need a small quantity of carbon; and consequently fewer hydrates of carbon in their food; and the approximate proportion of nutritive substances, as given by us above becomes still more probable, even if it is not confirmed in all its details. It also appears that, with an equal quantity of food, fish will grow more rapidly than land animals, because in the same quantity of food they receive a much greater portion of albuminous matter which is changed to flesh and blood. This increase of weight in fish, which is sometimes marvelous, as the example of Mr. Poppe's carp in California shows, proves that with an increased quantity of albumen, introduced into the body, there will be a corresponding increase of flesh and fat.* The growth of the carp is also promoted by the extraordinary digestive power of which these fish are possessed, and which among the rest is shown by the fact that they appropriate from the excrements of animals nutritive substances which these animals were not able to digest.

We will now compare with the most favorable proportion of nutritive substances, as calculated above, the proportion of these substances as existing in the food which nature provides for them in the ponds. Besides vegetable matter and various nutritive substances dissolved in the water, this food comprises worms, maggots, snails, beetles, and other insects. Beetles and insects generally, when dried, contain on an average 95 per cent of nitrogenous substances. As regards the nutritive matter contained in worms, maggots, and snails, no observations have been made. Delius† is of opinion that the quantity of proteine contained in them is like that of the silk-worm, viz., 15 per cent; I think, however, that this percentage is too low as far as snails and maggots are concerned, which latter are generated in flesh and blood; for they are formed from strongly albuminous substances, and therefore probably contain a good deal of nitrogen. It is well-known that snails form a very nutritious article of food, and probably contain much proteine. However this may be—for we cannot entertain mere suppositions—we will take, as a tolerably safe basis, beetles and other insects and their larvæ (the former are formed from the material of the latter, and their quantity of nitrogen will probably not vary much), which compose the larger portion of the natural food of the carp.

The circumstance that the percentage of proteine (95) given above applies to dried beetles and insects, while carp always eat them alive, will not make any difference in our present calculation, as the proportion of nutritive substances remains the same, no matter whether the food is dried or fresh.

According to Prof. E. Wolff, the proportion of nutritive substances

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* Wolff, *Fütterungslehre*, p. 423.
† Delius, *Teichwirthschaft*.

in cock-chafers—which in years when these beetles are plentiful doubtless in great part form the food of the carp in ponds which are surrounded by trees and shrubs whence the wind casts them into the water—is Nh : Nfr=1 : 0.6. We are justified in supposing that the proportion of nutritive substances in other beetles and insects, as well as in their larvæ, is very similar. Our calculations showed the proportion to be 1: 0.38, and 0.43, and 0.57, respectively, so that the difference between the two proportions is not very great, especially if we take into consideration that the proportion of nutritive substances, in all probability, varies a little in the different insects. We shall, therefore, not be far from the truth if we say that the most favorable proportion of nutritive substances in carp-food is Nh:Nfr=1:0.5 (or 0.6), and that consequently food containing a good deal of nitrogen is the best and most profitable for carp. Before entering upon a further examination of the question which is the most suitable quantity of food, we will give, in tabulated form, the various articles used as carp-food, showing the percentage of nutritive substances contained in each, following in this the tables prepared by Prof. E. Wolff:

In 100 pounds of food.	Per cent of—				Proportion of nutritive substances. Nh.=1.
	Water.	Digestible substances.			
		Albumen.	Hydrates of carbon.	Fat.	
Blood, fresh	80.0	19.1	....	0.1	0.1
Blood, dried	12.0	54.1	2.6	0.5	0.1
Horse-flesh, lean	76.3	21.6	....	1.1	0.1
Fish guano	12.6	44.1	....	1.6	0.1
Curds	52.5	38.0	....	7.7	0.2
Gluten, dry	....	68.9	16.0	1.5	0.3
Meat, dried and ground fine	11.5	69.2	....	11.2	0.4
Heart, lungs, liver, and brains of oxen	....	16.3	0.3	7.3	0.5
Worms, maggots, beetles, other insects, and their larvæ.	....	....	....	....	0.5 to 0.6
Cock-chafers, fresh	70.4	13.0	....	3.1	0.6
Cock-chafers, dried	13.5	38.0	....	9.1	0.6
Pumpkin-seed cake	12.0	50.0	9.7	10.5	0.7
Beef	70.0	18.3	....	15.8	0.9
Linseed flour, from which the oil has been extracted	9.7	27.8	33.9	2.1	1.4
Hemp-seed cake	9.9	20.9	17.4	5.2	1.5
Poppy-seed cake	11.5	26.8	35.4	7.4	1.7
Rape-seed cake	11.3	25.3	23.8	7.7	1.7
Rape flour, from which the oil has been extracted.	8.5	26.5	26.2	2.5	1.9
Skimmed milk	90.0	3.5	5.0	0.7	1.9
Linseed cake	12.2	24.8	27.5	8.9	2.0
Vetches	14.3	24.8	48.2	2.5	2.2
Field beans	14.5	23.0	50.2	1.4	2.3
Malt germs	10.1	14.4	45.0	1.7	2.5
Lentils	14.5	21.4	51.2	2.2	2.6
Buttermilk	90.1	3.0	5.4	1.0	2.6
Peas	14.3	20.2	54.4	1.7	2.9
Pea flour	11.4	20.9	55.4	2.8	3.0
Refuse from breweries	76.6	3.0	18.8	0.8	3.4
Refuse from distilleries	91.0	1.7	5.4	0.3	3.5
Red clover, before it has bloomed	83.0	2.3	7.4	0.5	3.8
Wheat bran	12.9	12.6	42.7	2.6	3.9
Rye husks	70.0	5.2	18.1	1.2	4.1
Refuse from potatoes used in distilling	91.9	1.5	5.8	0.2	4.2
Cow's milk	87.5	3.2	2.0	3.6	4.4
Rye bran	12.5	12.2	46.2	3.6	4.5
Gluten, refuse from starch factories	70.0	6.4	24.5	0.5	5.0
Wheat husks, from starch factories	71.0	3.7	15.1	1.8	5.3
Red clover in full bloom	80.4	1.7	8.7	0.4	5.7

In 100 pounds of food.	Per cent. of—				
	Water.	Digestible substances.			Proportion of nutritive substances. Nh.=1.
		Albumen.	Hydrates of carbon.	Fat.	
Grains of wheat	14.4	11.7	64.3	1.2	5.8
Grains of oats	14.8	9.0	43.3	4.7	6.1
Whey	92.6	11.0	5.1	0.6	6.6
Grains of rye	14.3	9.9	65.4	1.6	7.0
Turnips	91.5	0.9	6.8	0.1	7.6
Grains of barley	14.3	8.0	59.9	1.7	7.9
Grains of corn (maize)	14.4	8.4	60.6	4.8	8.6
Malt, dry	7.5	7.5	67.2	1.8	9.4
Potatoes	70.5	2.1	21.8	0.2	10.6
Potato fiber, refuse from starch factories	86.0	0.8	18.7	0.1	17.4
Excrements of cattle	71.0	0.5	12.3	0.2	*30.5

*From experiments made on the farm of Mr. J. Schwarz, at Hofgarden, in Sweden, with feeding milch-cows on horse-dung, it appears that, as to their nutritive qualities, 300 pounds of horse-dung are equal to 100 pounds of straw. One hundred pounds of straw contain, on an average, the following quantities of digestible nutritive substances: about 1.5 per cent albumen, 36.9 per cent hydrates of carbon, and 0.5 per cent fat, and the average proportion of nutritive substances is 30.5 per cent, therefore the same in 300 pounds of horse-dung, and in 100 pounds of excrements of cattle. (See the agricultural journal *Der Landwirth*, 1875, No. 71.)

If the food of the fish is to be thrown into the water, the question will have to be considered whether in case it has to lie in the water for any length of time it will not lose some of its nutritive qualities. Wherever there is any danger of this it will be necessary either to substitute food which will resist the influence of the water or to envelop the original food in it. Mixing the food with clay will also have a good effect. Cooked food, *e. g.*, the various kinds of grains, peas, beans, potatoes, &c., is in that condition less exposed to the influence of the water than when raw. The manner in which pond cultivators in former times prepared their food shows that they had the same experience.

The spoiling of food in the water and the precautionary measures referred to above may be avoided by giving the food to the fish regularly at stated times and throwing it all into the water at one and the same place not far from the bank, so that one may observe how much of it is eaten. If the fish have once become accustomed to a regular feeding time and place they will always gather there at that time, and it is said that they will even follow the sound of a bell. It will soon be seen how much or how little of the food is eaten, and the quantity of food can be regulated accordingly. It will require a little experimenting to find the right quantity, and all we aim at here is to give a theoretical basis for such experiments. The kind of food, and the proportion in which different kinds of food should be mixed, is determined by the proportion of nutritive substances most favorable for carp, as given above, according to which concentrated or condensed food is the best, as in other kinds of food there is a waste of hydrates of carbon.

The most suitable articles of food, therefore, are blood, horse-flesh, fish guano, curds, meat dried and ground fine, refuse from slaughter-houses, &c. All these, however, require to be mixed with other articles of food containing less nitrogen, so as to restore the proper proportion of nutrititive substances. On the whole the food for carp will have to be mixed very much on the same principles as that for cattle and other domestic animals.

Two other questions will have to be answered, viz.: (1) How much food is to be given? and (2) How is this to be calculated? As there are no data on the subject, it will be difficult to lay down exact rules as to the quantity of the food. It will be correct to presume that at least approximately the same principles will have to serve as a basis as those prevailing in the feeding of cattle, and we shall, therefore, be enabled to fix a standard which will come as near the true one as possible.

As a sufficient supply of food causes the growth, and consequent increase of weight, to be very rapid both in the carp and the hog, and as the carp, like the hog, is an omnivorous animal, we will take the needs of the hog as a basis for determining the quantity of food required by the carp. To produce the greatest possible quantity of flesh and fat, say 1,000 pounds live weight, a hog needs on an average about 4 pounds of albuminous matter per day. Two pounds of hydrates of carbon and fat, respectively, will correspond to this on the basis of nutritive substances needed for carp-food, as calculated above. As 100 pounds of worms, beetles, and other insects, when fresh, contain 30 per cent dry substance (comprising 13 per cent albuminous matter and 3.1 per cent fat, the latter being for purposes of respiration equal to 8 pounds of hydrates of carbon), and as the proportion of albumen to hydrates of carbon in carp-food is as 2 to 1, we may lay it down as a rule that 1,000 pounds of live carp will require the following quantity of food: 9 pounds of dry substance, 4 pounds of albumen, and 2 pounds of hydrates of carbon, which in all probability the carp will find in a good pond. This would be the standard quantity of carp-food, if nature did not supply any food besides that which is thrown into the pond. This standard may, therefore, be used only in cases where a pond is to be stocked with a larger number of fish than its natural conditions of food allow.

If artificial feeding is simply to supplement the natural food, the quantity of aritficial food will have to be determined by the quantity of the former contained in the pond; the proportion between dry substance, albumen, and hydrates of carbon should, however, remain the same as that given above. On this basis a pond which according to its quantity of natural food could sustain 2,000 two years' fish, weighing on an average a half pound each, would, if stocked with 4,000 fish, *i. e.*, with an additional 2,000, have to receive the following quantity of food per day: 9 pounds of dry substance, 4 pounds of albumen, and 2 pounds of hydrates of carbon, since the additional weight would be 1,000 pounds. This quantity of food will have to be gradually increased with the corresponding increase of weight of the fish.

If natural food is found in the pond, the additional 2,000 fish weighing one-half pound each, would, in a summer, even in medium ponds, increase to at least 1¼ pounds apiece, making an increase of three-quarters pound per fish; the total increase for the 2,000 would therefore be 1,500 pounds, which, counting the pound at 50 pfennige [12½ cents], would represent the sum of 750 marks [$178.50]. It should be remembered that if an additional number of fish, like the one referred to above, is placed in a pond, regard should be had not only to a proper supply of food, but also to an ample area of water. We would require, for a period of one hundred and eighty days—April to September, inclusive—for the 2,000 original and the 2,000 additional fish (all in one pond), which supplies food for only 2,000, the following quantity of food: $180 \times 4 = 720$ pounds albumen and 360 pounds of hydrates of carbon. Add to this one-half more, in consequence of the increase of the rations corresponding to the growth of the fish, and the total quantity of albumen to be supplied would be 1,080 pounds. To supply this we would need, say, of meat dried and ground fine, 15.6 hundred-weights, at 15 marks [$3.75], making the total outlay 234 marks [$58.50]. Subtracting this amount from the gross income, given above, we would get a net profit of 516 marks [$120].

It appears from these figures that even a comparatively expensive food will pay in the end, which result, in part at least, is brought about by the fact that this food possesses, at any rate, approximately, the correct proportion of nutritive substances. In order to provide the desired quantity of hydrates of carbon it will of course be necessary to mix with the ground meal some other food containing less nitrogen; this will rather diminish than increase the price of the food. The addition of some article of food containing less nitrogen will be all the more necessary—if the ground meat, as in the example given above, is to be used almost exclusively—because otherwise the fish would not get the needed quantity of alkali, of which ground meat contains but little. As regards supplying the necessary quantity of hydrates of carbon, it may not always be required to add anything to the ground meat, as the proportion of hydrates of carbôn may vary from 1 to from 0.4 to 0.5. For this very reason I have selected ground meat as an illustration, because the calculation will be simplified; also because it is one of the most expensive articles of food, but can be easily furnished at any time and in any desired quantity, which, of course, is not the case with articles like blood and refuse from slaughter-houses, excellent as they may otherwise be. It also applies here what Professor Wolff says in his *Rationelle Fütterung der landwirthschaftlichen Nutzthiere*, 1814 (Rational method of feeding domestic animals), p. 191, "that the rules laid down for feeding should be followed only in their general outline, and that it is not necessary to have everything agree down to the least fraction."

Next to ground meat, fish guano may be recommended for feeding carp, because it possesses excellent nutritive qualities, and can easily be obtained. In order to obtain the quantity of albumen in animal excrements needed for our example, we would—presuming with Delius that on an average they contain 3 per cent of albumen—need not less than 3,600 pounds, which at the lowest rate (60 pfennige [15 cents] per 100 pounds), would cost 216 marks [$54]. In using this food there would consequently be some saving, but it is doubtful whether the same favorable results will be obtained as with ground meat, because the proportion of nutritive substances is not so favorable, and because the fish would need an enormous quantity of it. It may, however, be assumed with absolute certainty, that even if fish guano is used as food, the increase of weight will be greater than if the 2,000 fish in one pond are confined to the natural food supplied by it. For in this case the quantity of food will decrease as autumn approaches, while by employing artificial food the daily quantity of food needed for the fish is regularly supplied throughout the entire period of their growth. The saving in the use of excrements is only a seeming one, as owing to their volume the transportation will involve considerable expense. To convey the 3,600 pounds to the pond would require twenty trips by cart, which, including loading and unloading, would come to 3 marks [75 cents] a trip. It must also be questioned whether the percentage of albumen in excrements, as given by Delius, is absolutely correct, and I think the circumstance has been lost sight of that only their digestible parts are of any value. Counting the digestible quantity of albumen—on the basis of the table given above—at 0.5 per cent (which, as we should state, refers only to the excrements of horses, which of all excrements contains the largest quantity of indigested matter) we would need not less than 211,600 pounds; but even supposing that the digestive power of the carp is twice as great as that of cattle, and consequently instead of 0.5 that 1 per cent was digested, we would still need the enormous quantity of 105,800 pounds to equalize the nutritive value of 1,560 pounds of ground meat. It will easily be seen that even if these excrements were otherwise of no value whatever, this method of feeding would prove exceedingly unprofitable.

Animal excrements may be used as an occasional addition to the food contained in a pond, and will, if so used, always yield astonishingly favorable results, probably because the natural food contained in the pond will be suitably supplemented thereby; but to use them as an exclusive article of food can hardly be recommended. There will, however, be many opportunities of using other concentrated articles of food, *e. g.*, blood, horse-flesh, refuse from slaughter-houses, &c., at comparatively much cheaper prices than ground meat, and with the same favorable results, either if used by itself or in connection with ground meat.

Another question remains to be answered: Would it be advisable, even in ponds having their normal stock of fish, to add artificial to the natural food during all summer, or at least during part of it? After all we have said, this question will have to be answered in the affirmative. Another reason why this may be recommended, is the fact that carp will fully repay by their increased growth any addition, if ever so slight, to their natural food. This is fully proved by the results obtained in ponds which have been sowed, or in ponds which receive much nutritive matter with their water supply, or in which cattle occasionally deposit their excrements, if compared with ponds where none of these conditions exist. Under favorable circumstances, such as those mentioned, it is no rare case that carp weighing ½ pound reach a marketable weight in one summer. I can mention such cases from my own experience, and from that of entirely trustworthy persons. Thus Delius mentions, from his own observations, that he has known carp to grow from 132 grams to 2 pounds (960 grams) in a single summer; and adds that he has been informed of still more astonishing results by reliable authorities. It may, therefore, be recommended for all ponds which do not have a sufficient quantity of food, or which are not in a natural way supplied with such food, to add some artificial food every day, or at certain stated periods; and in any pond, where it can be done, artificial food should be introduced from September, the time when the natural food begins to decrease, and when the weather grows cooler, and when the feeding process is to serve likewise for supplying that degree of heat which is necessary for the growth of the fish. Heat, as is well known, is a most important element in the growth of fish, and the results both of natural and artificial food should always be judged from the stand-point of an equal temperature.

The experiences gathered from the Wittingau pond farm show that the increase in the weight of carp was 10 per cent in May, 30 in June, 35 in July, 20 in August, and 5 in September. The greatest increase, therefore, was in July and the smallest in September. We are, therefore, justified in supposing that in July nature supplies the normal quantity of food needed by fish, leaving out of the calculation the element of heat and the varying quality of the ponds. If we intend to keep up the same supply of food during all summer, we would have to add in May 25 per cent of artificial food, in June 5, in August 15, and in September 30 per cent.

Even supposing that, owing to the great extent of the pond farm, it is impossible to introduce a regular system of feeding in all the ponds, throughout the entire period of growth, for the simple reason that the necessary labor cannot be obtained, it should on no account be omitted in September; for, as we have seen, this month furnishes the least food for the fish, while this is the very time when, in stock ponds, the fish should be fattened for the market. Let us, as an example, see what will be the results if ground meat is fed to the fish from the beginning of September till the middle of October, *i. e.*, forty-five days. We will suppose that a pond having an area of 10 hectares has been stocked with 1,200 carp, weighing each 1¼ pounds, which by the end of August have reached a weight of 2 pounds apiece, whose entire original weight has therefore increased from 1,250 to 2,400 pounds. The increase would be 1,150 pounds, and for the month of July 35 per cent, *i. e.*, 402.5 pounds. We desire to obtain the same increase for the period from the beginning of September till the end of October—forty-five days—*i. e.*, for September 402, for October 201; in all, 603 pounds. Five per cent of this desired increase—in round figures, 30 pounds—is obtained by means of natural food, and the remainder, 573 pounds, will have to be produced by artificial food. We know that 1 pound of ground meat produces an increase in the weight of fish of almost 1 pound. In order, therefore, to supply the required quantity of food during these forty-five days, so as to make the supply equal to that of July, we need 573 pounds of ground meat, which, at the rate of 15 marks [$3.75] per 100 pounds, would involve an outlay of 86 marks [$21.50]. By using this quantity of ground meat we are able to produce 573 pounds of fish flesh, which, at the rate of 50 pfennige [12½ cents] a pound, would realize the sum of 286.50 marks [$71.53], leaving a net profit of 200.50 marks [$50.12½], from which sum there should be deducted the comparatively small amount for conveying the food to the pond. We are, therefore, fully convinced that the use of artificial food for carp, even if there is used still more expensive food than the one given in our example, will insure quite a handsome profit; for although all the above calculations may not be correct in every little particular, they are certainly approximately correct.

As regards the other articles of food mentioned in the table given above, those must always be considered the most profitable whose proportion of nutritive substances comes nearest to the standard proportion. The proper proportion can in all cases easily be restored by adding a suitable quantity of food containing less nitrogen. Even in employing food containing more nitrogen the pond cultivator will still realize some profits, but he will find it impossible to restore the proper proportion of nutritive substances. This, however, would hinder the carp from deriving the greatest possible benefit from their food; and, with an equal (and often greater) expense, it will be found impossible to obtain the same favorable results as with a food or mixture of different articles of food which, not only as to quantity but also as to the proportion of its nutritive substances, comes nearer to the standard proportion. Food containing but little nitrogen, if used exclusively, will always prove injurious. An example will serve to make this clear. If rape-cakes are used the expense for 1,080 pounds of albumen, *i. e.*, for 4,265 pounds of rape-cake, at 6 marks [$1.50] per 100 pounds, would be 256 marks, 8 pfennige [$64.02]. The difference in the price of this food, which contains much nitrogen, will not be very great, but by the necessary addition of some article of food containing still more nitrogen and less hydrates of carbon, *e. g.*, blood, the cost may be increased to about 300 marks [$75]. Peas, even at their lowest market price, will be too expensive. The necessary quantity of albumen is contained in 5,400 pounds of peas, at 8 marks [$2] per 100 pounds, and this would make the outlay 452 marks [$113]; and, as with rape-cake, some other food would have to be added, reducing the net profits to a minimum.

If we take food containing but little nitrogen, *e. g.*, dry malt, we would need 14,400 pounds, at 8 marks per 100 pounds=1,152 marks [$288]; of potatoes we would need 51,400 pounds, at 2 marks [50 cents] per 100 pounds=1,028 marks [$275], and at 3 marks [75 cents] per 100 pounds=1,542 marks [$385.50]. A mere glance at these figures will show that there will be an absolute loss. The expense of mixing with a nitrogenous food some other food containing less nitrogen will be a little higher than if a single article of food is employed whose proportion of nutritive substances is very near the standard. If, for instance, we use fish guano, it will be absolutely necessary to mix with it some other food containing less nitrogen. We would get nearest to the quantity (1,080 pounds albumen) and the standard proportion of nutritive substances by mixing the following:

2,360 pounds fish guano, at 10 marks [$2.50] per 100 pounds=	236 marks [$59].
2,000 pounds potatoes, at 2 marks [50 cents] per 100 pounds=	40 marks [$10].
	276 marks [$69].

This would still yield a good profit, even if we count in some additional expense for cooking the potatoes, but it will never yield the same profit as ground meat used by itself. The same results will, to some extent, make themselves felt in cases where artificial food is employed in addition to the natural food.

It may, therefore, be laid down as a rule that, if artificial food is to be used exclusively, only those articles of food should be employed whose proportion of nutritive substances comes nearest to the standard, or which contain a large quantity of nitrogen. The same rule applies if artificial food is used only to supplement the natural food (as a deviation from this rule, though not of such serious consequences as in the first case, will nevertheless prove injurious); and food containing little nitrogen should only be used to restore the standard proportion of nutritive substances, if the principal food is blood, horse-flesh, fish guano, curds, &c. In the table showing the various articles of carp-food, I have also given fresh red clover; and I have done so because it is my idea that if there is a clover field near the pond, clover may be used in small quantities mixed with other food. If used in large quantities, however, or by itself, it would not be found profitable, for, to return to our example, to obtain 1,080 pounds of albumen would require 47,000 and 59,300 pounds of clover, respectively, which, at 2 marks [50 cents] per 100 pounds, would cause an outlay of not less than 940 marks [$235] and 1,186 marks [$296.50], respectively.

In using this food we would, moreover, have to take into consideration the fact—which applies to all articles of food which have to be given in great masses, especially to the excrements of animals—that the dry substance does not in the least come up to the proper standard of food, and that such enormous quantities would have to be used as to make it a matter of impossibility for the carp to consume them, simply to obtain the small quantity of nutritive matter which they possess. Although it may, for various reasons, be found difficult to adopt a systematic method of feeding, a chance to supply the carp with food at no extra expense should never be allowed to pass by.

In many parts of our country the ponds are on all sides surrounded by pasture-lands, where the cattle drop their excrements, which soon dry in the sun and become the habitation of worms, maggots, &c. Without incurring any special expense these excrements may be gathered by the person in charge of the ponds, and either be kept till the months of September and October or be thrown into the ponds at once. This need not even be done every day, as one cart-load of these execrements per hectare, thrown into the pond once a week, will be accompanied by beneficial results. Owing to the maggots contained in the excrements they will prove an excellent article of food.

If there are distilleries near, good results may be obtained by throwing into the pond, every week, a quantity of fresh potato refuse from the distillery. Thus, we have been informed that by throwing 60 liters of such refuse into a pond having an area of 500 square meters every week from April 10th to November 9th, 104 carp, weighing originally one-half to 1 pound apiece, reached a weight of 2¾ to 3¼ pounds.*

If a cow or ox dies and cannot be used as human food, it may be made to do good service either by feeding it direct to the fish or by using it for generating maggots. This may be done in the following manner: (1) By simply placing large pieces of meat on poles rammed in the bottom of the pond. Without any further aid maggots will form in the meat and fall into the water; or, as birds of prey and other animals will often get the lion's share, it is better still (2) to use wooden boxes which have a lid and a perforated bottom, and rest on four slanting poles, or legs, so that they can be placed in the water, the legs touching the bottom. A carcass or a piece of meat is placed in this box, the flies crawl into it and deposit their eggs, and the maggots fall into the water†; (3) it will also answer the purpose simply to throw a carcass, or pieces of one, into the pond, so that the water covers it; and maggots and water insects will soon be generated in large numbers; (4) if it is intended to carry on the generation of maggots on a large scale, pits 60 to 70 centimeters deep and broad, and of any desired length, are dug in some sunny place near the ponds, which, to add to their security, may be paved and their sides lined with bricks or stones. At the bottom of these pits is placed a layer of rye straw cut fine, to the height of 15 to 20 centimeters, on the top of this a layer, 5 to 8 centimeters thick, of fresh dry horse dung, containing a good deal of straw; these two layers are covered with a layer of sifted earth, 15 meters thick, on which to the height of about 9 centimeters are thrown the blood of horses, oxen, or other animals, entrails, meat, decayed roots and vege-

**Deutsche Fischerei-Zeitung*, 1878, No. 8.

†J. Wirth, *Zeitschrift des Deutschen Fischerei-Vereins*, 1871, VII, 48.

tables, kitchen refuse, dead animals, yeast, &c. The whole is covered with a thin layer of straw cut fine and some earth, and the pits are in rainy weather covered with boards.

All through the summer, but especially on warm, sunny days, a large number of flies of the species *Sarcophaga*, *Musca*, *Stomosis*, and others, attracted by the odor of the decaying matter, visit these pits to deposit their eggs, from which are developed quickly-growing larvæ, which, according to the state of the weather, may reach their full development in eight to fourteen days. After that period they change to tube-shaped cocoons, from which, after fourteen days, flies emerge to engage immediately in the propagation of their species. The gigantic scale on which these flies increase may be judged from the fact that the females of some species lay as many as 200,000 eggs, which, in about twenty-four hours, are transformed into maggots, the entire transformation from the egg to the fully-developed insect occupying only twenty-nine days. Only those larvæ which are developed late in autumn live through the winter as cocoons. The maggot-pit will also produce eggs, larvæ, and cocoons of other insects. The maggots, with the rest of the contents of the pit, are dug up with spades and thrown into the water. Such pits should be far from human habitations, and at some little distance from the ponds, on account of their nauseous and unhealthy effluvia.*

Before closing this chapter on the feeding of the carp I would strongly recommend to make experiments in feeding, and give my views as to the manner in which this should be done. Unfortunately, I had to give up pond culture before I was enabled to carry out this idea which I had cherished for a long time. The difficulty in these experiments is caused mainly by the circumstance that carp cannot be kept in a stable like horses or cattle, and that consequently they cannot be prevented from taking other food than that which is given to them. Experiments made in tanks of wood or stone, filled with pure water, would, on the other hand, lead to erroneous results, as the increase of growth gained by using a certain article of food would be neutralized by the stay in cold water and by other unnatural conditions. At the time when I conceived the idea of making such experiments, Mr. Horak was kind enough to write to me and suggest various ways of meeting the principal difficulties. He says: "It will be best to make comparative experiments, viz., to construct 6 to 10 ponds of the same size, all having the same soil, and stocked with the same number of fish. Each of these ponds should be supplied with a different kind of food, and the result should be carefully noted. One pond should be left to nature, and no artificial food should be introduced into it. Each pond should have its separate ditches for supplying and carrying off the water. The results of the fisheries would be the results of the different methods of feeding." To this I would add that it will be advisable to choose for these ponds a soil containing as little fish-food as possible.

* Baldamus, *Handbuch der Federviehzucht*.

Everything which is apt to influence the results of the feeding should be considered and carefully noted down. A certain stated weight of food should be given every day, and the quantities of albumen, dry substance, hydrates of carbon, and fat should be accurately ascertained. Observations of the temperature of the water should be taken daily at certain stated hours, in the morning, at noon, and in the evening, both near the banks and in the deep places. Similar observations should be taken of the temperature of the atmosphere, so as to get the maximum and minimum temperature. Careful notes should be taken of the rainfall, the wind, and weather, drawing the averages for the entire feeding period, *i. e.*, the whole summer or portions of it. These experiments should extend over a period of several years, so that the results of different years may be compared. The main object, viz., to ascertain the effect of different articles of food under the same conditions, will be attained in one year, and this will suffice for fixing a standard of feeding, which will stand the test of practice, although in the course of years it may become necessary to modify this standard in some particulars.

All the various articles of fish-food should be used as food, both those containing much nitrogen and those which contain but little; and the matter of expense should never prevent the use of any article of food, for the question to be answered is this: Are these different articles of food cheap or expensive as compared with the results attained? And this question cannot be answered until the experiments have been completed. It should not be omitted to supply one pond only with such articles of food as nature furnishes for the carp, *e. g.*, beetles, worms, snails, insects of every kind, &c., which should be gathered from ponds containing a superabundance of such food. Great care should be taken that the number of fish, their age, and, if possible, their weight, are the same in all the ponds; and, both in stocking and fishing the ponds, every individual fish should be weighed.

As it must be supposed that the effect of food will, as with other animals, vary according to the age of the carp, the fish placed in the ponds for the purpose of experimenting on them should be retained in these ponds until they have reached a marketable weight, or the number of experiment ponds should be increased, so that during the first year fish of every age can be placed in the ponds, there to be fed on different food. We would suggest a period of four years, even if, as is highly probable, the fish will, during this period, owing to the feeding, exceed the marketable weight. It is to be presumed that in four years sufficient data can be collected showing the influence of the weather, the food, and the different age on the increase in weight of fish. The number of fish to be placed in each pond should be those given for medium ponds. It is my firm conviction that if experiments are made in the manner indicated above they will lead to positive results sooner than if they lack this basis. It will also be well to catch a certain number of fish at stated periods, especially during the summer months, with a view to ascertain the increase in weight during these periods.

To find the natural capacity of the different ponds for producing food, according to the difference of soil and the more or less sunny location, ponds of the same size should be constructed in different localities and be stocked with an equal number of fish. The most favorable dimensions of experiment ponds will be 10 meters in length and 10 in breadth, with a depth of water as indicated in former chapters.

These hints must suffice; and the rest should be left to the ingenuity and skill of the experimenter, which will enable him to find the shortest way to reach the desired end. Scientific education, a knowledge of the principles of fish-culture, combined with the greatest exactness in making experiments and observations, and the careful noting down of every observation, are absolutely necessary to insure success. The experimenter must be able to distinguish the essential from the unessential, and, fully alive to the great importance of his efforts, enter into the subject with enthusiasm. Only a person who is thus qualified will be able to gather all the necessary data and therefrom draw his conclusions with mathematical accuracy. A person who does not possess the necessary education, or who shuns the labor and seeming waste of time connected with such experiments, had better not attempt them. It will be a great mistake to intrust the conducting of these experiments to servants or other uneducated persons, for even if you give them the fullest and most accurate instructions, they will not carry them out fully, either from a lack of intellect or because they do not take sufficient interest in the subject. Even if they begin all right, they will soon get into a routine way of doing things and neglect one or the other of the instructions. In short, these experiments should be conducted by no one else but the educated proprietor or manager of the pond farm in person.

Supervision of the ponds.—We have to mention the subject here as the third point in the care of fish, but we deem it proper to reserve its full discussion to a later chapter, and give first all those subjects to which this supervision relates.

11. THE WINTERING OF FISH, OR THE STOCKING OF WINTER PONDS.

The object of winter ponds is to receive the older fish, and also in some cases the young fry, from ponds which, owing to their small size and insufficient depth, do not afford safe winter-quarters for fish. Besides the regular stock of fish, these ponds may also, according to circumstances, be used for those fish which are kept for sale, if there is no chance to sell them immediately after the autumn fisheries, but if it is likely that they can be sold during winter; as, confined within a narrow space, they can easily be caught whenever needed. If they were left in the large stock ponds it would frequently be impossible to catch them; and such winter fisheries will also invariably be connected with many difficulties and considerable loss. The stock ponds should be ready to receive the fish from the raising ponds late in the autumn, and considerable difficulty may be experienced in adding to the already large number of fish in the stock ponds. On the safe wintering of the regular stock of fish the success of the entire pond farm will depend to a great extent. If many of these fish perish during the winter, the farm is thrown back for a whole year; and if the losses are very great, the consequence will be felt for several years, especially if the young fry have been injured. If such losses were to repeat themselves for two or more consecutive years, the pond farm would be unavoidably ruined. Winter ponds should, therefore, be selected with the greatest care, according to the conditions needed for such ponds, as given in a previous chapter. If for a number of years there have been no losses in these ponds, they may safely be considered good winter ponds. If, nevertheless, losses should occur, they are not caused by the nature of the winter pond, but by lack of proper supervision and management during the winter season.

The number of winter ponds must always be greater than is absolutely necessary for the number of fish that are expected to be kept during winter. Supernumerary winter ponds will often prove not only a great advantage, but they will become an anchor of safety in time of need. Thus, if an excess of young fry is caught in autumn which can successfully be brought through the winter, they can frequently be sold to advantage in spring, and there will be no necessity for placing pike in the stock ponds in autumn. Suppose, however, that from some cause or other the fish begin to droop and perish in one of the winter ponds, and the only way of escape would be to fish the pond clean, it would be exceedingly awkward if there was no other pond to which the fish can be transferred; or, to suppose another case, in what a difficult position would a pond cultivator be placed if he should find it impossible to sell all the fish from the stock ponds in autumn, without having at his disposal a supernumerary winter pond for receiving the fish which he cannot sell.

If a winter pond meets all the conditions required of it, but has not the necessary depth of water, the pipe for the outflowing water should be placed higher, and the necessary quantity of water will soon be obtained; and if this should not suffice the fish-pit will have to be dug out deeper. The principal requisite of a good winter pond is in all cases a sufficient supply of fresh water, which, however, does not imply that ponds which do not have such a supply at all times are absolutely unsuitable for winter ponds. For I know from my own experience that even sky ponds, if of sufficient size and corresponding depth, may carry fish safely through the winter, in spite of the fact that their water supply is purely accidental, subject to frequent interruptions, and often ceases entirely during a severe winter. Such ponds will have to be of larger size and greater depth if they are to become good winter ponds.

Winter ponds should be allowed to lie dry during summer, so that the soil may lose its acidity, and also to prevent the growth of aquatic plants. It will also be well to plow the winter ponds as soon as they have been drained, and so let them remain in that condition for some time; or, better still, to sow them. A short time before the fish are placed in the winter pond it should be filled with water, so as to have its full supply when the fish enter it.

The number of fish to be placed in winter ponds will depend on their size and quantity of water, on the depth of water and the depth to which it will freeze in winter, on their supply of water, and on the size and weight of the fish. Von Reider counts, according to the size and depth of a pond and its possible supply of water, 28,000 to 35,000 two years' fish per hectare, but as a general rule only 17,500 per hectare; of one year's fish, 42,000 per hectare; and of young fry, 84,000 to 105,000; and large carp only 3,500 per hectare.* Horak (without specifying what classes of fish he has reference to) counts in round figures 5,200 to 6,200 per hectare.†

Every possible precaution should be taken to prevent any transfer of fish from one winter pond to another, for if the water is low and its supply scanty this may seriously injure the fish, which are crowded in a narrow space.

Breaking holes in the ice and admitting air will not protect the fish from dangers in the winter ponds; but the only efficient means of protecting them is to give them sufficient room and a constant supply of fresh water, which will not only provide the fish with air, but also prevent the spoiling of the water, even if the surface is frozen firmly and covered with a thick layer of snow. The case is, of course, different in sky ponds, which during winter receive hardly any supply of fresh water, and here it will be a matter of necessity always to have some holes in the ice.

In order not to make the sorting of the fish difficult when the winter ponds are fished in spring and to make this process unnecessarily slow, large and well-regulated pond farms should have separate winter ponds for the different classes of fish, *i. e.*, one for the young fry if it cannot be wintered in the spawning ponds, one for the two years' fish, and one for the three years' fish (if, after the fisheries, they are not immediately transferred to the stock ponds). If other kinds of fish, especially fish of prey, are to be wintered, they should be assigned separate winter ponds, as they must on no condition share a pond with carp. Wherever it can be done, those fish of prey which have not yet reached a marketable weight, and can therefore not be sold, should immediately after the fisheries be returned to the stock pond. This applies to pike, perch, &c. If fish of prey are wintered, their winter ponds should be separate from those of the other fish. Tench also should, if possible,

* Von Reider, *Das Ganze der Fischerei*, 1825.
† Horak, *Teichwirthschaft*, 1869.

not be kept in winter ponds with carp. On small pond farms it may become necessay to keep carp of different ages in one and the same winter pond. In that case it will be well, with a view of preventing an unnecessary delay caused by the sorting of the fish and a consequent delay in the fisheries and the transfer of the fish to the raising ponds, to place in one winter pond only fish whose age can easily be distinguished. As a rule, the three years' fish are immediately after the autumn fisheries transferred to the stock ponds; but there may be cases when this transfer cannot be made at that time, and when these fish have to be wintered. In placing these fish in the winter ponds great care should be exercised to arrange matters so that the different classes of fish can easily be distinguished in spring. If the quality of the ponds varies very much it will be exceedingly difficult to distinguish the one year's fish from two years' fish, and these from three years' fish. Young fish which for some cause have been retarded in their growth are frequently not any larger during the first year in the raising ponds than young fish which have enjoyed greater advantages at the the end of their first year. In such cases the one year's fish and the three years' fish should occupy the same winter pond, and the two years' fish should share a winter pond with the stock carp (in case these have to be wintered). If the space is limited and if the pond farm is so small as to possess only one winter pond, nothing remains to be done but to put all the fish in this pond, and sort them as well as possible in spring. It will, however, in that case be almost impossible to prevent fish of different classes from getting into one and the same raising pond.

In view of the great importance of successfully wintering fry and young fish, the winter ponds should be under constant supervision during all winter, as in severe winters the great cold, deep snow, and especially the freezing of the pipes or ditches through which the water enters and flows out, may prevent fresh air from entering the pond, and may cause a vitiation of the water, owing to the lack of oxygen, which may prove fatal to the fish. The entire contents of a winter pond may be lost if fresh water is not introduced constantly and if no holes are made in the ice. If the supply of fresh water is irregular, especially in sky ponds, or when winter ponds have been overstocked, there will invariably be great danger that the fish will perish during an exceptionally severe winter. I repeat, therefore, that the overcrowding of winter ponds must be avoided.

Horak mentions the following indications of approaching danger: "The first indications of danger, which is particularly great during the latter part of winter, are small air-bubbles which make their appearance in the holes in the ice; the water begins to change its natural color; it is no longer clear, but of a brownish-yellow or whitish color, according to the different soil and mud. This change of color is also frequently caused by microscopic plants and animals, which increase with incredible rapidity and at an enormous rate. Before the fish appear near the air-holes, there are seen in them small, and soon also large, spiders and beetles in a languid condition or dead; and one or two days later, fish begin to make their appearance in the air-holes more or less languid and gasping for breath. If the water of a pond becomes spoiled, the first to suffer and die are the crawfish, next come the frogs, then the fish of prey, and last of all the carp. At the first indication of such a condition of affairs crows begin to hover around the pond and about the air-holes, and thus become in truth birds of ill omen to the pond cultivator."*

The only help in such cases, which cannot be brought too soon, is the immediate introduction into the pond of fresh water and fresh air. The latter object is reached by quickly making as many air-holes as possible, and fresh water is introduced by freeing the ditches from ice and by increasing the depth of water as rapidly as possible. The ditches through which the water flows out should of course also be freed from ice, so that the water in the pond is kept in constant motion by the fresh water flowing through it. This process should be continued until all the vitiated water has been removed. If this cannot be done quickly enough, or if it has not the desired effect, so that fish gasping for air crowd the air-holes, and if there is no immediate prospect of thaw or rain, it becomes an imperative necessity to take all the fish out of the pond and transfer them to another one. The appearance of a few fish in the air-holes should not cause the pond cultivator immediately to empty out the pond, for these may be only fish which have fallen sick from some other cause, and have therefore sought the fresh air. Such fish should be carefully examined with a view to ascertain the actual cause of their having left the depths of the pond. Carp which are suffering in consequence of a vitiation of the water have, according to Horak, always an unusually large gall bladder, a bluish mouth, and a pale color generally. Carp which show these signs should not be used for stocking ponds.

The fish which have been removed from a pond whose water has become vitiated should not be placed in the same winter ponds with other fish; for they are languid and sick, and are apt to give their disease to the other fish. If some of the fish should die after they have been removed to another pond they will corrupt its water, and the first loss is followed by a second one. Sick fish should, therefore, be transferred to ponds which contain no other fish, and the importance of having a few supernumerary winter ponds will be recognized. In order to prevent such occurrences, or at any rate to bring speedy relief, winter ponds should at all times, but especially during severe winter weather, be kept under the most careful supervision. The water, however, may become vitiated, and the fish die, even if it is not covered with ice, unless fresh water is from time to time introduced into the ponds, and the same may occur if the winter ponds are too much crowded. Pond cultivators should, therefore, see to it that their winter ponds are

* Horak, *Teichwirthschaft*, 1869.

constantly supplied with fresh water, and often examine the ponds with the view to ascertain whether the supply is sufficient. It would be a great mistake to wait till the fish begin to appear at the air-holes gasping for breath.

It is a very general opinion that in severe winters the fish are apt to perish owing to the lack of air-holes, and the consequent lack of fresh air. I deem it proper, therefore, to give a different view which is entertained by Von Reider. He says: "If the pond is deep enough, the water flowing into it will prevent it from freezing. If the water flows out freely, the water in the pond is kept in constant motion and is therefore not so apt to freeze. The fresh water will also introduce fresh air into the pond, and there is no danger whatever that the water in the pond will become vitiated. Even if the pond is covered with ice, and the supply of fresh air from above is cut off, the water which flows in and out under the ice will keep up a constant current of fresh air, and prevent a vitiation of the water. If a winter pond, therefore, has a well-regulated supply of water, no harm will be done by a covering of ice even if the snow lies deep on it; on the contrary, it will keep off the frost from the water below, and the fish will, in the constantly running water, which owing to its cover of ice and snow is kept at a pleasant temperature, always be safe and healthy. All that has to be done in a very severe winter is to keep the ice from stopping or impeding the flow of the water. It will rarely freeze if kept in constant motion, but it will be well to give a little aid by breaking holes in the ice at the places where the water flows in and out. It is unnecessary, and may even be injurious, to make air-holes in the ice, as the cover of ice and snow is to prevent the frost from entering the depths. If, however, extremely cold weather should continue for a considerable length of time, it may happen that the water flows over the ice, and in that case it will become necessary to make holes in the ice, but only in those places where the water flows in and out. Here the ice should be removed, so the water can resume its usual course." Von Reider goes on to say that "the above statement satisfactorily settles the question whether it is useful and proper to break the ice in winter ponds. All that is needed is to secure ready access to the pond for the fresh water and to facilitate its outflow."*

Delius† is also inclined to think that there is little use in making air-holes in the ice for the purpose of a constant contact between air and water, because, as he says, the existence of the fish is already endangered when they seek the air-holes. He thinks that even if the pond is frozen and the flow of water is stopped, the fish will, at any rate in large and deep ponds, be fully protected against the danger of freezing, and that only in small ponds are they apt to become languid and seek the holes to get a breath of fresh air; and if they do not succeed in this,

* Von Reider, *Das Ganze der Fischerei*, 1825.

† Delius, *Teichwirthschaft*, p. 35.

they will float about under the ice in a dazed condition and finally freeze to the ice with their fins. Delius is of opinion that the lack of oxygen cannot cause this condition, but that it is rather occasioned by an accumulation of gases from the mud at the bottom which cannot escape through the ice, and which will be particularly strong in shallow water. While Von Reider considers air-holes unnecessary only in those ponds which have a constant supply of fresh water, Delius thinks they are not needed even in ponds which have no such supply, but which are of sufficient depth.

I am inclined to share these views, all the more as I have found them correct as regards sky ponds, but I have for my own part never omitted to make air-holes, and would not recommend any one to omit it merely for the purpose of ascertaining whether air-holes are necessary or not. The majority of pond cultivators, both in former and more recent times, consider air-holes necessary, at any rate in severe winters, and it will under all circumstances be better to be too careful than to exercise too little care. I consider it, however, injurious to make air-holes right over the place where the fish congregate, or in its immediate neighborhood, as thereby they are deprived of the protection against cold which the cover of ice affords them. In small ponds of sufficient depth, and with a continuous flow of water, the air-holes may be dispensed with, but the breaking of the ice near the places where the water flows in and out should in no case be omitted. In large ponds, where the water flows in at a considerable distance from the place where it leaves the pond, and where the current is not very strong, air-holes become an absolute necessity, and this is probably the reason that on the Wittingau pond farm, which possesses many ponds of great size, great stress is laid on supplying a large number of air-holes.

Considering the great importance of this question, it may be desirable and proper to quote some other practical pond cultivators. Tscheiner says: "In winter, when the pond is covered with a thick coating of ice, it is necessary to make holes in the ice in several places, so as to give the fish some fresh air; and to prevent these holes from freezing two sticks are stuck in them crosswise, and on these is placed some straw or brush-wood. The snow which falls on this covering of ice is probably more helpful than hurtful, because it lessens the cold, and thereby prevents the ice from becoming too thick. On the other hand, it produces darkness in the ponds, which may prove dangerous to the fish. Around the air-holes, therefore, the snow should always be swept away." *

Reimann says: "The less water flows into the pond the more and greater air-holes must be made in the ice. The same applies to large ponds, even if they should have a constant supply of water. The more water flows into a moderate sized pond, the less in number and smaller in size need the air-holes be. Ponds whose water supply is scant must

* Tscheiner, p. 193.

have air-holes at intervals of 146 meters. Air-holes should be made especially in the places where the water flows into the pond and on both sides of the pond, so as to procure a current of air under the ice."*

The number of air-holes should not be excessive, nor should they be too large, because this would deprive the fish of some of the necessary warmth. But, as Reimann says in another place, "Winter ponds, which are fed by a rapidly flowing river, or even by a good spring, will rarely need any air-holes."

Horak,† as has already been stated, thinks that air-holes are absolutely necessary; but as appears from his statement relative to the signs which indicate the approaching death of the fish, air-holes cannot altogether prevent it, as the first indication are seen in the existing air-holes, which, so to speak, become points of observation. He likewise says that air-holes are made in the ice, not merely to produce a current of air, but also to enable the pond cultivator to watch the fish in their winter-quarters. According to this author, air-holes in large ponds should be 9 to 14 meters long, .8 to 1 meter broad, and distant from each other 17 to 35 meters. They should be of considerable size, and be made in great numbers, because they are intended to keep up a current of air and act as outlets for vitiated air. Horak thinks that a pond will rarely need more than three or four air-holes, unless it is very large. Air-holes should be made as soon as the ice has reached a thickness of 5 to 7 centimeters [about 2 inches].

Tscheiner has probably hit the nail on the head when he says: "If proper care is taken to keep the water clear and pure, and if the number of fish is not disproportionate to the quantity of water and the size of the pond, the safe-keeping of the fish may unhesitatingly be intrusted to Mother Nature, who cares for all beings with equal wisdom."

The fisheries in the winter ponds take place in spring, generally in April, and are carried on in exactly the same manner as in the raising ponds; but as the number of fish will be greater, care should be taken to get through as quickly as possible, and to place those fish which are destined for the raising ponds into these at once. To try to save labor and expense by employing but few men and carts would be a great mistake. In order to carry on the fisheries rapidly and systematically, the pond cultivator should, during winter, prepare a careful plan for stocking his ponds in spring, and the material for such a plan will be furnished by carefully noting down the results of the previous autumn fisheries. As the fish do not receive any food in the winter ponds, except what may have been dissolved in the water, they will lose some weight during winter. This loss is generally 2 or 3 per cent, sometimes greater. When the fisheries have come to an end, the ponds should be drained entirely, and be allowed to lie dry during the summer. If any fish have died in the pond during winter, the pond must

* Reimann, p. 116.

† Horak, *Teichwirthschaft*, 1869.

be sowed. On small pond farms it will be advisable, if many fish have died in the winter ponds, to supply this loss by buying fish, so as not to cause an interruption in the working of the farm. But if the losses are very heavy, it will, especially on large pond farms, become necessary to make another distribution of the ponds, or if many young fish have perished while an unusually large quantity of fry has successfully passed through the winter, to place these in ponds which, owing to the loss of young fish, would otherwise receive no fish at all. Another plan would be to sow these ponds, so as to obtain a harvest of grain or grass, and also to cause the fish which are placed in these ponds during the following year to grow more rapidly, with a view to make up for the loss sustained.

B.—*The culture of some other kinds of fish.*

1. THE TENCH (*Tinca vulgaris*).

An extensive and systematic culture of the tench will be found advantageous only in very few localities, because this fish does not find either a very ready or extensive sale, and does not grow as rapidly as the carp. There are localities, however, where tench are esteemed as much as carp, and bring as high a price. In many places the tench is a favorite soup-fish, and is sold when it weighs only one-quarter of a pound at the same price which is paid for carp. On the Wittingau pond farm tench are considered marketable when they have reached that weight. At one time I sold a good many of these fish at the same price as carp, but the lightest weight at which I could find a sale for them was 1 pound. It may, therefore, be recommended to cultivate the tench on a limited scale with the carp; but a good deal of this cultivation should be left to nature, *i. e.*, the tench are not assigned any separate spawning and raising ponds. If possible, they should not be placed in spawning ponds, as they will spawn there, and great difficulty will be experienced in separating their fry from that of the carp. The tench proves advantageous in carp-culture, as it continually roots in the mud, and thus makes the food contained in it, such as snails, worms, &c., accessible for the carp; and as it will thrive even in very poor water, it is found in the carp ponds of most pond farms. Pike are very fond of tench as an article of food; if they are to be placed in stock ponds, they should be of sufficient size to prevent their becoming an easy prey to the pike. If there should be on a pond farm several ponds in which carp will not thrive owing to the poor quality of the water, or if the ponds of a small pond farm should all suffer from this defect, it may be recommended to cultivate the tench systematically like the carp, and it may even be profitable to cultivate them extensively.

2. THE CRUCIAN (*Carassius vulgaris*).

This fish is cultivated in the same manner as the carp and the tench. The crucian can also stand poor and muddy water better than the carp.

It can, however, be hardly recommended for systematic cultivation, as it does not find a ready sale. In former times this may have been different, as we read that the crucian was cultivated on a large scale. Crucians may, under certain circumstances, prove injurious to the carp.

3. THE PIKE (*Esox lucius*).

A special culture of the pike, as of all fish of prey, must be considered inexpedient, as their principal food consists of fish, and as they destroy more than they can produce (a pike will, in one week, consume a quantity of fish equal to double its own weight), and as, moreover, they generally bring a lower price than carp. It would, therefore, hardly pay to cultivate them regularly, as this would necessitate the raising of special food-fish for them. As an addition to carp ponds they may be recommended principally to keep these ponds clear of worthless fish, which eat up the food intended for the carp, and also to destroy the superfluous fry of the carp. Carp stock ponds are therefore the spawning, raising, and stock ponds of the pike, which are here left to the care of nature. In the chapter on stock ponds hints have been given as to the number and size of the pike to be placed in each pond. On the subject of special pike ponds, Von Ehrenkreuz says: "Ponds containing many frogs are particularly suited for pike ponds. If for some years these ponds have been stocked with vigorous pike, the number of frogs decreases rapidly, and as soon as the pike have accustomed themselves to this kind of food, it is quite amusing to watch them hunting frogs. If the ponds contain no frogs, some fish of an inferior kind, which spawn profusely, should be placed in them, or some carcass should be thrown into the water for pike food. Pike will thrive best in ponds with carp weighing 2 or 3 pounds apiece, crucians, tench, &c., as these fish spawn frequently, and thereby furnish an ample supply of food for the pike. If they are to have special ponds, these should in spring be stocked with crucians and other common fish; after these have been in the pond for one year, and have spawned, pike are put in weighing one-half to three-quarters of a pound apiece; after two years they will have reached a weight of 3, 4, and even 6 pounds; and when the pond is fished it is quite probable that, besides pike, a considerable quantiy of crucians will be caught, especially if they were good-sized fish when they were placed in the pond."*

4. PIKE-PERCH (*Lucioperca sandra*).

As to its mode of life, this fish strongly resembles the pike. It increases very fast, fetches a higher price than pike and carp, and, wherever the conditions are favorable for its cultivation, it may be recommended as an addition to carp ponds. All that can be said against it is its tenderness, which makes its transportation difficult. On the Wit-

* B. von Ehrenkreuz, *Angelfischerei*, 1873, p. 227.

tingau pond farm, where the carp stock ponds contain 10 per cent of pike, 5 per cent of pike-perch are added; and these fish, which have been cultivated here for a long time, seem to thrive. Mr. Horak, the former manager of the Wittingau pond farm, says: "A goodly number of pike-perch is always welcome in the fisheries; if, however, their number becomes excessive the consequent loss of weight in carp is not compensated thereby. The proper proportion between the number of carp and pike-perch should therefore not be lost sight of. In a pond with cultivated fish the pike-perch forms an unruly and disturbing element, and, if in large numbers, becomes injurious to the carp. It does not only live on fish, but also on insects and worms, and thus deprives the carp of its food. Its prickly fins become sharp weapons of attack, which the carp fear with good reason. As there are no separate spawning ponds for fish of prey, they must be placed in the carp ponds. From a small stock of the fry of pike-perch a strong breed of fish cannot be looked for with absolute certainty, although it may sometimes be the case. To obtain the necessary quantity of fry of the pike-perch in carp ponds it is advisable to put spawning pike-perch in these ponds at the time when the carp are approaching their full growth."*

5. THE PERCH (*Perca fluviatilis*).

Horak says, regarding this fish: "The perch is a good fish, possessing delicate flesh and a very hardy nature, but it is a fish of prey which also devours the carp food. In large numbers it becomes dangerous to the carp, and should not be cultivated, but left to shift for itself. Its prickly fins make it a dangerous companion for the carp, which, especially after thunder-storms, it drives away from the edges of the pond, and thus prevents it from obtaining its necessary food." I have nothing to add to Mr. Horak's remarks.

6. THE SILURUS.

The silurus is a voracious fish of prey, which, like the pike, can be kept in carp ponds, and which, when it has reached a size which makes it dangerous for the carp, should be caught.

7. THE LOACH (*Cobitis barbatula*).

As I have never raised loach, and never had an opportunity of observing loach culture, but at the same time consider it profitable, I have to quote from other authors on the subject. According to Delius, loach are sometimes raised in ditches fed by running water. Their food consists of excrements and refuse. The loach is a favorite food-fish, and has the advantage that it can be caught all through the summer when it is difficult to obtain other fish. They may also be raised to provide food for trout. The bleak and minnow, however, will answer the same purpose.†

* Horak, *Teichwirthschaft*, 1869.

† Delius, *Teichwirthschaft*, p. 74.

B. von Ehrenkreuz says: "Wherever the opportunity offers, the culture of this delicate fish in ditches should not be omitted simply because it involves a small expense. These ditches are nothing but small brooks, with gravelly or sandy bottom, whose sides are lined with boards, and in which perforated pieces of tin have been placed through which the water can flow in and out freely. In these ditches the loach are fed on the excrements of sheep, poppy-seed, linseed-cake, the entrails of various animals, refuse, husks, cooked grain, potatoes, bread, &c. As they increase very rapidly in these ditches, it is advisable and even necessary to have two or more of these ditches in the neighborhood, one for the spawning fish, the second for the fry, and the third for those loach which are to be fattened for the table. The basins of fountains are also suitable for loach-pits; care should be taken, however, that no injurious substances, *e. g.*, soap, lime, &c., get into it. If loach are to be raised in ponds, they must have a supply of fresh running water and be of small size, so that the wind does not create waves, which the loach cannot stand.*

8. THE GOLDEN IDE (*Idus melanotus*).

The culture of the golden ide may be recommended in localities where there is a demand for these fish as ornamental fish for the basins of fountains, and they can be raised like the tench by being allowed to shift for themselves.

9. THE GOLDFISH (*Cyprinus auratus*).

The culture of the goldfish is subject to the same rules as that of the carp. They also need separate spawning, raising, and stock ponds. Goldfish need warm water, and therefore small, shallow ponds. Special care should be taken to keep away all animals which may prove injurious to the goldfish, and frogs especially must not be allowed in goldfish ponds. These ponds should have as little vegetation as possible. For these reasons goldfish can but rarely be successfully raised in natural ponds, and it will be well to construct for them small, shallow ponds, every portion of which can easily be watched. Although the goldfish, like the carp, are not very choice as to the quality of their water and food, and are not easily influenced by changes in the weather, the spawning ponds should not be stocked before May or June, as these fish require very warm water. To every three milters there should be two spawners, or one spawner to two milters. If the bottom of the pond is rich in food, no artificial food is needed; but if the bottom is sandy or strong, the goldfish must be supplied with food, consisting of linseed-cake, the dung of cattle or horses, broken into small pieces, bread, cooked or crushed peas, &c. The raising of goldfish may prove very profitable, but it needs constant care and attention. During winter goldfish, like carp, must be transferred to deep ponds.

*B. von Ehrenkreuz, *Angelfischerei*, p. 177.

One of the largest goldfish establishments is that of Mr. Christian Wagner, at Oldenburg. It extends over a moist peaty bottom, embraces an area of about 3 hectares, and consists of 120 ponds, measuring about 100 square meters each, and separated from each other only by narrow dikes. These ponds receive their water partly through ditches from the river Hunte, and partly from a factory, and from other ponds. By means of steam the temperature of the water can be raised to from 30 to 50 degrees R. [99½ to 144½ degrees F.]. The ponds are divided into (1) spawning ponds, (2) raising ponds, (3) ponds for hardening the skin of the fish, and (4) coloring ponds.

The spawning ponds and the ponds for hardening the skin of the fish are fed principally by water coming from the bottom of the ponds. The water of these ponds is almost stagnant, but is occasionally agitated by leading river water into the ponds. Although the water in these ponds is occasionally only 15 centimeters deep, their usual depth is about 60 centimeters, and near the outflow pipes as much as 120 centimeters. The bottom of these ponds, which is purposely kept uneven, is here and there covered with aquatic plants, on which the goldfish like to deposit their eggs. Owing to the artificial heating of the water and an abundant supply of the best and most nourishing food, the majority of the fish in these ponds reach their sexual maturity in the twelfth month, and spawn two or three times a year. Under favorable circumstances the first fry is obtained in March or April; the second fry is forced, so as to make its appearance in July or even sooner; and the the third generally comes in August or September. The female fish are changed round from time to time, so that the same females and males do not remain together too long. In rare cases a goldfish is capable of spawning for more than three years. To supply the fry with suitable food, especially insects, the raising ponds are drained seven to eight weeks before they are stocked with fry, and are allowed to lie dry during that period. The natural food is occasionally supplemented by blood in clots or lumps, refuse from slaughter-houses, or malt germs, all of which are placed in shallow portions of the pond. If this method of feeding is applied, the fry will double their weight in one week, and reach a length of 3 to 6 centimeters in autumn. Their marketable size, however, they do not reach till the end of the second summer. Rapid artificial coloring is obtained by water containing iron, lime, and tannin. Mr. Wagner's ponds contain a good deal of iron, but in spite of this he increases its quantity artificially. Fish in the Prussian (black and white) and German (black, white, and red) national colors are in great demand, and by undergoing a suitable treatment a fish which is originally red and white can easily be transformed into a black, white, and red fish. If fish which have reached a suitable size for globes or aquaria, do not show the proper color, they are placed in the coloring pond, where they are exposed to the rays of the sun which soon completes their coloring. Occasionally, however, the sun may prove dangerous, especially if the bottom of the pond has a very light color, and if there is an absolute lack of shade; under these circumstances the fish become blind or die. To make goldfish less tender, so that they can easily be handled, they are placed in the ponds for hardening the skin. The water of these ponds contains a great deal of iron, and by adding some lime it has the effect of rendering the skin of the fish very hard. In spite of this hardening process, it is not immaterial in what kind of water the grown goldfish are kept. Mr. Wagner recommends, above everything else, spring or pump water, and where this cannot be obtained, river water. In his opinion meat, either cooked or raw, and scraped fine, worms, insects, larvæ, ant-eggs, &c., are the best food for goldfish in globes or small aquaria. These receptacles for goldfish should always contain a few aquatic plants, as *Lemnaceæ* or *Potamogeton*. Too much food becomes injurious, and it is better not to feed the fish at all for a whole month, than to give them too much food. Under no circumstances should more food be given than can be eaten at one time. Prior to sending the fish any distance Mr. Wagner lets them fast for a week, and thus prevents them from polluting the water during transportation. The vessel in which the fish are transported is an oval keg, with a perforated bung on the upper side. To keep the water in motion, and introduce fresh air, the keg is never filled entirely. The number of goldfish raised annually in Mr. Wagner's establishment is about 300,000. Mr. Wagner employs a book-keeper, a night-watchman and fifteen laborers, all of whom he pays good wages, and the net annual profit accruing to him is very considerable. The same area used for agricultural purposes would hardly support one family.

10. THE BROOK TROUT (*Trutta fario*).

As brook trout always command a good price, their culture will pay three and four times better than that of carp, provided cheap food can easily be obtained. To raise trout systematically on a pond farm, ponds are required which are fed either by springs or a small gravelly brook, and on whose banks are found aquatic plants and shade-trees, like the alder. If there are no such trees, they should be planted. For trout-culture, as for carp-culture, there are needed spawning places, raising ponds, and stock ponds. As trout differ greatly in their growth, there should be enough ponds to place all fish of one and the same size together, because otherwise the large fish will devour the smaller ones. Care should be taken that no mud accumulates on the bottom of the ponds where there should always be found some large stones under which the trout may hide. The bottom of the ponds must not be gravelly, as this may induce the trout to spawn in them. In place of spawning ponds one should either have suitable spawning ditches, or the fish may be allowed to spawn in the springs or brooks which feed the ponds. Ditches will be necessary if the spring or brook has no gravelly or sandy bottom, if it does not offer sufficient room, or if the water has too little fall. In these cases the bed of the brook is, according to circumstances, widened ½ to 1 meter, and about 15 centimeters fall is given to every 6 meters length. The depth of water should not be below 10 or above 30 centimeters. The bottom is covered with coarse gravel to the height of 10 centimeters. The ditch must slope gradually towards the bottom of the pond. If the fall is more than 15 centimeters in 6 meters, a few boards may be placed across the ditch or brook, which at one side have an opening for the fish to pass through. The depth of water, however, should not be raised by these boards above that given before, as the trout like to spawn in shallow water. The boundary line of the spawning place should be indicated by a very narrow grate, so the fry cannot escape and go up the stream to the spring. Above this narrow grate there should be a common grate for keeping off mud, dry leaves, &c. After the trout have deposited their spawn they are driven back into the pond, and the spawning ditch is also closed towards the pond by a very narrow grate. In this spawning ditch the fry are left for one year; or if the old trout have spawned particularly early, the fry may be placed in a pond in spring. If the natural condition of the spring or brook which serves as a spawning place meets all the requirements mentioned above, nothing need be done but to fence off the spawning place by grates. To protect the eggs and fry against their enemies, the spawning ditch is covered with dry brush-wood, but not so close as to prevent a current of air from passing through. Every year, before the spawning season commences, the ditch should be cleaned of mud and aquatic plants. As soon as the young fish have slipped out of the eggs, hiding-places should be provided for them, which can easily be done by placing in the water good-sized stones, hollow tiles, &c. If there are no aquatic plants, such as water-cresses—which, if not found in the ditch, should by all means be planted—and if there are no shrubs or trees on the banks to afford shade, the covering of brush-wood should be made thicker in some places. To provide both currents and calm places, small boards are placed in the ditch at suitable places, of course with openings for the little fish to pass through. The temperature of the water in the spawning ditch should not exceed 12° R. [59° F.]. Seventeen degrees are dangerous, and 23 become fatal. To prevent a rise of temperature in very hot weather, more brush-wood can be piled on the ditch. The fry need not be fed, if there is in the ditch a sufficient quantity of aquatic plants such as *Lemnaceæ*, *Nasturtium officinale* (water-cresses), *Veronica beccabunga*, &c., for these plants are always inhabited by numerous diminutive animals which serve as food for the fry. These plants are planted in the ditch simply by laying the roots on the bottom and placing stones on them to prevent the water from carrying them off. It is also advisable to introduce into the ditch insects, especially of the genus *Gammarus*, which is done in a very simple manner, by catching these insects in stagnant water, where in the beginning of spring they are found in enormous numbers, and transferring them to the ditch.

According to Meyer, infusoria may easily be procured in the following manner: "Take a large glass vessel, put at the bottom fresh leaves and other parts of plants, on the top of these some animal excrements (particularly those of cattle), and on these another layer of leaves, fill up with water and place in the sun, when in a very short time an enormous number of small crustaceans and infusoria will develop, which form the favorite food of young trout. To use these diminutive animals for trout food, a quantity of the animated water is filtered through a small dipper of mull, by which process a residue is left, which on close examination is found to be composed of thousands of animalcules."*

Before another spawning period commences, the one-year-old trout are taken to the raising ponds, and the ditch is given a thorough cleaning. As to the general requisites of raising ponds the necessary information has been given in a previous chapter. As regards their depth it should be stated that for one-year-old trout it should be 60 centimeters, for two years' trout 120 centimeters, and for older trout 1.5 meters, which is also a sufficient depth for wintering trout. If the fish in the raising and stock ponds are not to be fed artificially, their number will be determined by the quantity of natural food contained in these ponds. If it is necessary to use artificial food, it will be best, to prevent any pollution of the water, to use only live animals, such as maggots, fish-fry, worms, &c. Besides vegetable food, animal food may also be introduced into the ponds by adding to the trout some small fish, such as loach, minnows, &c., whose fry serves as food for the trout; but this method will have the disadvantage that these fish will devour many of the worms and insects which were intended for the trout, and on the whole, therefore, it cannot be recommended. To use scraps of meat as food can be only recommended if the quantity is very small and in small tanks, so that it can be eaten up at once, and, if necessary, the remainder can easily be removed from the water, which otherwise is apt to become polluted. Von dem Borne says that the time when the trout is most voracious is in spring, while in hot weather it eats but little. During the spawning season, and during winter when the temperture reaches zero (R.) [32° F.] trout do not eat anything. Trout should therefore never be fed during the noonday heat, but early in the morning and in the evening. As for the rest, all that has been said regarding carp-culture also applies to trout-culture, of course with such modifications as the nature of the trout demands.

11. SALMON (*Trutta salar*), SEA TROUT (*Trutta trutta*), AND LAKE TROUT (*Trutta lacustris*).

We cannot properly speak of culture as regards those kinds of fish whose young are not produced on the pond farm, but have to be obtained from abroad. To the keeping, therefore, of salmon, sea trout, and lake trout, all that has been said relative to trout-culture will apply

* Meyer, *Praktischer Fischzüchter*, p. 62.

as a general rule; and I would only call attention to the necessity of obtaining the fry in an embryonic condition or of getting young fish from fish-cultural establishments. Mr. Kuffer, of Munich, has informed me that in his establishment he has raised salmon-trout weighing 3 pounds and more. His establishment is fed entirely by pure spring water, which comes from the top of the hill on which the establishment is located. It consists of some very small shallow ponds and a number of granite tanks. As food, he generally uses the entrails of fish but also live and dead fish. As these different kinds of fish have been successfully raised in various localities, and in other than spring water, experiments on a small scale, according to the method given for the raising of brook trout, may be recommended. These experiments can be made only where besides large, there are also a number of very small, ponds. Large ponds are never suitable for experiments, in the first place because they are difficult to overlook, and secondly because, in case of failure, the loss would be doubly great, as a large pond area would be rendered useless for carp-culture. If the experiments should prove successful, the culture of these fish may be carried on more extensively.

12. THE VARIOUS KINDS OF COREGONUS.

To the keeping of these fish we may apply, in a general way, what has been said regarding the salmon. I cannot urge fish-cultivators too strongly to bring both these kinds of fish within the reach of pond culture, as I feel convinced (if I prove a false prophet I shall be greatly pleased) that by fish-culture and the placing of fry in open waters the number of the finer kinds of fish will increase to such an extent as to lower the price of carp, so that pond cultivators will find that exclusive carp-culture does no longer pay, and that it will have to be confined to those pond farms where it is impossible to raise or keep the finer kinds of fish. Experience has proved that the raising or keeping of the finer kinds of fish is in most cases successful. As an illustration, and for the encouragement of enterprising pond cultivators, I shall quote the following, relative to the keeping of the *Coregonus maræna*, from a report by Mr. Eckardt in Lubbinchen, near Guben.*

According to a report of Mr. A. Stenzel, inspector of fisheries, in No. 7 of the Circulars of the German Fishery Association for 1875, it appears.

1. That the *Coregonus maræna* grows rapidly.

2. That proof has been furnished that this fish, by means of artificial culture, can be planted anywhere in suitable water, and that it will soon accustom itself to a different quality, depth, and temperature of water, and to a different food.

3. That the very general but erroneous opinion that the various kinds of *Coregonus* which live in lakes could only thrive in these, has been

* *Deutsche Fischerei-Zeitung*, 1878, p. 10.

thoroughly refuted by the simultaneous successful experiments in raising these fish in ponds made at Lubbinchen and Tankow. It has also been shown that the *Coregonus marœna* (and probably other kinds of *Coregonus*) will thrive in water containing iron and coming from peat-bogs; and that it can, in comparatively small ponds, by feeding, be developed to one year's fish, and very probably be raised to any desired age. The various kinds of *Coregonus* should therefore be brought within the reach of pond culture; and for this purpose special *Coregonus* ponds should be constructed.

4. By numerous experiments it has been proved that *Coregonus*, even when placed in ponds which in every way were well suited for the purpose, did thrive, but would never propagate. The reason for this must be found solely in the peculiar manner in which the *Coregonus* spawns. If the spawning of the *Coregonus* is to be successful, the number of spawning fish should be very large.

5. Five years' experience in the Tietzel Lake has proved how well these fish thrive. This lake covers about 10 hectares and is 20 meters deep; it contains clear, soft water, is not fed from any outside sources, and is amply supplied with fish-food, principally tadpoles, small fish, *Gammarus pulex*, various kinds of snails, mussels, &c. The bottom is composed of clayey marl, and is thickly covered with aquatic plants.

Mr. Eckardt adds, that in 1877 he raised in his ponds *Coregonus* nineteen months old which measured 32 centimeters in length, and that these fish also thrive in marshy ponds. He gives the following hints for introducing these fish in lakes and ponds:

1. Proprietors of hatcheries should buy impregnated *Coregonus* eggs and have them hatched in their establishments. Eight days after the young fish have slipped out of the eggs they should be placed in lakes or in protected ponds containing no other fish. The latter will probably be the better place.

2. Proprietors of lakes without hatcheries or ponds may scatter the impregnated eggs in the lakes in places where the bottom is sandy, taking care that the eggs do not accumulate in any place, so that no spoiled eggs, which are soon covered with mold, spread disease among the healthy eggs.

3. Mr. Eckardt states that *Coregonus* eight to twelve days old may be ordered direct from his establishment at Lubbinchen. The management and feeding of *Coregonus* in winter is like that of the brook trout.

13. THE EEL (*Anguilla vulgaris*).

As at present eels fetch a pretty good price, and as young fry, called in French *montée*, can be obtained comparatively cheap from the Huningen establishment, the keeping and raising of these fish is well worth the attention of every pond cultivator. As soon as eels have reached a suitable size they form an excellent addition to the pike in carp stock ponds. It cannot entirely supplant the pike, because it is said not to propagate in fresh water, and eats only small fish, while the large, worthless fish contained in the carp ponds can be destroyed only by the pike. There is this disadvantage connected with the keeping of eels: that they will deprive the carp of some of their food, as, besides small fish and roe, they also eat worms and insects. This applies, however, also to the perch-pike, the keeping of which, nevertheless, is profitable, when confined within certain limits. Eel ponds must have high banks, so that the eels cannot easily escape, as on moist grass they can move for the distance of several kilometers, and thus be enabled to reach other ponds. The ditches by which the pond is fed and through which the water flows out should, therefore, be closed by narrow grates. All places on the sides or the bottom of the pond where the eels could escape must be carefully stopped up. Eels should never be placed in ponds with a peaty bottom, through which they can work their way. Eel ponds should also have hiding-places consisting of stones, roots, holes in the banks, &c.

In good carp ponds the feeding of eel-fry may, during the first year, be left to nature. If artificial food is needed, the same should be used as for brook trout. Food may also be supplied by placing in the ponds crucians, tench, &c., whose fry will form an excellent food for the eels. During the first year they generally reach a length of 8 to 10 centimeters and a circumference of 2 to 3 centimeters, and I have repeatedly seen eels of that age and size which Mr. Kuffer, in Munich, had received from the Huningen establishment. He keeps about twenty eels in a tank, measuring hardly a square meter and fed by spring water. In this tank he has thrown pieces of coarse ticking, under which the eels hide. For food he uses roe and the entrails of fish cut fine. The Huningen establishment charges 9 marks [$2.25] for 1,000 *montée*, 2,000 of which go to a pound. Orders should be sent in February or March. Mr. von Stemann, in Rendsburg (Holstein), and Mr. Brüssow, in Schwerin (Mecklenburg), also sell eel fry. It is to be hoped that this useful fish will soon be caught in many of our North German rivers.

V.—The Pond Fisheries.

Pond fisheries take place partly in spring and partly in autumn. In spring the first fisheries take place in the winter ponds, with a view to supply fish for the spawning and raising ponds, and after a while those spawning ponds have their turn in which fry had been left during winter. The fisheries should not commence until there is no longer any danger of spring frosts; therefore some time between the end of March and the end of April. First the winter ponds are fished and next the spawning ponds. It is of course necessary that those ponds which are to be stocked with fish from the winter ponds should receive their full supply of water before the fisheries commence. The autumn fisheries are intended partly to supply the grown carp for the market, and partly to transfer younger fish from the raising ponds to the winter ponds. They generally commence about the beginning of October; on large pond farms, however, they should commence sooner, so they may be brought to a close before frost sets in.

For fishing, cool days should always be selected; and fishing should commence very early in the morning, so that one or more ponds may be finished before the sun stands high in the heavens, as heat makes the fish languid and renders them unfit for transportation. No more ponds should be drained during one day than can be fished that day.

As regards the order of the autumn fisheries in the various ponds, it will be best to make the beginning with those spawning ponds in which no fish are to be wintered, so that the fisheries in these ponds may be brought to a close before frosts, or even hoar-frosts, which are injurious to the fry, set in. Next in order come the stock ponds, and among them first those which are to be filled with water immediately after the close of the fisheries, so that they can be stocked that same autumn; next come the raising ponds, which are to supply the fish for the winter ponds; and lastly those raising ponds whose fish are during that same autumn to be transferred to the stock ponds. As regards the fisheries in the raising ponds, it will be advisable to take those ponds in close succession whose fish are to form the stock of one and the same winter pond. Before the fisheries commence it will, especially on a large pond farm, be necessary to prepare a well-arranged plan, taking special regard to the length of time which each pond will need for draining.

At the beginning of the fisheries the necessary apparatus, which should have been looked over some time previous in order to make any needed repairs, should all be ready; and the required laborers and carts should be on the spot, so that the fishing, sorting, weighing, and transporting of the fish may proceed as rapidly as possible, to prevent the fish from reaching their winter ponds and other ponds and tanks in a languid condition. The apparatus used for fishing and for the sorting and transporting of fish will be described in another chapter.

Letting off the water.—Before fishing commences in a pond, the water should be let off. This matter is intrusted to a reliable person, who has charge of and supervises all the preparatory labors, and whose duty it is to have the pond completely ready for the fisheries. Before the water is let off, it is necessary to carefully examine the tap-houses and fish-pits, and if needed, to clean them, to substitute new stocks for broken ones in the grates, and to clean the ditches through which the water flows off, so that it flows out evenly, without causing an inundation. If, however, there are meadows below the ponds inundations will actually prove beneficial, while if the ground below the pond is occupied by other ponds, they will be injurious. In this latter case measures should be taken to prevent any damage to dikes and dwellings, and to hinder the fish from floating away. The pond should therefore be drained slowly. At the places where the water flows out, nets should be securely fastened in front of the grates, so that no fish can get through and reach the outer fish-pit. As fish generally get hurt in passing through the pipes, no fish should, if possible, be allowed to enter them. The outflow of the water is regulated by stand-pipes and taps, by opening them gradually and letting the water pass through by slow degrees.

After these preliminaries have been finished, the weirs, wherever there are such, are opened; and where there are stand-pipes the small boards are taken out one by one. Even if they are fastened with screws or nails, this can soon be accomplished with a screw-driver or a pair of pincers; and it will, therefore, be well to have these tools near at hand.

Where there are tap-houses, the drawing of the taps will occasion a little trouble, and will always require the combined efforts of several laborers. Short taps can, as a rule, be drawn by one strong man. For the drawing of long taps special contrivances are needed, and two, and often more, men. If the tap is not too long and heavy, it may be gradually lifted by means of a pole stuck through a ring at the top, or a hole in the tap itself. Very large taps can be drawn only by means of a very stout and long pole with holes, and shaped like a roller, of such a length that it can easily be placed on the tap-house from the dike, so as to project beyond. This pole is placed close to the tap, and round it is wound a chain fastened to the tap from below (a stout rope may also be used), whereby the tap is gradually drawn from its hole. If earth has been rammed down round about the tap, it is rocked up and down until the earth becomes loose. In thus rocking the tap up and down, it will be easy to hold it suspended for a while, and thus to regulate the outflow of the water. In the beginning the tap should be drawn gradually so that the water can flow off slowly, and the fish may gradually be drawn from the edges of the pond towards the deep places. Great care should be taken in ponds having many reeds, because the fish are apt to remain among these, and either perish or become the prey of birds and other animals. While the water flows off, some men should be engaged in driving the fish from the reeds into the deep places.

One man should always be stationed at the place where the water flows out; the outer fish-pit should also be under constant surveillance, so that the fish which may get into it accidentally can immediately be removed. If, as is frequently the case in small ponds, there is no outer fish-pit, baskets should be placed where the pipes open on the outside of the dike, in such a manner that the water flows through them, and that any fish which may accidentally have got into the pipes are caught in these baskets. The water should not be brought to its lowest level until everything is ready for the fisheries. At the moment when the tap is lifted entirely out of its hole the tap-basket is placed in the opening by which fish are prevented from escaping, but which lets the water flow through. In spite of this precaution fish will sometimes reach the outer pit, owing to the fact that the water occasionally lifts the tap-basket from its position.

The degree to which a pond is to be drained depends on its size, and whether a seine or small net is used in fishing. In the former case the water should not be drained off as much as in the latter, and should be left to stand in the fish-pit to the depth of one meter, as otherwise the fish will be injured by an excessive accumulation of mud. If it requires several days to drain a large pond the operation should be occasionally looked after during the day; and during the last days should be watched constantly, partly to regulate the outflow of the water and partly to prevent thieving.

Other preparations for the fisheries.—Before fishing commences the necessary number of tubs, filled with a sufficient quantity of water, should be placed along the edge of the fish-pit; baskets or large pieces of cloth, for carrying the fish to the kegs, should be in readiness, and the required number of persons for attending to this work and for drawing the nets should be on hand. Particular care should be taken that there is no lack of carts, placed in convenient positions, for if the fish, after having passed from the pond to the tubs, and from these, after having been sorted, to the kegs, have to wait any length of time for the cart the tubs will become too crowded, and it may even at times be necessary to stop the fisheries for awhile. Thus the entire process is retarded, and will take twice as much time as if everything had been in readiness. By such delays the fish are apt to become languid in the tubs, they cannot stand the hardships of transportation, reach the pond in an exhausted condition, and many die. It would, therefore, be false economy to try and save laborers and carts in the fisheries. It should be remembered that the death of one fish occasions a greater loss in money than the daily wages of a laborer, and that the loss of several fish exceeds the daily cost of a cart. After everything has been prepared, and the pond has been drained, fishing commences.

If in a large pond a seine is used, it is set at some distance from the fish-pit, in a place where, after the pond has been drained, the water gathers, and it is held in a perpendicular position by a number of men, who gradually approach the fish-pit, and drive the fish before them by beating the water with sticks. When they arrive at the fish-pit, the seine is drawn through it by pulling both ends towards the shore. The two ends are gradually brought closer and closer, and are finally pulled ashore, where all the fish are inclosed. If the seine corresponds in length to the extent of the pit, all the fish will certainly be caught at once. Reimann says: "With a view to get all the fish together in the seine, care should be taken that from the very beginning the lower part of the seine rests on the bottom of the pond and leaves no openings through which the fish can escape below the seine."* In very large ponds it will be necessary to use one or several boats in setting and hauling the seine.

If the ponds have other holes besides the fish-pit, fishing should commence in the smaller and end in the larger ones. In small ponds which

*Reimann, *Praktischer Abriss der Fischeri*, 1804.

have no deep holes and only a a small and shallow fish-pit, a purse-net is used—an instrument which is indispensable in pond fisheries, and cannot be done without, even when a seine is employed, as the fish are by it taken from the seine. Once begun, the fisheries must be brought to an end as rapidly as possible.

The size of the pond, the number of its holes, and finally the quantity of fish will determine the number of men to be employed. In no case will it be a disadvantage to employ a large number. Some enter the pond with purse-nets, others place baskets and buckets by their side, which, when filled, are immediately carried to a tub and emptied into it. Those men who take the fish from the water empty their purse-nets in the tubs or baskets which are close by them. With a view to expedite matters, an empty basket or bucket is immediately put in the place of the full one. In a large pond, even a great number of men, if fully supplied with the necessary apparatus, will not interfere with each other. Some experienced and trustworthy men should exercise a careful supervision over all parts of the pond, to prevent the stealing of fish and their being retained in holes, grass, reeds, or mud. Some men have a peculiar skill in treading fish into the mud during fishing, with the view of taking them out when the fisheries have come to a close; others manage to slip them under their baggy trousers, which are firmly tied at the ankles.

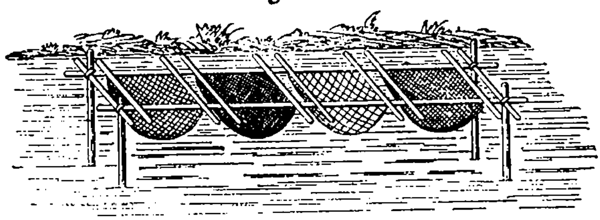
To remove the fish from the pond in baskets will be necessary only when holes in the pond are to be cleared of fish, or when the fish-pit is not in the right place, and consequently the distance from the pond to the tubs is too great to allow of their being emptied direct from the purse-nets into the tubs. If the fish-pit is large enough to haul a seine, this should by all means be employed in preference to the purse-net, as thereby the fish are kept in the water all the time till they are transferred to the water in the tubs. If the purse-net is employed exclusively, the fisheries should commence in those places where the fish, owing to a scarcity of water, lie in the mud, and gradually following the greatest depth of water in the ditches, proceed towards the fish-pit where the fish have gathered. If fish are taken from the pond with the hand, which becomes necessary when they lie in the mud, they should be taken round the middle of the body, or by the head and tail at the same time, and not be held in the hand long but carried to the tubs by the shortest road. Great care should be taken not to catch the fish by their tender gills or to have the fingers on their eyes. The laborers employed in fishing should be strictly enjoined to handle the fish as carefully as possible, and especially not to throw them into the tubs from a distance, as the fish will occasionally fall on the edge of the tub and be hurt or killed. The general rule will always be to take the fish from the pond with the purse-net. This will, however, be impossible as regards small fish, and more particularly fry, which must be carefully taken up with the hands. In emptying the purse-nets in the sorting-baskets or in the ordinary baskets and tubs, one should proceed very slowly, so that the fish do not strike the bottom of these receptacles or each other violently and be injured.

In fishing a stock pond containing several kinds of fish, the tender kinds should be removed first, as much as possible at least; perch-pike, being the most tender, should be taken from the seine singly with the hand, be placed immediately in tubs filled with pure water, and thence as soon as possible be removed to the kegs, as they cannot live long out of the water; then follow the larger pike and perch, the carp and the tench, and finally the smaller pike. Eels must be caught with special purse-nets, and not with the hand; as eels will entwine themselves around the arm, and sometimes break it. Special care should be taken to clear the ponds of fish, as eels, tench, and pike will hide in the mud and thus escape the attention of the fishermen. It is especially important that no fish of prey should remain in the pond, as these, in case the pond is filled with water soon after the fisheries, would in the following year make sad havoc among the carp. If not so dangerous, it is, nevertheless, injurious to leave large carp in the pond, as they will spawn during the following year, which will not prove an advantage from a fish-cultural point of view.

In order to remove fish which have remained in the pond, it will be advisable, immediately after the fisheries, to go through the mud with a long broad-pronged dung-fork. To be absolutely certain, it may be recommended to secure the place where the water flows out, if there is no outer-pit, for a few days with a basket, in which the remaining fish will be caught. This may be particularly useful when there is reason to suppose that some eels have remained in the pond, as these fish are very apt to hide in the mud, and leave their hiding-places only during the night or the following day. For transporting eels very tight baskets are needed. During the fisheries the water in the fish-pit should, wherever the circumstances allow it, be renewed as often as possible, so that the fish are not covered with mud and thereby become languid. Before being placed in the kegs they must be washed clean. On some pond farms a ditch measuring 1 meter in depth and of corresponding breadth and length, and located near the outflow of the water, is substituted for tubs. This ditch is filled with water from the pond. Here the fish are sorted, and thence they are taken direct to the kegs. I am not in favor of this arrangement, as it will be impossible to make separate ditches of this kind for every species of fish, since it would make too much work to dig and again fill a number of these ditches, but if they remain unfilled from one fishery to another it cannot be avoided that, especially in rainy weather, when the water of the ponds overflow the banks, these ditches will be filled with water. In such ditches the fish like to gather, and thus become an easy prey to fish thieves. I must here state that I speak from experience, although among the 50 ponds which at one time I had under my care, there was only one which had such ditches. If these ditches are outside of the pond, on the other side of the dike, they can be secured against being filled with water, but in that case they will have the disadvantage that the labor of fishing is retarded, as the fish cannot be taken direct from the pond to the kegs, but have to be carried over the dike to these ditches—which, if not in clayey or loamy soil, must be lined with wood-work—have to be sorted in them, and finally carried to the kegs which are on the carts or wagons, which as a rule must drive on the dike. Such delays may be avoided by placing near the fish-pit a sufficient number of tubs, which make it possible to carry on the fisheries with the utmost regularity.

On some farms, tubs or ditches are dispensed with, and in the nearest pond a scaffolding of poles is erected near the shore, on which are

Fig. 19.



placed a number of nets which hang down into the water. From the baskets or nets the fish are thrown on the ground, and are thence put in the nets, assigning a separate net for each kind. This arrangement offers the advantage that the fish remain in pure, fresh water up to the moment when they are placed in the kegs, but on the other hand it will often be found difficult to get close enough to these nets, some of the fish in being thrown will strike the poles and will be injured or killed, while others will fall beyond the nets in the open water and thus escape. As some of these nets have wide and others narrow meshes, to suit the different kinds of fish, it will often happen that mistakes are made in throwing the fish, small ones sometimes getting into nets with wide meshes which favor their escape. If among these escaped fish there should be some small pike, they will, during the following year make great havoc among the fry. Frequently the number or size of these nets is not sufficient for the different kinds of fish; the nets become crowded; the lower fish seek to rid themselves of the fish which are on top of them, and in the general commotion caused thereby, many fish escape into the pond. The whole arrangement, moreover, consumes considerable time in its construction.

Much time is also wasted in employing a method, mentioned by Delius, according to which the fish are not sorted until they arrive at the tanks or winter ponds. Delius says, regarding this method: "The fish which have been caught in the pond are put on wagons, either loose or in baskets, and driven to the tanks. Care should be taken that the baskets, which are made of willow branches with the bark on, have no sharp points on the inside; such points must always be on the outside, because the carp may be injured thereby. The carts or wagons should have a removable board at the end, and no sharp points or edges on the inside. Arrived at the tanks, the back-board of the cart is reremoved and the fish are rapidly emptied into a large tub placed immediately under the back of the cart. Close to the tub is placed an immense table with high edges, on which 300 to 400 pounds of fish can find room. This table is perforated so that the water can flow off. The fish are taken from the tub with a large dipper of muslin or other thin material and laid on the table, where, if necessary, pure water is poured over them. The fish are counted, putting the same number in each basket, so that only the number of baskets need be remembered."* The only advantage of this method seems to me to be the transportation of the fish in wagons instead of in kegs, but this will be an advantage only so long as the distance to be traversed is not very great. Although I will not altogether condemn this method, I cannot speak in favor of it. From the description of the well-regulated fisheries on the Wittingau pond farm, which I shall give in another chapter, the waste of time connected with this method will become apparent to every reader. It therefore follows that the most suitable and expeditious method of fishing the stock ponds is this: The fish are removed from the seine (or direct from the pond) with purse-nets and placed in the fish-baskets, which lie close to the tubs placed along the sides of the fish-pits; here they are washed, then sorted and put in the different tubs, weighed, and transferred to a lined tub. From this they are counted into cloths, which extend to the kegs, and are held by a number of persons. As soon as they are in the kegs they are carried to their final destination. To avoid mistakes, it may be well to attach to the tubs labels indicating the kind of fish contained in them. If a pond farm is carried on systematically it is absolutely necessary, with a view to book the results, to sort, count, and weigh the carp and other fish. As regards the carp, it is essential to their sale that they should be counted; and even if this was not the case, the counting will be necessary to ascertain how many of the fish originally placed in the pond have been lost, and to find the average weight per fish and per hundred. The noting down of these figures is needed in judging of the quality of a pond. In weighing fish intended for sale it will be best to use scales with two arms.

Spawning pond fisheries.—The spawning pond fisheries should be managed with particular care. The water must not be let off too rapidly, because otherwise the fry is retained in the small holes which form in the mud of the pond, and do not reach the fish-pit, which not only retards the fisheries, but is also apt to injure the little fish. The same care should be exercised in picking up the young fish; and the ma-

* Delius, *Teichwirthschaft*, p. 90.

jority of them should, if possible, be caught in deep water. The fisheries should be carried on as rapidly as possible, so that not too many of the fry perish, and they soon get again in fresh water—in autumn in the winter ponds and in spring in the raising ponds. The spawning carp must be handled just as tenderly as the fry during the fisheries and during their transfer to the raising ponds, as the least injury done to them will hurt not only them but also the fry. Although any injury done to the spawning fish is not as serious after spawning as prior to it (as probably they will be sold immediately or after a short stay in the stock ponds), it is self-evident that, owing to their size and their value, they must be handled with care.

While the fisheries are going on in the spawning ponds, the fry should at once be sorted and arranged in two or three classes. The best way to do this is to put the fry in the sorting-vans covered with linen and to wash them, care being taken that the water does not fall on them too heavily. Experienced men should attend to the sorting, and should place them in the tubs, from which they are taken with nets or dippers, counted, put in the kegs and at once carried to their destination. It should not be omitted to weigh a few of each sort as a test. The necessary hints regarding the transportation of spawning carp have already been given in a former chapter. In these fisheries it is even more necessary than in other fisheries to have a sufficient number of carts on hand (better too many than too few), as the quantity of young fish cannot be calculated beforehand with any degree of certainty. If the fry have to be transported a considerale distance—as will be the case on extensive pond farms—the kegs should be refilled with clear fresh water every two hours; and if this is not found near at hand, one should not hesitate to go out of his way to obtain it. In order not to let the water fall on the fry too heavily, so as to injure or kill them, it should be poured into the kegs through a bunch of straw. The kegs must first be filled with pond water, so as to avoid a too sudden change of temperature which is apt to injure the fry. Care should therefore be taken not to pour in during transportation too much cold water at one time, because this would cool the temperature too rapidly. If the fish are only to be conveyed a short distance, it will not be necessary to add any water.

Raising pond fisheries.—The raising pond fisheries are carried on in the same manner as those in the stock ponds and spawning ponds, In sorting the fish, however, it will be necessary only to distinguish two kinds, small and large ones. To divide the fish into three classes will be necessary only if the pond had originally been stocked with fish varying greatly in size; and this should, if possible, be avoided. A few of each sort should be weighed for a test, which can easily be done in a few minutes. The weight and number of the fish are carefully noted down.

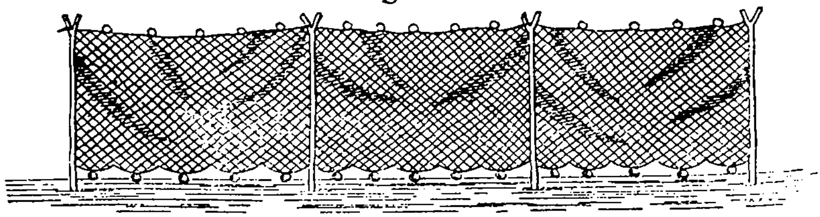
Summer and winter fisheries.—A few remarks must be added regarding the summer and winter fisheries. Both of these fisheries will occur only in exceptional cases. Summer fisheries may become necessary, owing to sickness among the fish, or to accommodate an old customer, who pays a higher price, which will, to some extent at least, compensate for the loss in weight. Full compensation cannot be made, as during summer the fish are in their best growth, and as their increase in weight up to autumn does not occasion any special expense. The regular fisheries will, therefore, always occur in autumn, when no further increase in weight is to be looked for. Summer fisheries must be carried on very early in the morning, and if the pond is large they should commence during the night, so that they can be brought to a close before the heat of the day. They generally commence at midnight, when the water has cooled off. In summer fisheries the tubs should be filled with particularly fresh water—if possible, spring or well water. If night fisheries become necessary sufficient light should be furnished by means of torches, for, in spite of all precautions, losses (especially by thieving) can hardly be avoided, particularly in large ponds. These losses will be greater in large ponds than in small ones, and in the stock pond fisheries many pike and especially perch-pike are always lost. The fisheries in small ponds will, as a general rule, pass off without any considerable loss. Under all circumstances, however, night fisheries should only be resorted to in extreme cases.

The same applies to winter fisheries, which should be carried on only in cases of urgent necessity. Unless there is sickness among the fish these will but rarely occur on well-regulated pond farms. Even on such farms winter fisheries may, however, become necessary, if the pond serves industrial purposes, which would suffer from summer fisheries. Winter fisheries are generally carried on about noon; and it will be necessary to remove all the ice from the fish-pit. As in winter fisheries it is impossible to avoid injuries to the fish, they should be sold as soon as possible.

VI.—Fishing Apparatus.

1. The *screen*, or *standing-net*, which is placed before the fish. In large

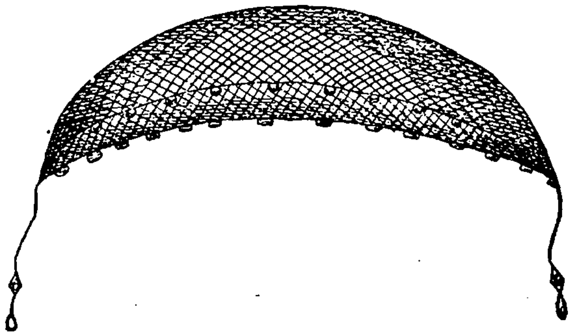
Fig. 20.



ponds, where the fisheries occupy two to four days, it is preferable to fish in deep water, so that the fish are not covered with mud, or, in warm weather, become languid. The fish are driven by men in boats from the edges of the pond toward the deep places, and inclosed within the screens the day preceding the fisheries, so as to reduce the fishing area. The meshes of these nets are either large, to allow the small fish to slip through, or they are narrow, so that even small fish cannot pass through.

2. The *seine* is a net of varying size, with wide meshes, and consisting of one or two pieces; along its entire length runs a rope both above and below, the lower one being weighed down with pieces of lead or stones attached to it at intervals of about 30 centimeters, while the upper one has at similar intervals pieces of cork, which keeps the upper part of the net floating in the water while the lower part rests on the bottom. In order to haul the seine to advantage it must be as long as the sheet of water in which the fisheries are to occur, and broad enough to exceed its depth by one-fourth of its breadth, so that it can bulge out and make folds, which is necessary to a successful haul.

Fig. 21.



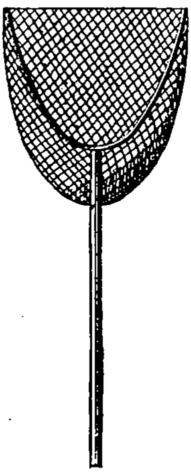
At each corner of the net a string is fastened, which is made movable by means of a piece of wood. These strings, called arms, are necessary to enable the men to haul the net with a full exertion of all their strength. When the seine is pulled when in the water a large bulging fold is formed in which the fish gather, so the fishermen have only to draw the lower and upper rope together. To clean a pond of fish with this apparatus, it is essential that the bottom where the fisheries are carried on should be even, so that the seine may in its entire length rest on the bottom and that no fish can slip away underneath it. The hauling of the seine will always require several persons, and sometimes a boat. In the latter case the boat is manned by three persons, while three remain on shore and hold on to one arm of the seine. While two of the men in the boat row towards the place where the fishing water begins (as far as the water will carry the boat), the third one lays the seine in the water. As soon as the men in the boat have reached the place where the water begins the men on the shore begin to pull the arms of the seine and drag it on land in a semicircle, while the boat is gradually approaching the shore, the men in it drawing the seine as far towards them and into the boat as is necessary to get the fish together in the trough formed by the seine. This apparatus is also employed in river fisheries, and should, in that case, occupy the full breadth of the river.

3. The *large seine* is the same kind of net, only on a larger scale. It is used in very large ponds, and for casting and hauling it several boats and often more than twenty men are needed.

4. The *single seine* is a small net of the same kind. Both of its ends are tied to poles and are hauled, while the upper part of the net floats on the water. As nets represent considerable capital, it is desirable that they should last as long as possible. The best and simplest means to attain this end is to lay them in a tan-pit until they have assumed a brownish color, which, if they are tolerably moist, will take place in about forty-eight hours.

5. The *purse-net* consists of a handle, 75 to 125 centimeters long, ending like a fork in two prongs, each 50 centimeters long, between which a round or square net is extended. The handle must be strong enough not to bend or break by the weight of the fish. The net should be well made and be strong so as not to become enlarged by constant use, which would render it difficult to empty out the fish. According to the kind of fish which are to be caught, the meshes will have to vary in size. This apparatus is used for taking fish from the seine, or, in small ponds, for catching the fish in the water. It may also be used for taking fish from tanks, tubs, or ditches.

Fig. 22.



6. The *fish-dipper* is a sort of purse-net. It consists of a bag-shaped net tied to a wooden or iron hoop, to which is fastened a handle measuring about one meter in length. It is used for taking fish from the seine or from tubs.

7. For *pike* and *perch-pike* purse nets are used, consisting of a two-pronged fork, each prong measuring 50 to 80 centimeters in length, with a handle 2 to 2.5 meters long. The net is fastened to and extends between these two prongs, and is shaped more like a trough than a bag, being longer and

Fig. 23.

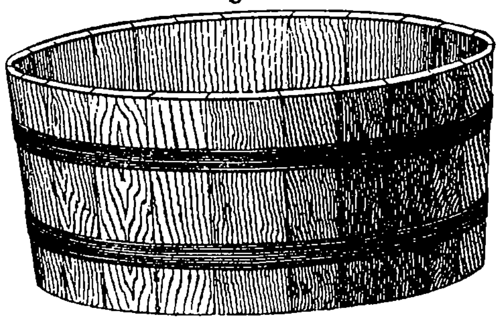
shallower than the purse-net. With this apparatus pike and perch-pike are taken out singly and immediately transferred to fresh water.

The purse-net used for eels has very narrow meshes and forms a deep bag, so that these slippery fish cannot easily escape.

Fig. 24.

8. The *sorting-tubs.*—These must be made of pine wood, and have at the top a diameter of 1 meter; they should be 50 centimeters high, so that they can easily hold 3 to 4 hectoliters of water. The diameter at the bottom should be a little smaller than at the top, just enough to keep the staves in position.

Fig. 25.



9. *Sorting-tables.*—The sorting-table consists of a large leaf perforated in many places, with a raised edge, about 20 centimeters high. It should be large enough to hold 300 to 400 pounds of fish. As a general rule it is 1.7 to 2 meters long, and 1 meter broad. Directions as to the manner of using these tables have been given in a previous chapter. Sometimes sorting-tables are used, which, instead of the perforated leaf, have a net drawn tight and firmly fastened to a square frame measuring about 10 centimeters in breadth. The meshes of this net are very wide, so that the small fish fall through into another net with narrow meshes extended below the first, and are thus separated from the large ones. If the sorting-table has the dimensions given above, it is well adapted to its purpose, but if it is only 60 centimeters long and broad, it does not fulfil its object. In tables of these dimensions the net cannot be drawn tight enough; the fish which fall on it are placed in unnatural positions, and it becomes impossible to sort them at a glance as the business requires, as a few fish will completely fill such a small table.

Fig. 26.

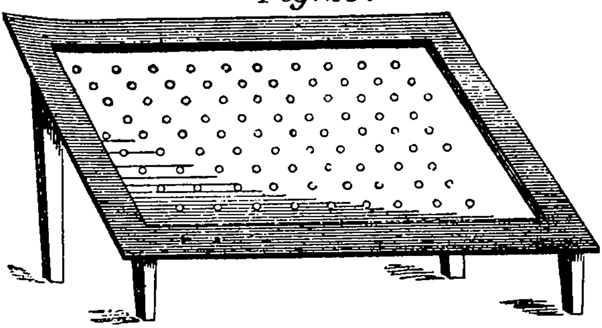
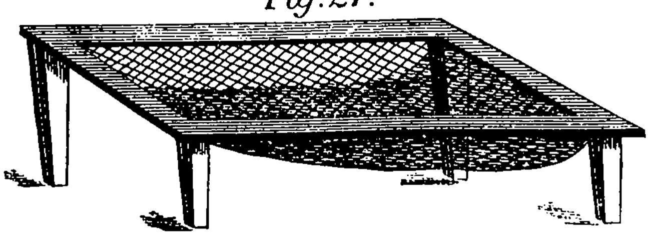


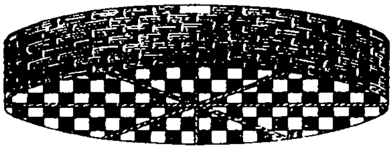
Fig. 27.



10. *Sorting-vans.*—These are the most practical apparatus for sorting fish. They have been in use for some time on the Wittingau pond farm, and from my own experience I can testify as to their usefulness.

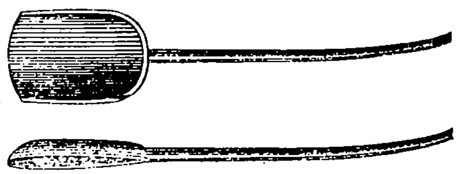
In this apparatus the fish lie stretched out full length, and an experienced person will be able to sort them without much loss of time. In their shape these vans resemble those which are used for winnowing grain. They are very firmly plaited of willow bands, and the bottom has numerous openings of a square centimeter each. To protect the bottom thick ropes are drawn below it in the shape of a star. These vans measure 70 centimeters in diameter and 20 centimeters in height. Each van is placed between two tubs, its bottom resting on the edges; the fish are placed in them, washed and sorted and put in the tubs.

Fig. 28.



11. *Water-dippers.*—These are small wooden shovels, made of a single piece of wood. The handle is about 70 to 75 centimeters long, and the shovel, somewhat resembling a trough, is 30 centimeters long, 20 centimeters broad, and 10 centimeters deep in the middle. These dippers are used for filling the tubs with water; and several men are employed in throwing the water by means of these dippers from the fish-pit into the tubs, in which manner they are filled very rapidly. They are also used for pouring water on the fish for the purpose of cleaning them while in the sorting-vans and for occasionally stirring the water in the tubs, to keep the fish in motion, and to further the absorption of oxygen by the water. They also prove useful in many other ways.

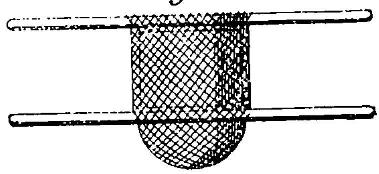
Fig. 29.



12. *Tubs and baskets.*—These are used for transporting the fish, if the fish-pit is not near the dike; and also if there are holes in the bottom of the pond, as is frequently the case in large ponds, which makes the distance to the tubs too great to carry the fish in purse-nets. If the fish are to be taken to ponds or winter ponds which are close at hand, kegs may be dispensed with, and baskets or tubs used instead. Both baskets and tubs are oval-shaped, the former of coarse wicker-work, and the latter of pine wood. Special care should be taken that no sharp points project on the inside of these baskets. These baskets and tubs are of different size. The most suitable dimensions are 70 centimeters in length, 40 in breadth, and 30 to 40 in height. The tubs for transporting single fish, *e. g.*, perch-pike, resemble in shape and size the small bath-tubs used for washing babies. On some pond farms they are used instead of tubs and baskets.

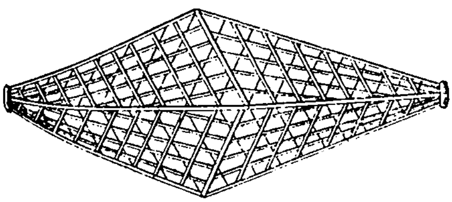
13. *Net-barrows.*—This implement consists of a bag-shaped net which can hold about 100 pounds of fish, and which is held in position by two long and two short poles. The long poles enable two persons to carry it. My experience has taught me to condemn the use of this implement, as the fish are kept in an unnatural position and press too heavily against each other. The lower ones will suffer most, as they are pressed against the net, frequently lose scales, and are seriously injured.

Fig. 30.



14. *Fish-cloths.*—These are large pieces of coarse linen cloth, about 1 meter long and broad, intended to convey the fish from the tubs to the kegs. They are exceedingly practical for this purpose, and may be substituted for baskets and tubs. There is no fear that the fish will be injured in them, and they are quite inexpensive.

Fig. 31.



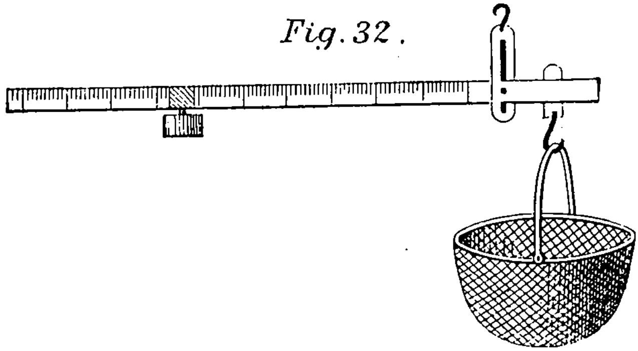
15. The *tap-basket.*—As soon as the tap has been drawn, this basket is placed in the opening. It is made of coarse wicker-work, the openings varying in size with the size of the fish, and has the shape of two obtuse pyramids, joined at the base.

16. The *great fish scales.*—For weighing carp intended for the market the scales used on the Wittingau pond farm appear to me to be the most practical, and I shall, therefore, give a short description of them. There is a frame-work, constructed of stout pieces of wood, which ends in a sort of gallows, between whose arms there is a shelf for the weights, &c. From the cross-beam is suspended a pair of scales, on one side a scale for receiving the weights, and on the other a shallow wooden tub held together with iron rims for receiving the fish. The length of this tub is 70 centimeters, and its breadth and depth 40. The sides have four rows of small holes, measuring about 2 centimeters, so that the water can flow off. Such a tub holds a little above 100 pounds. As this is the quantity weighed each time, the weighing proceeds very rapidly, and 10,000 pounds of carp can easily be weighed in one hour.

17. The *small scales.*—This consists of a long iron arm or pole, at the one end of which a basket hangs in a hook, while from the longer part of the arm the weight is suspended, which is moved backwards and forwards until the equilibrium is restored. The weight can then be read off from the marks on the long pole. In order to avoid the deducting of the weight of the basket each time fish are weighed, it may be well, when the scales are gauged, to take into account the weight of the basket in a moist condition. These scales are used for taking test weights in the spawning pond and raising pond fisheries, or if a few

fish are to be sold at the dike. For the purpose of weighing fish with these scales, two men as near of a size as possible lay one of the water-

Fig. 32.

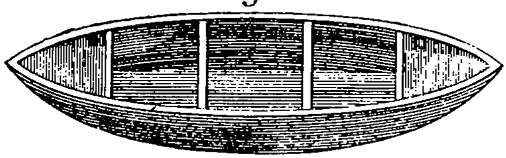


dippers described above over their shoulders; the scales are suspended between the two men from the handle of the dipper, and weighing begins.

18. *Fishermen's clothes.*—Of special articles of clothing we will only mention large leather boots reaching above the thighs; and to these may be added, in very large ponds, a leather jacket buttoned to these boots.

19. *Boats.*—There should be on hand a suitable number of flat-bottomed boats, which by boards placed crosswise are divided into several compartments, so that if necessary fish can be stored away in them.

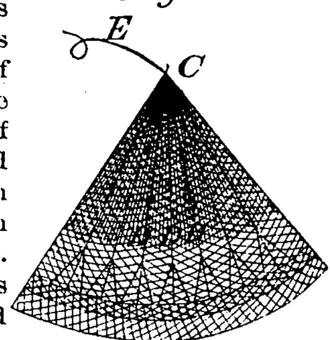
Fig. 33.



20. In *river fisheries* some other nets and seines are used in addition to those described. These are:

(*a*) The *cast-net*, described by Molin, as follows: The cast-net is cone-shaped, its mouth is very wide and must be proportioned to the height. At the point C, a rope, E, varying in length, is fastened. If a net of this kind measures 20 meters in breadth, it should be 4 meters high. As a general rule the proportion of its height to its breadth is as 1 to 5. The edge of the mouth is hemmed with a rope of the thickness of a quill, from which depend lead balls, weighing 30 grams each, which are placed at equal distances from each other, and weigh 10 to 12 kilograms in all. The edge of the net projects beyond this rope about 22 to 33 centimeters, but is folded inside and fastened in some places to the lines D D D, which extend from the top to the edge, so that the edge folded inside forms a series of pockets round the mouth of the net,

Fig. 34.



in which the fish become entangled. The meshes of the net decrease in size from the point towards the edge, being about 6 centimeters wide near the point, and so narrow near the edge that a finger can hardly be pushed through. Large nets of this kind are drawn and small ones are cast. In the water it opens out like an umbrella, and when taken out it is twisted so as to inclose the fish securely. It can be used only where the bottom is free from aquatic plants and other impediments.

(*b*) The *dip-net.*—This is a square net, whose sides are 1 to 2 meters long, and which is fastened to a strong rope. The meshes get narrower

Fig. 35.

towards the bottom, so that the small fish, which go towards the bottom, cannot fall through. The four corners of the net are fastened to two hoops placed crosswise, which serve to keep it extended. At the place where the hoops cross each other it is, by means of a rope, fastened to a pole 5 to 7 meters long. When fish are to be caught with this net a bait is placed in it and it is dipped into the water.

(*c*) The *hose-net.*—This apparatus consists of a net 10 to 12 meters long, which is very wide at the top and, gradually getting narrower, ends in a pointed bag. This net is only used in very narrow rivers, where it covers the entire breadth of water. The fish enter through the wide opening and go up into the narrow portion of the net, whence they cannot retrace their way, but where they are frequently crushed to death. To remedy this evil,

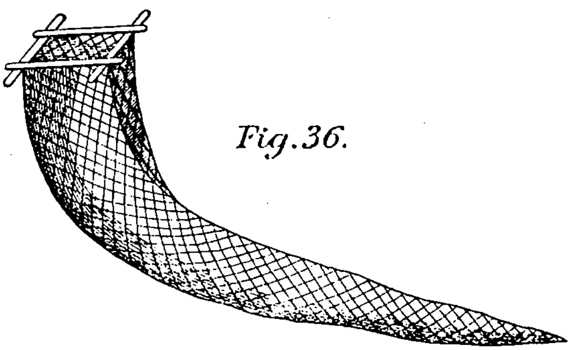
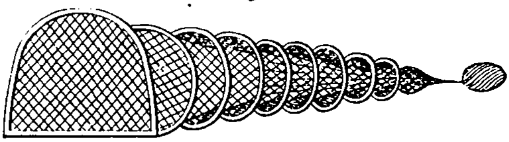


Fig. 36.

(*d*) The *bag-net* has been constructed, which in its use closely resembles the hose-net. It differs from this net by the fact that the bag is kept extended by hoops. At the mouth a very large hoop is fastened, and at certain intervals hoops follow each other, which gradually become narrower, and keep the net extended, so the fish can move about in it.

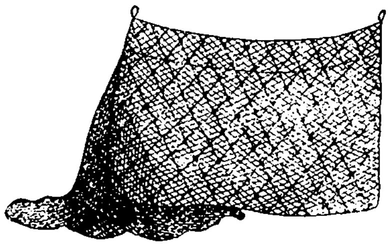
To each hoop nets are attached, not longer than the distance from one hoop to the other, and shaped like a funnel, their wide upper opening being fastened to the hoop and the lower narrower one floating freely in the bag. The fish enter through the mouth of the bag, pass from one net to the other, and cannot get out again.

Fig. 37.



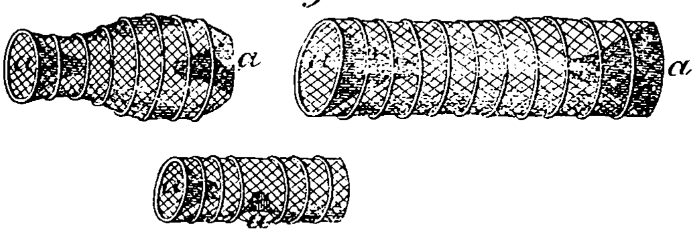
(*e*) The *threefold net.*—This consists of three nets placed one over the other. The two outer nets have very wide meshes (about 15 to 30 centimeters). The inside net is twice as large as the outer ones, and the size of its meshes varies from 5 to 7 centimeters, according to the kind of fish which are to be caught. These nets are used where the banks are covered with a dense growth of shrubs and aquatic plants. They are weighted by pieces of lead attached to the bottom, placed in the water, and the fish are driven towards them, become entangled, and can easily be caught.

Fig. 38.



(*f*) *Fish-pots.*—These are a kind of baskets made of wicker-work, and varying in size, long, round, barrel-shaped, &c. The width of the openings in the wicker-work depends on the size of the fish which are to be caught. These openings, however, must never be so narrow as to prevent the water from flowing through. These fish-pots have one or more funnel-shaped entrances, *a*, which are constructed of willow branches from which the bark has been removed. The wide opening of the funnel is toward the outside and the narrow one toward the inside of the fish-pot. When the fish enters through these funnels, the willow branches give way, but close again after the fish has passed through, so that it cannot escape. For large fish, and especially for eels, these fish-pots must be made very strong, as they use great force in their endeavors to get out.

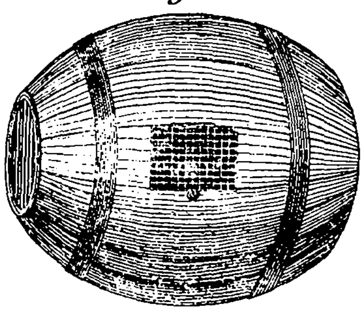
Fig. 39.



(*g*) The *night-line or bottom-line.*—This is a long line, to which are fastened several hundred hooks, attached to horse-hair lines 60 centimeters long, and placed at intervals of 1.75 to 2 meters. To these hooks bait is fastened. It may be of any desired length according to the area of the sheet of water where it is to be used. By means of large stones, weighing 15 to 20 pounds each, it is sunk to the bottom close to the shore, and retained there by these stones and by smaller ones, one of which is fastened to the line between every two hooks. This line is set in the evening and lifted from the water in the morning by means of a strong iron hook.

21. The *fish-kegs* should not be very large, but capable of holding about 5 hectoliters of water, so that, according to the temperature, they can hold from 200 to 400 pounds of fish. The inside must be perfectly smooth, and should not have a bung stopper, however short, so that the fish cannot be injured by any uneven places on the inside. At the top these kegs should have in the center a hole large enough to admit the largest fish. The hole should be covered with a perforated tin lid or with a lid made of wicker-work. On some farms it is the custom, after the fish have been put in the keg, merely to stop up the hole with a large bunch of straw. The kegs are generally of a long shape. Small kegs, flattened at the end, capable of holding about 100 pounds of fish, are more serviceable than round kegs, and are to be specially recommended if fish are to be transported any great distance. In such kegs the fish are not piled up one on the top of the other, but can lie comfortably side by side, Such oval kegs generally measure 87.5 centimeters in length, the same in breadth, and 22 centimeters in height. The bung-hole is very wide, and can be closed with a grate-lid and locked with a padlock. To the sides two rings are generally attached, so that two men can conveniently carry it. But, as these kegs do not afford absolute security for the transportation of tender kinds of fish—as perch-pike, pike, and trout—to any considerable distance, even if a piece of ice is thrown into it or fastened to the bung-hole in such a manner as to allow the water to drip from it into the keg, self-acting fish-wagons have been constructed, in which air is introduced into the water of the kegs by means of a pair of bellows kept in motion by the action of the wheels.

Fig. 40.



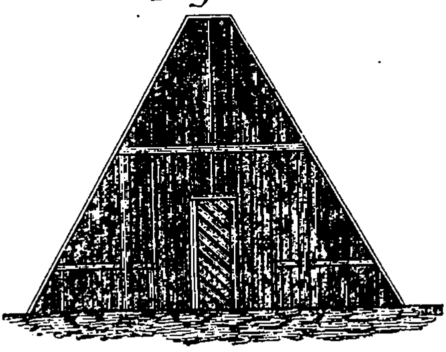
For transporting trout by railroad Mr. Jean Richard, of Lorraine, in 1876 constructed an apparatus which renews the air of the water during transportation in the same manner in which this object is attained in nature by the rushing of mountain streams over rocks and stones. This apparatus consists of a tin box, which is divided in two compartments by a perforated piece of tin. Both compartments are only half filled with water. The trout are placed in one, while in the other there is a sort of a mill-wheel, which is set in motion by clock-work which is wound up. In this manner the water is brought in constant contact with fresh air, and the trout travel by rail under the same conditions as in the mountain streams of their homes.*

VII.—Pond fisheries at Wittingau.

To give an idea of the manner in which pond fisheries are conducted, and of the work connected therewith, I shall describe the fisheries in one of the Wittingau ponds in Bohemia, having an area of 320 hectares, which I witnessed in October, 1877; the practical manner in which these fisheries were conducted impressed me so strongly, that I immediately followed this example and procured all the necessary apparatus for my own fisheries. I have never regretted the expense, for fishing with this apparatus proved exceedingly practical even in small ponds. The fisheries were brought to a close much sooner than formerly, and the fish were treated in a much more humane manner. I prefer to give a description of the fisheries in one of the Wittingau ponds, instead of one of my own ponds, because my largest pond only measured about 50 hectares, while many of my readers doubtless own ponds of much larger extent, and will probably be more interested in the description of the fisheries in a large pond. It is, moreover, easier to adapt the methods followed in a large pond to a small one than to reverse this.

The pond in question, owing to its great size, took a long time to drain, and towards the end of this process it had to be watched by day and night. For sheltering the necessary number of fishermen an exceedingly practical and simple shed had been built on the enormous stone dike. A square is marked off, and at each corner strong posts are driven in the ground. These posts are about 2 meters high, and are at the top connected by strong cross-beams. Along the four sides of this scaffolding long poles (stout hop-poles) are placed close to each other, leaving an opening at the top to let the smoke out. The spaces between the poles are so closely stopped up with reeds that neither wind nor rain can enter. On the inner side of the shed bunks are constructed, by driving a number of short posts into the ground close to each other, which are connected at the top by beams, and on which boards are placed, which are covered with a thick layer of reeds; a blanket serves as a cover, and in this manner a very comfortable bed

Fig. 41.

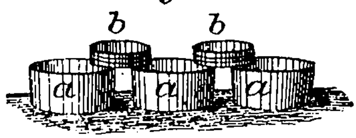


* *Mittheilungen ueber Fischerei-Wesen* (organ of the Bavarian Fishery Association), 1876, No. 5.

is provided. This shed, which has a narrow door in front, and in the center of which an open fire is lighted, can accommodate about 20 men.

Below the dike, next to the fish-pit, a shed had been erected for the officials and the buyers of fish. It was a simple frame building with windows, in one corner a small iron stove, and in the center a table and some chairs. A shed like this one, which can easily be put up and taken down, is erected only near the stock ponds, while there is a fisherman's shed near every pond which has to be watched continuously for one or several days; the size of this shed will depend on the size of the pond, and the number of people which it requires to watch it. At the small ponds where no fishermen's sheds are needed, an immense umbrella is used, which protects the official who keeps the books against wind and rain, a small table and chair being placed underneath. This simple apparatus, which proves an admirable shelter, cannot be too strongly recommended. After this digression we will return to our pond. The entire ground bordering the fish-pit as far as the edge of the sole of the dike, and thence along the scarp up to the crest, is covered thickly with reeds, so that there is a dry walk to the fish-pit, and that the fish which accidentally fall to the ground may not be injured. Along the fish-pit, close to the water, there are placed twenty tubs of the kind described above, filled with pure water. On the tubs in the center, *a a a*, some sorting-vans are placed, *b b*, on the edges of two adjoining tubs. On the dike there are from sixty to seventy carts, each loaded with two kegs filled with water. About fifty fishermen, clad almost entirely in leather, stand ready to engage in the fisheries, commanded by a fishing master and an assistant. The water has been let off so that in the fish-pit it has a depth of about 1 meter.

Fig. 42.

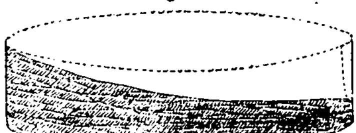


The fisheries commence by some of the fishermen (about twenty) entering the pond, carrying a net about 1 meter broad, and each provided with sticks about 1½ meters long, and ending in a natural two-pronged fork. Every 4 meters a man holds the upper part of the net, the lower part weighted with lead balls resting on the ground.

While the fishermen hold the net in a vertical position they proceed towards the fish-pit, and by beating the water with their sticks drive the fish towards the pit. As soon as this has been reached the sticks are driven into the ground and the top of the net fastened to the prongs, so that the fish-pit is entirely inclosed, and no fish can escape. The length of the net must, of course, correspond to the water area; in the present case it was probably 80 to 100 meters. This driving of the fish is a difficult matter, as the men have to wade in deep mud, and is, especially in large ponds, done in the early morning hours of the day preceding the fisheries. It offers the advantage of fishing within a small area and in deep water. After the fish have been driven into the fish-pit, nine to ten flat-boats, each containing two men, are rowed into the pond. The middle boat contains the fishing master, who directs operations. From these boats the large seine is cast and is drawn towards the shore by ten men, while the boats gradually approach the fish-pit in a semicircle, constantly growing narrower, and whose diameter is the length of the fish-pit along the shore, so that the fish are finally entirely inclosed in the seine. As soon as this is accomplished the fish are taken from the seine. While some men catch the tender perch-pike singly with the hands in sorting-vans held floating on the water, others carry them to the kegs in tubs; other men, armed with purse-nets and dip-nets, catch the carp, occasionally mixed with pike, and carry them to the tubs, from which they are sorted and weighed. As the taking of the fish from the seine is, of course, a much more rapid process than the sorting and weighing, the fish are first put in the outer row of tubs and thence in the middle row, where they are sorted. For sorting the fish are taken from the tubs with purse-nets—if possible direct from the ponds—and placed on the sorting-vans, where fresh water is poured over them several times by a man specially engaged for that purpose, whereupon they are sorted in the tubs to the right and left, whence they are taken to the scales. It is of course understood that in a pond as large as the one in question several persons are engaged in sorting. As long as the fish are in the tubs, water is continually poured over them with the water-dippers, and they are occasionally stirred carefully with the same instruments, so that the same fish are not kept at the bottom all the time, and also for the purpose of continually introducing fresh air into the water.

Close to the scales there is placed a tub of the same size as the sorting-tubs, the interior and sides of which are thickly covered with reeds, over which a piece of linen is spread. These reeds are arranged in such a way as to form in the tub an inclined plane, whose highest point is on the side near the scales. When the fish are quickly taken from the scales they gently slide down into the hands of the persons counting them, and there is very little chance of their being hurt. Two men stand near this tub and count the fish into a large piece of cloth held up by two women, each holding two of the four corners. After 12 fish (or, if they are not very large, 15) have been counted, each woman twists her two corners together and hands the cloth to the next two women, of whom a double row extends all along the scarp of the dike. Thus the fish pass from hand to hand until they reach the keg. Here they are received by two men standing on the wagon. The one twisted end of the cloth is stuck into the opening of the keg, and the other lifted up, so the fish glide slowly into the keg without touching the edges of the hole. As soon as one cloth has been emptied into

Fig 43.



the keg it is returned to the scales the same way it came, so as to have a constant supply of these cloths on hand and not to interrupt the weighing and counting. After the two kegs contained in a wagon have each received 200 to 300 pounds of carp (in cool weather 400 pounds may safely be put in one keg) the wagon drives away and another takes its place, and thus it goes on until the end is reached. The weighing is conducted by the assistant fishing master, who, with a loud voice, calls out every hundred-weight. (Buyers get from 2 to 5 per cent additional fish, to make up for the water remaining in the tub.) The counting into the cloths is likewise done in a loud voice, and the number contained in each cloth is called out very distinctly. Near the fish-pit stands the comptroller, who puts down every hundredweight and the quantity contained in each cloth. Near the wagons stands another comptroller, who notes down the number of fish emptied into the kegs from each cloth, the number of hundred-weights called out, the name of the driver, and the fish-dealer, or the name of the pond to which the fish are taken. In this manner it becomes almost impossible to make a mistake, which at any rate would soon be discovered.

While this work is going on, another squad of the fishermen make another large haul—the first one in this case yielded 50,000 pounds—and the fish which, after the seine fisheries have been brought to a close, still remain in the pond, are gathered with purse-nets and dip-nets.

The meshes of the seines and of the purse-nets are 3 centimeters wide from knot to knot, but are preferable to narrower meshes, because these bring up too much mud, while in the nets with large meshes the fish come out of the pond much cleaner. The only disadvantage is that many small pike stick in the meshes with their gills and perish, but as a general rule their number is such that the loss is amply compensated by the advantages which these nets offer to the carp and other fish.

The small pike are immediately transferred to the carp stock ponds. The perch-pike, which is a very tender fish, should be handled as carefully as possible; they are carried in tubs to the kegs, in which they are put one by one, a limited number only being assigned to each keg. The large pike which have not been sold on the spot are temporarily placed in fish-tanks. The same applies to the tench, some of which, however, are immediately transferred to the carp ponds. Large fish of other less valuable kinds, as well as carp which have suffered injuries, are gathered in a separate tub, and are given to the day laborers assisting in the fisheries, instead of paying them money, most of them preferring this way of being paid. Small fish of inferior kinds are transferred to special tanks and serve as pike food.

The fisheries in the Zablat pond, belonging to the Wittingau farm, began at 6 o'clock in the morning and were finished at noon, the total yield amounting to 69,000 pounds of carp, 1,800 pounds pike, 800 pounds perch-pike, 3,000 small pike, 840 perch, and 540 tench (the latter weighing about 400 pounds).

The carp fisheries in small stock ponds differ from those described above merely by the circumstance that they are often carried on with only one boat and a seine, and by employing fewer tubs and other apparatus and a smaller number of men. As for the rest, the method pursued is exactly the same. The number of persons and the quantity of apparatus needed should, however, not be calculated according to the proportion of the yield expected to the quantity of apparatus, &c., used for a certain given yield, *i. e.*, one should not calculate in the following manner: If for fishing a pond area of 300 hectares, or the taking of 70,000 pounds of fish, I need 20 tubs or 50 fishermen, &c., I will for an expected yield of 10,000 pounds need one-seventh the number of tubs and fishermen. In the latter case, not 3 but 15 tubs will be needed to expedite business, viz., one for the large pike, one for the small pike, two for sorting the tench, one for inferior kinds of fish, one for other fish which are to be sorted, and nine for the carp. Two to three men should be employed in sorting the fish, and two for cleaning them and for renewing the water in the tubs. For the fisheries proper 20 persons will not be too many, and to these should be added a number of women, corresponding to the distance between the fish-pit and the kegs. The number of wagons will be determined by the quantity of fish put in each keg, and by the distance which these wagons have to travel; also by the circumstance whether these wagons can return to the ponds before the fisheries are over and thus take another load, or whether one trip is all they can accomplish. In the latter case, and counting 400 pounds of fish per keg—therefore 800 per wagon—an expected yield of 10,000 pounds would require 13 wagons, or, better still, a few more, as the yield can never be accurately calculated beforehand. If a wagon can make two or three trips, only one-half or one-third the number of wagons is required. The quantity of apparatus and the number of wagons and men needed for one pond can only be determined with any degree of accuracy after fisheries have taken place in it once.

In the raising pond fisheries the weighing process is dispensed with, and no tubs are needed for inferior kinds of fish. The number of tubs will, therefore, be determined by the quantity of fish with which the pond was stocked. Allowing for their being assorted in two or three classes, comparatively few tubs will be needed, and for a small pond two to three will often suffice. It will be well, however, always to have in readiness an extra tub for inferior fish. As regards the weighing, it will be sufficient to weight 100 of each class in two or four divisions, and on this basis to calculate the average weight of the entire class. This weighing will consume but very little time. The same applies to spawning ponds. Care should, however, be taken to have on hand the required dip-nets or other measures for ascertaining the quantity of fry and to have the sorting-vans covered with linen cloth.

VIII.—The Sale of Fish.

Regarding the methods pursued at the carp exchange at Cottbus. province of Brandenburg, Prussia, I quote from a report by Mr. von Treskow-Weissagk:* "As a general rule the fish which are sold are delivered at the nearest railroad station at the expense of the seller. As soon as the fish are weighed they belong to the buyer, who has to bear all further risk. Many pond owners have tanks to which the carp are transferred from the ponds, and whence they are taken by the fish-dealers as they need them. In some places the fish are weighed at the pond, and the buyer places them in the tanks, taking all the risk of loss of weight, while in other places the fish are not weighed until they leave the tank. As this is not done till near Christmas, fish sold on this condition fetch a higher price than those delivered from the ponds in autumn. The fish are conveyed to the cities in fish-tanks resembling boats, and of late years by railroad."

On the pond farm which I formerly managed, the fish were only sold wholesale for cash, and delivered to the buyer at the pond, he furnishing the wagons to take them away. Immediately after the fish had been weighed they became the property of the buyer, he taking all the risks. On the largest pond farm in Bohemia—probably the largest in the world—the fish are (according to Mr. Horak's report) sold only for cash, and delivered to the buyers at the dike; and only in rare cases buyers are allowed to take the fish away by simply paying a portion of the money. The minute the fish leave the scales they become the property of the buyer. If the buyers desire it, wagons are furnished them by the authorities of the pond farm; the expenses, however, are borne by the buyers, who are also held responsible for any expenses incurred in supervising the transportation of the fish. Those fish-dealers who do not immediately carry away the fish which they have bought, but temporarily place them in tanks on the pond farm, must also, as a general rule, pay cash, or at least part in cash. The transportation from the pond to the tanks, and the keeping of the fish in the tanks, is at their risk. From these tanks, which are kept under special supervision, the fish-dealers can take fish at any time and in any desired quantity by simply giving a written order. Dead fish discovered by the persons intrusted with the supervision of these tanks must be shown to the authorities of the pond farm; whereupon they are dried and kept for the purpose of showing them to the fish-dealer whenever a suitable opportunity offers. As soon as this has been done their heads are cut off, to prevent any possible abuse.

IX.—The Transportation of Fish.

Fish are either transported from one pond to the other, or to winter ponds and tanks, or to some distance, if they have been sold. In the

* *Deutsche Fischerei-Zeitung*, 1878, p. 195.

first case, the conditions being the same (as to the size of the keg, the temperature, &c.), more fish can be put in a keg than in the latter case.

In kegs filled with water.—The kegs intended for transporting fish should be carefully examined, to see whether they have any rough places or holes where the water might flow out, and should undergo a thorough cleaning. New kegs should be filled with water and allowed to stand for some time before they are used; and fish should not be put in them until the smell of the wood has entirely left them, as it is apt to stupefy the fish. For filling the kegs, pond, river, or brook water is used; they are filled only one-half, whereupon the fish (carp) are put in carefully one by one, so as to avoid their rubbing against the edges of the hole. If the fish are emptied into the kegs from a cloth, they should also be allowed to glide in one by one. If pike are to be transported, it will be well to put them in the keg singly, and tail foremost, so as not to run the risk of hurting their tender snout by bumping against the sides of the keg. After the keg has received its quota of fish, an empty space of about 10 centimeters should remain between the bunghole and the water, so as to give a moderate motion to the water, which is necessary, as the gills of the carp when in the keg are apt to be closed up by a sticky slime, in consequence of which they fall into a death-like slumber, from which they must be roused. Whenever there is a stoppage on the journey, the kegs should be shaken, which will also furnish fresh air to the water. The water may also occasionally be stirred carefully with a stick. The water in the keg should always be kept at the same height. The same applies to the transportation of tench, crucians, and eels. If fish with prickly fins, such as perch-pike, perch, &c., are to be transported, the keg must be entirely filled with water to prevent the fish from hurting each other when thrown about by the rocking motion of the water. Whenever an opportunity offers, water must be put into the keg during the journey. After the keg has received its quota of fish, the bung-hole is closed with a wire grate, or a perforated tin lid, or even with a lid made of wicker-work. Occasionally the opening is simply stopped up with a bunch of straw. This latter method, however, cannot be recommended, as, in order to stick firmly, the bunch of straw must be pushed into the keg to the depth of several centimeters, so that the fish are easily injured, especially in their scales and eyes, by pushing against the sharp points of the straw. A wagon may hold two to three kegs, each containing 5 or 6 hectoliters of water. The kegs are generally placed on the wagon lengthwise; for long distances, however, this position is not favorable, as the waves (caused by the motion of the wagon) will move in the direction in which the wagon goes, and will, therefore, hurl the fish against the bottom of the keg, so that, if the journey is long, or if the wagon is driven very rapidly, the fish may be killed. Slow driving should, therefore, be the rule, and the kegs should rest on a thick bed of straw to avoid the rocking motion of the water as much as possible.

Wherever it is practicable the kegs should be laid on the wagon crosswise; and the waves, also following the motion of the wagon, will generally move in a circle along the sides of the keg. The fish which follow this motion do, therefore, not come in such violent contact with the sides of the keg as to be hurt. This manner of placing the kegs should, therefore, be adopted in all cases where fish are to be transported a long distance, but may also be recommended for short journeys. In transporting carp and tench short distances, *e. g.*, from one pond to the other, on cool spring or autumn days, the following quantity of fish may be put in a keg:

Age.	Holding 1 hectoliter.	Holding 5 hectoliters.
Fry	400 to 500	2,000 to 2,500
Small two years' fish	100	500
Medium-sized two years' fish	80	400
Large two years' fish	50	250
Three years' fish	45	220
Four years' fish	25	120

On warm days the number should be smaller. In transporting pike, perch-pike, and trout, one-fourth less should be counted.

If fish are to be transported several days' journeys, they should be prepared for this transportation, *i. e.*, they should not be taken direct from the pond, when they are generally covered with mud, but be placed in tanks containing pure water for several days, so that their gills may be thoroughly cleaned from any mud which may adhere to them. During that time they should not receive any food, so that they can be placed in the kegs with an empty stomach. The rocking motion will then not cause them to throw up and pollute the water, which in that condition is apt to paste the gills together. Prepared in this manner, and if the kegs are not overcrowded, even tender fish can be transported safely a considerable distance. For long journeys a keg holding 5 hectoliters of water should never contain more than 100 pounds of fish, and only in very cool weather 200 pounds of carp, while of tender fish, such as perch-pike, trout, pike, &c., 70 pounds is the utmost limit. Different kinds of fish, especially fish of prey and other fish, should never be transported in one and the same keg.

During long journeys the keg should be refilled with fresh water at least every eight hours. Spring or well water will be the best for this purpose. If it is possible, cool days should be selected for transporting fish any considerable distance; the cooler the weather the better for the fish. If the transportation occupies several days, the fish must be taken out of the kegs during the night and placed in tanks, so that they may enjoy some rest and be prepared for the fatigue of the following day. If the fish can be transported by water in perforated boxes attached to rafts or boats, this is, of course, the safest method. In that case a large number of fish may be put in one box. In transporting fish during the warm season, it may be recommended to throw a piece of ice into the keg or lay it on the lid of the bung-hole. Kegs have been constructed where the ice is kept in a separate box attached to the bottom of the keg. For long distances those means of transportation are the most suitable where a self-acting apparatus introduces air into the water. If the fish have been prepared for the journey in the manner described above, if the kegs are not crowded too much, and if they are placed on the wagon crosswise, even very tender fish can be transported safely several days' journey. The kegs should not be more than 1 meter long, and if possible be obtuse at the ends, so that the fish can lie side by side and not one on the top of the other.

Without water.—Tscheiner teaches different methods of sending carp dry, which should be mentioned here, as there may be cases where this method of transportation will be more advantageous than that in kegs, for instance, where the market is near, or if there is a lack of kegs. Tscheiner says:* "If the carp are to be transported dry, it is above everything else necessary to clean them well from all mud, which is best done in some small shallow pond. After the carp have been cleaned a cart is brought which has strong boards on all four sides, and a thick layer of straw on the bottom. Hay kills the fish. To the front part of the cart plaits of straw should be attached, but not too firmly, so the fish can get enough air. After the cart has been prepared, a number of carp are taken up with a purse-net and placed in the cart in the following manner: The first carp is put in the straw, back downward, close to the straw plait, so that its head rests on it. The head and tail are kept in position by fresh, moist moss, and a few stalks of straw made tough by water are pulled from the bottom of the cart and laid crosswise over the fish. Another nest is made in the straw, in which the second carp is laid close to the first; moss is placed between the fish, and stalks of straw laid over them. In this way the row is continued to the end. The second row is commenced by placing the head of the first fish between the tails of the two last fish of the first row. Care should be taken that the fish in the second row are not hurt by the movements of the tails of those in the first row. This process is continued until the bottom of the cart is completely covered. As soon as a cart has received its load it should start immediately, prior to which, however, the fish must be covered with a thin layer of straw and a wet cloth. This must not delay the starting of the cart, because rest is injurious to the fish when packed in this manner, while motion is very beneficial to them. If the load of the cart is to be increased by one or two rows, the carp must be placed in another way. They are laid on the stomach, because when placed on the back the weight of the upper rows would press too hard on the stomach of the lower ones, while when laid on the stomach the hard back resists the pressure which is brought to bear upon it. As the back of the carp is

* Tscheiner, *Der wohlerfahrene Fischmeister*, 1821.

raised, the fish of the upper rows are placed in such a manner that every fish rests against the front part of the backs of two carp of the lower row. No more than three rows should ever be placed in a cart, and a thick layer of straw should be put between every two rows. For drawing these carts horses are better than donkeys or mules, because they will accomplish the journey in the shortest possible time. South wind, which is injurious to fish when transported in this manner, should be carefully avoided.

"If the place of destination can be reached in six or seven hours, the journey can be continued without interruption; but if the distance is greater, a halt should be made every evening in some place where there is pure river or spring water. The cart is driven to the water, the back straw plait is loosened, the horses are unhitched, and the fish are placed in the water, which should not be deeper than from 9 to 12 centimeters. Through the rapid motion the carp are roused from their torpor, and as soon as they feel the water, they endeavor to get into their natural position. If some of them remain lying on the side, one should blow into their gill openings, place them on the edge of the water, and hold them for a few moments in their natural position. After all the carp which compose the load have somewhat recuperated, it will be advisable to place them, if possible, in a second tank some time during the night. This tank should be at least 25 to 37 centimeters deep, and be filled with pure water. The next morning the fish are packed in the wagon as on the day previous, and thus the journey is continued, until the fish arrive at their destination. Fish may also be transported in baskets, whose wicker-work is sufficiently wide to let the air through, and which are placed on mules, donkeys, or horses. In such baskets the carp are generally placed on the stomach. For this purpose baskets with compartments will be the most suitable, in which the fish can be transported safely, as each compartment receives only one layer of fish. If the fish are to be sent to any considerable distance in these baskets, they should be packed in the same manner as described above."

Tscheiner thinks that this is the safest method of transporting carp. If carp are to be sent a distance of only 14 to 22 kilometers, they may simply be placed in a cart well padded with straw, and a thick layer of straw, well fastened with strings, be put on the top of them. Upon arrival at their destination, the carp must not be immediately placed in deep water, but they should be placed in water where they can be watched until they have sufficient strength to swim about in the pond.

The above are the methods of transporting a large number of fish. Singly carp are transported in the following manner: The fish are laid on the back upon a thick layer of clean and fresh moss, which is moistened from time to time. A small piece of apple or moistened bread is occasionally put in the gills of the carp. The fish must lie immovable, and have its mouth free. Packed in this manner the fish is put in a hand-basket. After eight or ten hours it is taken out, the piece of apple is taken from the gills, and fresh air is blown into them. After this has been done, the fish is put in its natural position into water, which is 10 to 20 centimeters deep, if possible, where the water is running, holding it with the hand all the time. If the fish does not move, air must be blown into its gills once more. This process is repeated every day until the destination is reached. All other kinds of fish, with the exception of eels and tench are transported without any water. According to Von Ehrenkreuz,* carp can be transported alive any day in the year, if a small piece of bread moistened with vinegar or brandy is put in its mouth and renewed from time to time. The fish are enveloped in straw and sewed up in a piece of linen. In winter the fish are packed loosely in snow, when they get into a sort of torpor, from which they revive as soon as they are carefully put in water. During the transportation they should not be left in a warm place for a single moment. Pike may also be transported in this manner.

X.—The Keeping of Fish.

In tanks or small ponds.—If at the autumn fisheries all the fish are not immediately sold at the dike they should be placed in small ponds to be kept till they can be sold with profit. Here they are kept both winter and summer, to be taken out as demand arises. There should be a greater or less number of these ponds according to the extent of the pond farm, the number of fish, and the number of different kinds. These ponds should be located as near the center of the pond farm as possible, so as to make the transportation from the large ponds less expensive and difficult. Where large quantities of fish have to be kept, the ponds, or tanks, as they are sometimes called, should be 10 meters long, 10 broad, and 3 deep. The depth of water, however, should be only 2 meters. It is advisable to line the sides with brick-work and cover it with a coating of cement. This becomes absolutely necessary if the soil is loose. If this is not done, the sides should be made as smooth and firm as possible, so that the fish cannot hurt themselves by pushing against any projecting points, such as stones, roots, &c. The bottom of carp tanks should be covered with clay or loam, which must be renewed every year; while the bottom of tanks intended for pike, perch, and trout should be covered with gravel, and that of perch-pike tanks with sand. The sides of the tank should slope gently, so that during winter there is no danger that the ice may injure the fish. The bottom of the tank must slope a little towards the outflow pipes so that the mud may be carried that way; and the pipe must be lower than the bottom, so that the tank can be thoroughly cleaned of mud and laid dry. The pipes should have grates on the inside of the tank, double grates placed at an angle being the most suitable. In tanks where fish of prey are kept, these grates

* Von Ehrenkreuz, *Angelfischerei*, 1873, p. 137.

should be very narrow, so that the small fish which serve as their food cannot escape. A few steps should lead from the edge down to the water. Tanks having the dimensions given above can hold 20,000 to 25,000 pounds of carp during winter, if there is a strong current of water; while in summer, if the current is weak, they will only hold half that quantity. As every kind of fish should have a separate tank, a number of these will be needed; they should all be in a row separated by wagon-roads about 3 meters broad. On very large pond farms it may be necessary to have several rows of tanks. The water for these tanks had best be supplied from ponds on higher ground. Such water is in all cases preferable to river or brook water, because it has a more even temperature, and during the thaws of spring does not carry any snow water into the tanks. Spring water is still better than pond water. A separate ditch should, if possible, lead from the main ditch to every tank. To keep the water at an even height, the influx and outflow should be steady. For this purpose it will be advantageous to have on one side of the tanks an influx and outflow ditch side by side, so that each tank may be supplied with fresh water and drained whenever necessary.

The more tender kinds of fish should be in the tanks which the water enters first; the order in which the fish occupy the tanks should, therefore, be as follows: Perch-pike first, followed by pike, perch, carp, and tench. Pike must be separated according to their size, so that the larger ones do not devour the smaller ones. When fish of prey are placed in tanks the inferior fish which serve as their food should be put in at the same time. Eels are kept in special boxes placed in one of the larger ponds. These boxes should be well secured, so the eels cannot escape. Horak recommends putting all the carp from one and the same pond in special tanks, because fish from different ponds, from some unexplained cause, will not be able to stand the winter weather equally well. Thus carp from one pond can easily be kept till after Easter, while those from another pond must be sold at Christmas. If fish from different ponds are mixed in one and the same tank, they must be constantly sorted, which is difficult, expensive, dangerous, and absolutely impossible if the pond is covered with ice.* As the contents of these tanks are exceedingly valuable they should be inclosed by walls or fences, and a watchman should dwell close by, aided by a good watch-dog. On a large pond farm, *i. e.*, where there are a great many tanks in which fish are kept for different fish-dealers, it is absolutely necessary that a special superintendent should be appointed who supervises the placing of the fish in the tanks, and from these, when needed, into the kegs, and keeps an accurate account. Where the quantity of fish which are to be kept is not very large it is best to have more small than large tanks. The carp can then be placed in one or several large tanks, while pike, perch-

* Horak, *Teichwirthschaft*, 1869.

pike, trout, and all those fish of which only a small number is kept are put in small tanks.

If during severe winter weather the ice in the tanks gets very thick, it must be removed so that the fish cannot hurt themselves by knocking against it. On small pond farms which have only a few small tanks, it will be well to prevent entirely the formation of ice by covering them in very severe cold weather with poles, over which is spread a thick layer of straw; on days when there is no frost this covering is taken off and again put on in the evening. If snow falls, it must be removed every day, so that the air has free access to the tank at all times. In very cold weather water should be poured into the tanks from time to time, especially when the influx and outflow are not regular.

In fish-houses.—Von Reider* gives the following directions for erecting fish-houses over brooks and ponds, which in medium-sized and small pond farms may prove useful: "Fish-houses are the most suitable receptacles for fish. They consist of large and small buildings according to the extent of the fisheries which they are to serve. They are placed over brooks or ponds which have a strong steady current. All kinds of receptacles for fish are benefited by being placed in swift-flowing water, or in ponds where many springs keep the water always at an even depth. Fish-houses may be of different size and shape, but they should never have more than one story. Their size will depend principally on the internal arrangements. The walls may be entirely of stone, or better still of framework filled in with clay. The walls of many fish-houses are composed of simple boards. Stone walls, of course, afford greater security; but boards keep the house warmer. The low roof is covered with reeds or straw, but in such a manner as to admit the air, which is very beneficial for the fish during their long imprisonment. According to the size of the house and the quantity of water, it contains either one or several fish-tanks. The houses should, if possible, rest on pillars or posts in the water, so that air and water may enter the different tanks simultaneously, at least on three sides. The separations of the different tanks or compartments, which have to be in the water, are made either of laths or boards, through which holes have been bored at certain intervals. Laths are preferable for this purpose, and may be intertwined with willow branches. Nets may also be employed for this purpose (I, for my part, would not recommend these, as they soon rot when left in the water for any length of time). At the bottom these tanks must be fastened to the depth of about 60 centimeters, between two beams. To secure them still more they are inclosed by strong poles placed at intervals of 60 centimeters, which rise 60 to 90 centimeters above the surface of the water, so that ice and drift-wood may not do damage to the inclosure of laths. It is very advantageous if the water can fall into the tanks from some height. The water in the different compartments should always be deep enough to prevent its freezing in winter.

* Von Reider, *Das Ganze der Fischerei*, 1825.

The size of the compartments depends entirely on the purpose which they are to serve. It may, under certain circumstances, be advisable to make the separations movable. It is absolutely necessary that light and air should have free access to all the compartments from above. In constructing these compartments care should be taken to have them arranged in such a manner as to give to each kind of fish the water and soil which their nature requires. Thus, in the first compartment, where the water enters, are placed trout, barbel, and *Thymallus;* in the second, pike and perch; and in the others, carp, whitefish, tench, &c. The size of the compartments should be regulated by the quantity of the different kinds of fish. Pike, barbel, or trout, *e. g.*, will never be kept in as great quantities as carp. Stone should be put in those compartments where trout or barbel are kept, as these fish, like the crawfish, love to hide under stones. The soil is left as nature has provided it. It is better to have several small compartments than a few large ones. It is immaterial what kind of wood is used for these compartments as long as it is thoroughly dry; generally, however, pine wood is used. Fish should not be put in the compartments until the water has been allowed to flow through them for two to four weeks, so as to take away the odor of the fresh wood.

"No general rules can be laid down as to the number of fish to be put in one compartment, and but too frequently it will be necessary to crowd some of the compartments. In winter, or whenever the weather is cool, and in deep and constantly fresh water, no evil results will follow, provided this crowding does not extend over too great a period of time. The compartments should be inspected every day, and dead fish, which will float on the water, should be removed as soon as possible. The most important point is cleanliness. If the water falls into the compartments from above, and a lively current goes through all of them, no further cleaning need be done; but if this is not the case fresh water should be allowed to flow into the compartments from time to time. In constructing a fish-house care should be taken that the water is clean, and that it does not come from places where there are breweries, tan-pits, rettings, &c. If the fish or pond master lives in the fish-house, his dwelling should be below the outflow. The different fish in the various compartments should have separate tanks; eels, for instance are kept most safely in strong wooden boxes, because otherwise they are apt to burrow in the bottom, and in this way make their escape from the fish-house. In fish-houses fish must be fed, and a sufficient supply of food suitable for each kind should be kept on hand."

From the above it will be easy for a pond cultivator to select the method of keeping fish best adapted to his circumstances. Brief mention should be made of the superintendent's dwelling in the fish-house, which should have a roomy shed and an airy garret for keeping the fishing apparatus and for drying the nets.

The work at the tanks consists in placing the fish in them, in superintending them, and in taking fish out of them. The superintendent should be a particularly faithful and reliable man, who should, at least for the work of stocking the tanks and taking out of the fish, have some assistants. The fish ought not to be thrown from the keg directly into the water, but should be allowed to slide slowly into a van held close to the opening of the keg. From this van the fish are carefully put into the water one by one and counted, the person who attends to this work standing on the steps leading down to the water. On large pond farms, like that of Wittingau, the fish are first put in tubs, and from these they slide down into the tank on a trough, which is well lined with straw. If any of the fish are injured or languid they must be placed in separate tanks, where they are carefully watched, and should be sold as soon as possible. As soon as a wagon-load of fish has been put in the tanks, the superintendent gives the driver a receipt and gets one from him. Orders for taking fish from the tanks are given the superintendent a day beforehand by the manager of the farm, who receives the orders from the fish-dealers.

When fish are to be taken from the tanks the water is let off, as much as is necessary to take the desired number of fish with a purse-net. In spring, summer, and autumn, this work is not very difficult; but in winter, when the tanks are frozen, it is much harder. Before the water is let off, the ice over the deepest place, where the fish generally congregate, should be broken, or, better still, sawed and removed. The fish are then taken out and put in a tub which holds about 200 pounds of carp. From this tub they are counted into large pieces of cloth (as described in a previous chapter) and put in the kegs. The superintendent meanwhile puts down the name of the driver and the number of fish; and after these have been delivered to the fish-dealer, he receives from the driver a receipt signed by the dealer. At the tanks a portable scale should be kept, which is specially needed if the fish have not already been sold at the autumn fisheries and are kept in the tanks at the risk of the buyers, but are sold in the course of the year, whenever it can be done with some profit.

In small fish-tanks.—In order not to disturb large tanks on account of a few fish which the pond owner may want for his table, every pond farm should have a number of small fish-tanks for keeping a limited number of fish for the purpose indicated above. Such tanks are generally constructed in brooks and rivers which never freeze entirely, or in ponds. They may be like the tanks in the fish-houses, only on a smaller scale; frequently, however, a perforated box will answer the purpose. This box, which should be kept locked, is attached to two posts by ropes or chains, so that it can be let down to the bottom and drawn up again. Wherever the opportunity offers, such small fish-tanks should be constructed in springs. I had a small tank in a spring in which the fish were kept all the year round. It was constructed close by the outflow of a strong spring, and consisted of three pits let into the ground to the depth of 1 meter, lined with bricks and cement, and measuring 1 meter in length and breadth. The water was never deeper than 60 centimeters. It entered the tanks at a distance of about 60 centimeters from the spring, and flowed through openings measuring 2 centimeters in breadth, and made at the height of 60 centimeters, from one tank into the other. The whole was covered with a little shed, about 60 centimeters high. At the front there were three doors, which could be locked. In this tank I could easily keep (in one compartment) 60 carp, weighing 2 to 3 pounds apiece. Pike I never kept in it for any length of time, because it was difficult to supply them with the necessary food. Similar tanks may also be constructed near wells with running water.

Jokisch gives the following directions for keeping fish alive for several days: "If there is no running water near at hand, and if it is desirable to keep fish for several days, as may be the case in cities or in small households, art must supply what nature has not furnished. Three vessels, all of different size, are needed. The largest is put underneath and serves to receive the water. Two sticks of wood are laid across it, and on these is placed the vessel containing the fish. On the top is placed the third vessel filled with water. A hole is bored in the upper and middle vessel and a quill is inserted, through which the water runs and is constantly kept in motion. This apparatus, of course, needs watching. Fish may in this way be kept for from eight to fourteen days. If the vessels are large, fresh water need not be added till after 6 or 8 hours."*

B. von Ehrenkreuz says: † "To keep fish when out of the water alive for several days, all that is necessary is to intoxicate them. In winter it is sufficient to put in their mouth a piece of bread soaked in brandy and cover them with snow, or if that cannot be obtained, with straw. In summer beer or wine may be substituted for the brandy—the beer should not be sour—and the fish should be wrapped in fresh grass or moss which should from time to time be moistened with the same liquor as the piece of bread. In this manner carp, tench, pike, and other large fish can be kept alive from twelve to eighteen days. When taken from their wrapping of moss or straw, the fish appear to be in a torpor, but they are soon revived by taking the piece of bread out of their mouth and wrapping them in a piece of linen which is gradually moistened with water. They are finally put in a vessel filled with fresh water, where they soon swim about in a lively style. Eels need be covered only with moist earth or grass. With some care and by keeping up a moderate degree of moisture they can be kept for a month.

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* Jokisch, *Handbuch der Fischerei*, 1804.

† B. von Ehrenkreuz, *Angelfischerei*, p. 209.

XI.—OTHER OBJECTS OF POND CULTURE.

Other objects of pond culture are (1) willows, (2) grass, (3) reeds, (4) mud, (5) different kinds of grain or plants.

(1) *Willows.*—To plant the dikes with willows is the best way for rendering them safe for a long time. Willows, moreover, yield a considerable income from the sale of branches for making baskets. No pond cultivator, therefore, should neglect to plant willows on his dikes. The planting by means of wicker-work is preferable to that by shoots stuck in the ground, as the former affords protection against breaks in the dike even before it has fully taken root, while the shoots will be able to resist the water only after three or four years, when the dike is permeated in all directions by the roots. The planting of willows has already been spoken of in the chapter on the construction of the dike. We shall, therefore, confine ourselves to giving a few hints on the subject, following in this a treatise by Mr. Ernst Heger,* who has given much attention to the matter. Willows can be planted in autumn, during winter, or early in spring. The willow plantation must be kept clean of weeds, especially of *Conalvus sepium*, which may prove very injurious. The *Untica dioica*, the different varieties of *Spiræa*, and the *Rubus cæsius* must be carefully weeded out at the time of blooming. After the willows have been cut in autumn the weeds and grass can be hoed, turned, and left for manure. The weeds and grass should be cut once or twice with a sickle during summer. It should be left to the discretion of the pond cultivator whether he wants to harvest the hay or whether in some places he will let it decay and serve as a fertilizer. The willow plantation may also be injured by fungi and by various insects, especially *Cossus ligniperda*, *Fidonia progenunaria*, and *Liparis salicis*, which should be removed as soon as they show themselves.

Willows which have not been disturbed or injured in their growth can be cut in the first year. The shoots are cut at half their height. From the second and third year a willow plantation will, under favorable conditions, yield a rich harvest, which reaches its normal height in the fourth year. It remains the same till the eighth or ninth year, when it begins to decline. To prevent this the trees are cut off close to the ground every seven or eight years, and in this manner a plantation may be made to yield steady harvests for about thirty-five years. Trees which have died must immediately be replaced by others. The simplest way is to bend over a branch from the nearest tree and stick it in the ground, severing it from its parent stem when it has thoroughly taken root. For cutting the branches a sickle-shaped knife with a hand-strap is used. In doing this a man stands close to the tree, takes all the branches springing from one head under his left arm, and severs them from the tree by one rapid cut made in an upward direction. Among the serviceable branches, every willow tree has some sickly or crippled

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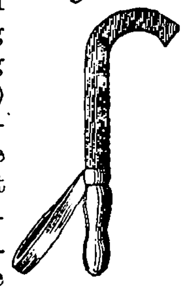
* *Wiener Landwirthschaftliche Zeitung*, 1876, No. 10.

ones. The laborers frequently overlook these in cutting. This should not be allowed, however, for these crippled branches will be the first to grow in the following year, and will hinder the growth of the healthy branches. The entire work connected with the willow harvest had best be done by contract. The amount paid for cutting, binding, taking to the wagons, and loading of 100 bundles of willow branches—the bundle measuring about 1 meter in circumference at the lower (thicker) end—is generally 8 to 9 marks [$2 to $2.25]. One laborer can cut thirty to sixty bundles per day. The wages are still better if three men work together, and let a woman do the binding, for which they pay her 2 pfennige (one-half cent) per bundle. The cutting of the willows can only be done, without injuring the stems, in the period between the fall of the leaves and their sprouting in spring. If basket-makers have rented a willow plantation, they like to do the cutting at the time when the sap rises in the trees, so that the branches can be peeled immediately. If cutting, however, is repeatedly done at that period, the plantation will soon be ruined. After the branches have been cut they are either sold immediately, with the bark on, or peeled later and sold as white willow branches."

Fig. 44.



One hectare of willows yields per year about 800 bundles of willow branches (with the bark on), viz.:

Number bundles.	Quality.	Per 100.	Value. Marks.	Value. Dollars.
		Marks.		
500	First	50	250	62 50
200	Second	30	60	15 00
100	Third	15	15	3 75
Total			325	81 25
Deduct expense of harvesting 800 bundles, at 8 marks per 100			64	16 00
Net profit			261	65 25

If the willow branches are sold peeled, the 800 bundles can be sold for 596 marks [$149]. Besides the expenses for harvesting, the following will be the running expenses of a willow plantation per year and per hectare: 500 shoots at 2 marks per 100 = 10 marks [$2.50]; cut down 300 old trees at 3.32 marks per 100 = 10 marks [$2.50]; weeding, &c., 5 marks ($1.25]; total, 25 marks [$6.25]; leaving a net profit of 236 marks [$59] per hectare.

The capital invested in starting a willow plantation need not be taken into account by the pond cultivator, as, strictly speaking, the willows are not planted for the direct purpose of yielding income, but for strengthening the dike, for which they are absolutely needed. The capital invested should, therefore, be accounted for under the head of dike expenses. The entire expense of starting a willow plantation, however, will be 1,340 marks per hectare [$335], the interest on which sum at 5 per cent would be 67 marks [$16.75]. To this should be added about 10 marks [$2.50] per hectare for taxes and various incidental expenses; so that a total of 77 marks [$19.25] would have to be subtracted from the net profit given above if the willow plantation was to be considered independent of the dikes. It is difficult to say to which variety of willows the preference should be given, as this will mostly depend on local circumstances, the nature of the soil, &c. Basket-makers want willow branches which are as long and thin as possible, exceedingly pliable, and which, when peeled, have white wood with a natural gloss. Most of these qualifications are found combined in the *Salix vitellina*. Next to it comes the *Salix aurata*, which has comparatively short branches, which, however, are exceedingly fine and suitable for fancy baskets, and finally the *Salix purpurea* and a variety resembling the *Salix viminalis*. The branches of the *Salix purpurea* and its varieties are particularly distinguished by their slender growth. *Salix pentandra* and *Salix viminalis* have also long branches, but these are also very thick and are not suitable for peeling. They are all the better for coarse wicker-work in which the bark is left on the branches. The pond cultivator has it in his power by suitable treatment to cause the branches to grow longer at the expense of the thickness. If planted very close together even the otherwise useless *Salix fragilis* does not have any side branches, but produces long and slender branches like the *Salix viminalis* and the *Salix pentandra*, while these latter, if planted close, will furnish also some material which can be used for fine work. Recently the *Salix caspica* has been favorably mentioned. It has a bark of a dark violet color and a very white wood, and it is said that in one year it grows very high and slender, and in the third year has many branches measuring 2 to 2½ meters in length, and a very large number measuring 1 to 2 meters. It requires a sandy loam soil which all summer through contains some moisture.

The cuttings, measuring about 30 centimeters in length, are planted in autumn, or early in spring, by sticking them into the ground in an oblique direction, so that about two-thirds of their entire length is under the ground and one-third above. They are planted at intervals of one-half or 1 meter, according as one desires thick or thin branches. At the latest, every spring all the branches which have grown during the year must be cut 3 to 5 centimeters from the stem. The thin branches may in part be peeled, and in part be used with the bark for fine wicker-work, while the thick ones, with the bark on, can be used for coarse baskets, &c. We would advise every pond cultivator to sell only his willow branches with the bark on, as he will be busily engaged with his ponds at the very time when the branches should be peeled. We shall, therefore, not give any details as to the methods of peeling. Any one interested in the subject will do well to peruse a pamphlet by

Mr. Krahe, in Prummern, near Aix-la-Chapelle, Prussia. This little work gives Mr. Krahe's experiences with a willow plantation of an area of 375 hectares in the valley of the river Roer-Wurm, gathered during a period of ten years. The plantations of the village of Wurm yielded a net profit, per one-quarter hectare, in 1870, of 79 marks [$19.75]; 1871, 82 marks [$20.50]; 1872, 100 marks [$25]; 1873, 123 marks [$30.75]; 1874, 152 marks [$38]; 1875, 227 marks [$56.75]; and 1876, 246 marks [$61.50].* The best way for the pond-cultivator will be to manage his willow plantation himself and not rent it out to any one, as it is not pleasant to have strange persons, *e. g.*, the laborers of the renter, about the pond at all times. Not only the dikes should be planted with willows, but also the banks and any waste places near the pond. The disadvantage of such plantations is, of course, that they become hiding-places for various animals which may injure the fish. Local circumstances will have to determine whether such plantations should be abandoned on that account.

(2) *Grass.*—The grass along the edges of the pond will in dry years, or when the pond is not filled with water to its utmost capacity, yield quite a little income to the pond cultivator. To cut the grass along the edges as long as these are covered with water is injurious to fish-culture, as the edges, when overgrown with grass, furnish the best pasture-grounds for the fish. After the fisheries are over the entire quantity of grass growing on the edges may be used for feeding cattle. It is very injurious to drain a pond on account of the hay harvest, which takes place at the very time when the edges yield the most food for the fish; and if it is desired to harvest the grass, it will be better not to have the pond very full of water and to make the number of fish proportionate to this quantity. Winter ponds which have lain dry during summer, or have been filled moderately with water for the purpose of being used as raising ponds, often yield a very considerable quantity of grass, which may be harvested without detriment to fish-culture. Any intelligent pond cultivator will find some way of harmonizing the interests of grass culture and fish-culture.

(3) *Reeds.*—Reeds may yield some profit, being sold for building material or for straw.

(4) *Mud.*—The mud of a pond forms a valuable fertilizer, which, if not used on the fields belonging to a pond farm, will always find a ready sale among the intelligent farmers of the neighborhood, who know its value, and who will at any rate remove it without charge. The best mud for fertilizing purposes is furnished by those ponds into which flows the rain-water from the surrounding fields, as it carries with it a great deal of animal and vegetable matter. The same may be said of ponds in which or along whose edges cattle are in the habit of grazing. The mud from ponds surrounded by forests or containing many reeds frequently contains too much acidity to use it as a fertilizer, and it should

* *Centralblatt für den deutschen Holzhandel*, 1877, No. 32.

simply be removed from the ponds from time to time. Before using the mud from ponds as a fertilizer the pond cultivator should have it carefully analyzed.

(5) *Different kinds of grain or plants.*—To sow the ponds at certain periods with different kinds of grain or other useful plants does not only add to the income of the pond cultivator, but it will also have a very beneficial effect on the growth of the fish, and can, therefore, not be recommended too strongly.

XII.—The Supervision of the Ponds.

A careful and constant supervision should be exercised over the ponds, as the results of pond culture will, to a great extent, depend thereon. The supervision of the ponds should be intrusted to a faithful, reliable, energetic, and thoroughly experienced man, who generally takes the title of "fish master" or "pond master." According to the extent of the pond farm he should have a number, more or less large, of assistants, called "superintendents of ponds," to each of whom a certain pond area is assigned, the pond master alone having the general supervision. Even if he does not take part in the manual labor connected with a pond farm, he should be everywhere and give his directions; nothing should escape his attention, and he should regulate and strictly supervise the work of the pond superintendents, who must make regular reports to him, and receive their orders from him. The pond master, as well as the pond superintendents, should frequently walk around the ponds; if their extent is not too great this should be done every day. In these daily rounds he must give his attention to everything which may be helpful or hurtful to pond culture, more especially to the height of the water, the condition of the dikes, the influx and outflow, and the grates; he should also ascertain whether traps have been set in places where this would be likely. Early in spring the dikes and other constructions should undergo a careful examination before the ponds are stocked with fish. If it is found that the dike leaks in any place, the necessary repairs must be made at once. The grates must also be examined, and, if necessary, repaired. They should at all times be kept free from grass, wood, and anything which may stop them up. When the thaws set in, in spring, even greater vigilance should be exercised so as to prevent any possible danger by inundations. For this purpose the ditches carrying off the superfluous water should always be kept open, and be cleaned at once if there is any indication of their becoming stopped up. Those ponds which during winter have been over-full of water should in spring be reduced to their normal depth; and the spawning ponds and raising ponds which have lain dry, after they have been examined carefully, and any pike which may have remained in them have been removed, should be filled with water. In those ponds which have been laid dry, and which are to be sowed, the ditches must be repaired and cleaned, and the small ditches be put in order through which the water is to be let out from the reeds and deep places.

Ponds which have been constructed only the year before are likewise filled at this time (in spring), but should not be stocked immediately, but be watched for some time, to see whether they have been constructed in a thorough manner, so that any defects in the dikes, tap-houses, &c., may be remedied during the summer. In April the fisheries commence in the winter ponds and in those spawning ponds which have remained full of water during winter; the stocking of the spawning and raising ponds should also commence about this time. The pond master has to superintend the fisheries and the stocking of the ponds, to see to it that everything is done in order, and especially to watch the laborers that they treat the fish carefully and do not throw or press them too hard. He should appoint reliable persons to transport the fish to the spawning and raising ponds, and remind them not to throw the fish direct from the keg into the water, but to receive them into vans at the bung-hole and thence carefully remove them and put them in the water. He should also caution the men not to leave the ponds until they have convinced themselves that the fish have left the reeds and the edges and have gone into deep water. He should remind them to examine the kegs once more, before leaving the ponds, to see whether some of the fish have accidentally remained in them. The men ought also to examine the wagons to see whether the driver or some other person has secreted any of the fish. After every trip a report should be made to the pond master so he can see whether all his orders have been properly obeyed. If several wagons start on a trip together the person in charge should be on the last wagon, so that he may easily watch the rest. No larger number of wagons should be assigned to him than he can superintend conveniently. In transporting carp and placing them in the ponds double care and vigilance should be exercised, so that no fish are stolen. Eel ponds should be stocked with *montée* (young fry). If trout are to be cultivated the young fry should be taken from the spawning ditches to the raising ponds, unless, owing to late spawning, it is found advisable to leave them in the ditches till autumn.

After the ponds have been stocked they should be protected against thieves and animals which can injure or destroy the fish. The large spawning carp and pike in the stock ponds will be a special temptation to thieves. Both these kinds of fish go near the edges during the spawning season, and are at that time so little shy that frequently they can be caught with the hand. Special precautions should, therefore, be taken during this period. Relative to the protection of fish against thieves, Horak says:* "Among the dangers which threaten fish, thieving is the most serious. The art of catching fish varies greatly; and, if coupled with a mania for fishing or with a thievish propensity, it becomes

* Horak, *Teichwirthschaft*, 1869.

dangerous. To watch human beings who have lax ideas as to the right of property requires not only great vigilance and perseverance, but in this case also a thorough knowledge of the various methods by which fish can be caught. It is, therefore, necessary to appoint as watchman a person who is conversant with the methods of fish thieves. The principal apparatus employed by thieves are hooks and nets. To secure fish at night-time by means of spears will rarely be successful, as the light which is necessary will betray the thieves. Fishing with hooks and artificial bait will in most cases prove more successful. The various nets employed by thieves, in the hands of experienced persons, and especially if the ponds are not carefully watched, become exceedingly dangerous. The pond cultivator will probably know the localities where thieving is likely to occur, and should endeavor to make them as inaccessible as possible. In puddles below the grates, juniper and thorn brushwood should be laid and weighted with stones, so as to render a prolonged stay in them disagreeable and make it difficult to use the hook and line. If during high water the fish should nevertheless get into these puddles, thick pine branches should be thrown into them and be weighted with stones. Piles may also be driven into the ground so that the nets cannot touch the bottom.

As such depredations generally occur late at night, when the grass is wet from the dew, the tracks of the thief can easily be discovered in the morning. This makes it necessary to stop watering by night-time, and to do it not only by day, but also in places which are not too remote and lonely. Thieving becomes most dangerous prior to or during the fisheries, when the water is low and the fish congregate in a few places, and is then generally done by nets or with the hand. To prepare the ponds for the fisheries should invariably be done by persons specially selected for the purpose; and large or very remote ponds should be guarded by reliable men. To enable the watchmen to discover the track of a thief, the mud-covered bottom of the pond should not be trodden by any one, unless this is absolutely necessary. The supervision of large ponds with an extensive growth of reeds becomes exceedingly difficult. Experienced watchmen have many signs which betray the thief. Thus, wading in mud or water is heard at a considerable distance during the silence of the night. Aquatic birds, especially gulls, are watched to see whether they remain quiet in the middle of the pond. As soon as any one enters the ponds these birds rise with a great noise and thus betray the intruders. An experienced pond cultivator will at once perceive whether any thieving has been going on with hooks and lines, or nets; and, especially during high water, when the fish are frequently carried far away, he will take every precaution to prevent thieving, and if necessary call in the aid of the authorities. For injurious animals traps should be set. In small ponds wild ducks, gulls, &c., can be kept away by scarecrows, made as much as possible to resemble a human figure, whose location should be changed from time to time.

From the beginning of May the spawning of the carp should be watched, and all hurtful and disturbing influences be kept away as much as possible. During this period, and later, cattle should not be allowed to graze near the spawning ponds; tame ducks and geese should not be suffered on them, and nothing like washing should be done in them. The frogs should be caught as much as possible, as they devour not only the spawn, but also the young fry.

In July it can already be seen whether and how much fry there is in the ponds. If the young fry or all the fish belonging to a pond farm are to be fed artificially, the pond master should see to it that the fish are fed regularly. Care should be taken to keep an equal depth of water at all times. In his rounds the pond master should not neglect to examine the taps and stand-pipes, to see whether they have been opened, whether the water flows freely through the grates, or whether it is impeded by an accumulation of grass, mud, &c., which is frequently caused by mischievous persons. I have known a case where a miller who could no longer draw the tap, as had been his habit, because a long tap with a padlock had been substituted for the short one, threw a great quantity of earth and sod into the water near the outflow grate, so as to let the water flow into a pond near his mill, thus causing a continued unequal depth of water in the two ponds. The ditches through which water flows into the ponds should be kept clear all the year round, and this applies particularly to sky ponds. The influx of rain and snow water from neighboring fields and meadows should be favored in every possible way.

During the hottest months, June and July, the temperature of the water, especially in sky ponds, should be watched incessantly, so as to take proper measures in good time to prevent sickness and death among the fish. During these months, when the water is low, cattle should on no condition be allowed to come near to or enter the ponds, useful as their presence might otherwise be by the addition to fish-food which their excrements furnish. When the heat is very great, care should be taken to have all the ponds abundantly supplied with fresh water, unless this supply is regular and constant.

Inundations.—During rain-storms which may possibly be followed by inundations, the necessary precautions should be taken by letting as much as possible of the superfluous water flow off through the ditches intended for this purpose and by opening all the sluices a little. Even while the rain is falling the ditches should be cleared to prevent any accumulation of mud, &c., and the grates should be freed from plants, brushwood, &c., which may have drifted against them. If, in consequence of inundations, a break in the dike appears unavoidable in spite of all precautions, an opening should be made in some place where the damage will not be very great. A break in the dike near the outflow is especially to be avoided. After inundations steps should immediately be taken to gather the fish which have been scattered over the neighboring meadows. If this cannot be done at once some trustworthy men should keep watch during the night to prevent thieving. An inundation will, of course, even under the most favorable circumstances, occasion some losses.

If a thunder-storm is approaching, all necessary precautions should be taken. The necessary boats, piles, poles, boards, ropes, sod, earth, clay, carts or wagons, carpenters' tools, shovels, pickaxes, rakes, &c., should be kept in readiness so as to be able immediately to erect protective works at threatened points of the dike and to remove grass, mud, &c., from the grates. If this becomes impossible, the grates must be removed altogether. If during a thunder-storm the lightning strikes a small pond, the water should be let off as soon as possible and be replaced by other water, as the sulphuric vapors with which the water has become saturated will generally kill the fish.

During July and August care should be taken to prevent the exceedingly injurious and even fatal retting of flax in the pond or its tributaries. Summer, particularly July, is the time when the growth of reeds is most luxuriant, and whenever they grow too rank they should be thinned out a little by cutting them below the surface of the water not far above the root. All the above-mentioned work is continued during August. In places where eagles pass on their way to the south, one should be on the lookout for them, and traps should be set in time. During this month (August) the preliminary work of the autumn fisheries commences. The fishing apparatus is overhauled and repaired; the fish-tanks are cleaned with a broom and washed. These labors are continued during September. During this month the winter ponds are filled. The fisheries commence in the spawning ponds which are not to remain filled during winter, and the young fry are put in the winter ponds. Those spawning ponds which are to remain filled during winter should be drained, as far as is necessary to ascertain the quantity and quality of the fry, and also to see whether any fish of prey have entered them, which should be removed at once. After this has been done, the ponds should be filled again immediately. The fisheries are continued in the raising and stock ponds, and the winter ponds should be stocked. Those fish which have reached a marketable weight are either sold at the dike or placed in tanks to be sold, whenever there is an opportunity. The stock ponds receive their quota of carp, young pike, perch-pike, or tench. The spawning carp are picked out and kept during winter in special tanks. Wherever trout culture is carried on, the time after the autumn fisheries is the proper season for stocking the spawning ponds, and making the spawning ditches accessible for the spawning trout. The fishing-apparatus is cleaned, the nets are dried and put in a safe place. During winter they should be repaired as much as possible.

The proper time has now also arrived to plant willows, which, if the weather is favorable, may be continued till spring. The branches of old willow plantations are cut and this is continued until the work is finished. The winter ponds—near which on large pond farms there lives a special superintendent—should be examined by the pond master every day, and, if necessary, several times a day. During the very first days after the fish have been placed in the winter ponds they should be carefully watched to see whether they become accustomed to their new place of sojourn, whether they have gone to their hiding-places and remain there quietly, or whether they frequently rise to the surface. If this is the case the cause should immediately be ascertained and remedied. If accidentally fish of prey have got into the ponds they should at once be removed. If the fish become languid, and keep near the surface, the water must be renewed; and if this has no effect the fish must be put in other winter ponds. If soon after the fish have been put in the winter ponds they seek their hiding-places, and stay there quietly, this is a sure sign that they have become accustomed to the pond and that the water suits them. Great care should be taken that the water flows in and out of the winter ponds freely and regularly, and as soon as ice forms near the outflow or influx it should be removed at once. The pond master should also give his constant attention to the tap-houses and grates and free them from ice, especially when thaw sets in, so that the ice cannot lift the tap and stand-pipe. If the pond master pays daily visits to the winter ponds, he will soon notice any indications of sickness among the fish and take timely measures to prevent its spreading. Wherever it is necessary, air-holes have to be sawed in the ice—not cut, because cutting will scare the fish from their resting-places and cause them to rise to the surface, when their fins will freeze to the ice. These air-holes should never be made over the lair of the fish, but at a considerable distance from it. The snow should always be cleaned off, especially near the air-holes. If thaw sets in, the water should be allowed to flow off the ice.

A lookout should be kept for otters, which like to visit the ponds during winter, and they should be caught or shot as soon as opportunity offers. Reeds protruding through the ice should be cut off. All that has been said regarding winter ponds also applies to fish-tanks.

If fisheries in open lakes or rivers are connected with the pond farm, the pond master should also give some of his attention thereto. In summer nets are used in the river and lake fisheries—the "wild fisheries," so-called—traps are set, and some fish are caught with hooks and lines. In July and August many bleak and other small fish are caught with hooks and lines. Eels are caught with the night-line. Crawfish are caught in the brooks, and net fisheries are carried on in the lakes and rivers. In autumn the line and net fisheries are continued. These few hints relative to the "wild fisheries" must suffice, as they do not properly come within the scope of this work.

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[NOTE.—The references are to page-figures in brackets.]