XL.—THE ARTIFICIAL FEEDING OF CARP.

By Carl Nicklas.

The rational feeding of carp, and in fact of all fish, is possible only when, like the feeding of domestic land animals, it rests on a scientific basis; and when, in accordance with such scientific principles, the various nutritive matters are given to the carp in such proper proportion as its nature demands.

Starting from this point of view, I made an attempt as early as 1879, in my textbook of Pond-culture,† to establish a proper rule for feeding carp, and have reached the conclusion that the most rational one is to reckon to each 1,000 pounds of live carp 9 pounds of dry substance, containing 4 pounds of albumen, 2 pounds of hydrate of carbon, inclusive of fat, which would make the proportion of nutritive matter 20 to 1.

The proportion of nutritive matter is exceedingly close in itself, and still more so if compared with the food standard of land animals; and the demand for hydrate of carbon is consequently very small.

The quantity corresponds to the demand for food by 1,000 pounds of live hogs, if the greatest possible quantity of flesh and fat is to be produced. I was of opinion that I must make the standard quantity of albumen the same as that demanded by the hog, and I did this for the purpose of not making it too low, remembering the fact that the hog is the most voracious of our domestic animals, requiring more food in proportion than any other, and that the rapidity of its growth resembles that of the carp.

The proportion of nutritive matter, and the demand for hydrates of carbon, is based on calculations made with data obtained from careful observations made by Miller and Bausignault, as to the quantity of carbon received in the body and exhaled from it, and on practical feeding experiments made on a full grown sheep at the agricultural station of Wende.‡

According to Miller the following quantities of carbon were exhaled

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† *Lehrbuch der Teichwirthschaft,* pp. 201-225.

‡ Dr. E. Wolff: "*Fütterung der landwirthschaftlichen Nutzthiere,*" 1874, p. 35.

per 100 pounds of living weight during twenty-four hours: by the tench, 12 grams; the frog, 43.5 grams; man, 146 grams; a pigeon, 1370 grams; which would give the following proportion: 1 : 3.5=12 : 114.

These investigations show an astonishingly small quantity of carbon exhaled by fish, as represented by the tench. As the quantity of carbon exhaled varies according to the quantity received with the food, it results from these investigations—which agree with those made by Bousingault and in Wende—that the quantity of hydrates of carbon mentioned in the rule for feeding is hardly too low.

This small demand for hydrates of carbon is explained as follows:

1. In warm blooded animals a considerable portion of the carbon received with the food is used for producing warmth, as in conjunction with the oxygen inhaled it occasions the burning of fat in the animal's body.

This demand does not exist in fish, as the body possesses no heat of its own; the demand for hydrates of carbon is limited to the quantity required for burning those substances which in the process of life become waste matter; and the quantity of carbon required for this purpose is of course very small.

2. Compared with land animals, fish make a small outlay of strength in locomotion. Even for standing quietly the land animal makes use of the muscles, and when walking requires them to support the weight of the body, but fish may float in the water or rest on the bottom without any special effort, because the water, its weight being equal to their own, holds them up.

This will become self-evident when we think of the ease with which a man can move a raft in still water, whilst on land he would hardly be able to move a single log of this same raft. It is true that swimming very soon tires a man, but this is not owing to the amount of strength required for the exercise, but simply to the fact that those muscles which come into play are not accustomed to this kind of exercise.

The circumstance that fish need much less exertion for their usual motions than land animals is an explanation of their small demand for hydrates of carbon and fat in their food. If, as is fully established, hard work does not so much promote the destruction of albuminous matter in the animal body as it intensifies the burning of hydrates of carbon (which demands an increase in the quantity of oxygen inhaled by the respiratory organs, which again creates greater heat, of which, however, a larger quantity is expelled from the body simultaneously with a greater evaporation of moisture), the contrary must be the case under the conditions of the life of fish.

3. The elementary composition of the carp also favors a small demand for hydrates of carbon, for, according to Dr. Kônig, of Münster, this composition does not contain any substances free from nitrogen, and, according to Prof. E. Wolff, the carp only possesses 4 per cent. of extractives (*Extractivstoffe*). The difference between the investigations

of these two naturalists has no bearing on the question before us, and we will, therefore, leave it undecided which of the two is correct.

Compared with land animals, fish can, therefore, in an equal quantity of food, obtain more albuminous matter than the former, and thereby also attain to a larger growth, as, up to a certain limit, the formation of flesh and fat in the animal body increases with the increased quantity of albuminous matter contained in food.

If we further compare the proportion of the various nutritive substances contained in the natural food of the carp with that found by us as the standard of food, this standard will be found to be correct, even when viewed from this standpoint.

The natural food of carp consists of worms, maggots, larvæ, snails beetles, and other insects. Of these only the beetle and a number of other insects have been examined as to the quantity of nutritive matter contained in them, and they have been found to contain on an average 95 per cent. of nitrogenous matter, which would correspond to a nutritive proportion of 1 : 0.05. This proportion in cockchafers is given by Professor Wolff as 1 : 0.6.

As regards the worms, snails, &c., we possess no data, at least none have come to my knowledge. The effect of these animals when used as food for fish, however, shows that they must contain a considerable quantity of nitrogen. Thus the "*Deutsche Fischerei-Zeitung*," 1880, p. 25, maintains that by feeding trout on worms their weight can be increased in one year from three-fourths of a pound to 2½ pounds. Although this may be somewhat doubtful it nevertheless shows that the quantity of nitrogen contained in worms is very similar to that contained in beetles and other insects.

As regards feeding fish on snails, Dr. Molin says, in his *Rationellen Zucht der Süsswasserfische*, p. 13, that Commander Desme had a pond containing 150 hectoliters of water on his farm at Puygirard, in which he fed young salmon and trout on pounded snails, by which method of feeding he increased their weight on an average by 1 pound per fish. It may, therefore, be safely assumed that the quantity of nitrogen in snails is not materially less than that in worms.

As carp take the above-mentioned articles of food mixed, and as some of them consist exclusively of nitrogenous matter, and, as in most of them, the proportion of nutritive matter is a very close one, the standard of food laid down by me will also, from this point of view, have to be acknowledged to approach very closely to the natural food of the carp.

I have started my theory from the fact, which I know from actual experience, that the food of the carp is principally animal and not vegetable matter, and I find that in this I agree with most of the practical pisciculturists; but I differ from the views of Professor Nawratil (*Oesterreichisch-Ungarische Fischerei-Zeitung*, 1880, No. 35)* when he as-

* The *Fischerei-Zeitung*, formerly published in Vienna, is now discontinued, and not to be confounded with the first *Oesterreichisch-Ungarische Fischerei-Zeitung*.

serts that carp, from their third year, live principally on fresh and decaying vegetable matter. This is contradicted by the experience that they are easily raised in ponds which contain but few plants, and by the circumstance that, if aquatic plants formed the exclusive, or even principal food of carp, vegetation would, in some ponds, be utterly destroyed in a few days after they had been stocked with carp, or at any rate in a couple of years, as carp are particularly fond of young shoots, which, by the way, show a pretty close proportion of nutritive matter. Such an occurrence, however, I have never yet been able to observe, nor has it been observed by any other pond-culturist; whilst, on the other hand, it has frequently been observed that in carp-ponds vegetation becomes so rank and luxuriant that it has to be checked. As long as decaying vegetable matter has not been examined as to the quantity of nutritive substances contained in it, no opinion can be formed as to its suitableness for carp food.

My own observations have taught me that the carp only takes to vegetable food when absolutely no animal food can be procured. I have not yet been able to ascertain whether the carp actually eats and digests decaying vegetable matter, because all I have so far been able to observe has been that the carp often swallows such matter, but almost immediately ejects it again, perhaps after having devoured worms and insects clinging to such matter.

When I began to make the attempt to fix a standard of food, based on the analogous theory of food of land animals, but keeping in view the difference in the nature of fish and these animals, my object was to provide some aid to pisciculturists, and more especially to carp-culturists, in the artificial feeding of fish, so as to enable them, to some extent, to calculate results; and as this standard is not intended to furnish anything but such an aid, it is not necessary, in mixing food, to be absolutely exact in observing the quantities given by me, as, in mixing the food of domestic land animals, such exactness is not essential. The quantities should, however, approach those given by me, and it would be wrong to increase the proportions three or four fold. Even if such an increase (presuming there is a sufficient quantity of albumen) might not affect injuriously the nutritive quality of the carp food, it would at any rate involve a waste of hydrates of carbon, which, when they have to be bought, make the food more expensive, and will more or less decrease, or even entirely do away with the revenue. More than a hundred observations as to the food and feeding of carp, made by me in my piscicultural establishment, have proved to me the approximate correctness of my standard of food, but have also shown that the quantity of nutritive matter per 1,000 pounds of live carp, might be less than has generally been supposed.

Calculations made on the basis of my standard of food and given in my *Lehrbuche der Teichwirthschaft*, p. 219, showed that 1 kilogram of meat flour (*Futterfleischmehl*), which contains 0.692 kilograms of digesti-

ble albumen, and 0.112 kilograms of digestible hydrate of carbon produce 1 kilogram of albumen or 1.428 kilograms fish-flesh; later observations, however, have shown that even a smaller quantity is sufficient to produce this result.

Thus, experiments in feeding, made on a large scale on the estate of Plan, in Bohemia, and described in the above-mentioned *Oesterreichisch-Ungarische Fischerei-Zeitung*, 1880, No. 32, and 1881, No. 19, and carefully reviewed by me in the same journal, 1881, Nos. 23–30, showed that, in order to produce 1 kilogram of carp flesh, there were required 0.496 kilograms of albumen, which quantity is contained in 0.664 kilograms of meat flour; in other words, 1 kilogram of albumen produced, in round figures, 2.200 kilograms of carp flesh, and 1 kilogram meat flour produced 1.540 kilograms of carp flesh.

In making these experiments there were fed in a pond of 2.41 hectares 1,150 young fish, and in another pond of 4.56 hectares 2,240 young fish, averaging 30 grams apiece in weight. The food consisted of a mixture of meat-flour, blood, malt, and flour. Nothing is said respecting the quantities of the different ingredients; all that we could learn was, that 4 kilograms albumen had been fed per 1,000 kilograms of living weight, and that the proportion of nutritive substances had been Nh : Nfr=1 : 1.95, and also that in this mixture the kilogram protëine had cost from 84 to 88 pfennig [about 19 or 20 cents].

These experiments, therefore, were only made respecting the quantity of albumen, on the basis of my standard of food, whilst the proportion of the nutritive substances was four times greater than the one prescribed by my standard, thus involving a very considerable waste of hydrates of carbon. But as the proportion of nutritive substances is increased, the amount of albumen remaining the same, the quantity of flesh produced will be smaller, and the above favorable result, obtained in spite of an increased proportion of the nutritive substances, only goes to show that, if this proportion had been smaller and more like the one prescribed by my rule, the fish-flesh produced would have been still greater.

My criticisms of these experiments were violently assailed by the superintendent of the Plan ponds, but they could not be effectually met by him, as he, leaving the subject proper, attacked the rule of feeding itself. In doing this, however, he did not venture to assail the scientific basis on which this standard rests, and consequently it could not be shaken. I have therefore left the article in question unanswered, and have quietly waited to see whether other pisciculturists would express their approval of the views contained in said article, to do which they were directly asked in the article itself. But so far no such approval has been given by any one, which, I think, sufficiently refutes the attack on my standard.

In that attack the following were the most serious objections presented: (I) that the quantity of food was too small; (II) that the required pro-

portion of nutritive substances could only be obtained if pure meat-flour was used; (III) that the cost of the food was too high compared with the results obtained.

We have already shown that the quantity of food is not too small, but, if anything, too great, and this has been proven by the experiments made, to the entire satisfaction of every one, except my critic.

The assertion that a quantity of food which is enough for that animal which is well known to need the greatest quantity of food, is not sufficient for fish, especially for carp, is so entirely at variance with the organism of fish, their powerful digestion, &c., that, if scientific researches ever prove the necessity of modifying my standard of food, the modification will certainly not consist in increasing the quantity of food, especially of albumen; although, on the other hand, I will not deny that there is a possibility that a larger proportion of the nutritive substances may be found to be better adapted to the purpose.

It is possible that as fish, compared with land animals, have very little demand for oxygen, a much larger portion of the hydrates of carbon, and of the fat received by the body—because not burned for the purpose of producing the heat of the body—is, instead of being expelled from the body as useless, utilized in the formation of flesh and fat. Too great a quantity will, therefore, act less injuriously on the utilization of the proteine, received with the food, than in land animals. We should not, however, be justified from this circumstance in drawing the conclusion that a larger proportion of nutritive substances than that found by me would be the most favorable and profitable proportion for the carp. It is doubtful whether sufficient light will ever be thrown on this subject by direct experiments on carp, because this would require a complete collection of all the excrements, and their chemical analysis, which, with fish, would be an exceedingly difficult matter, considering the fact that no way has as yet been found to make a complete collection of all the solid and fluid excrements of a domestic land animal like the hog.

All the experiments in feeding known to me have yielded higher results than the calculations based on my standard of food—0.7 kilogram of albumen for 1 kilogram of fish-flesh. I think that this was caused by the circumstance that, in mixing the food, I calculated the digestible albumen and the hydrates of carbon (according to Prof. Em. Wolff) which were produced by the digestion coefficient (*verdaungscoëfficienten*) for the land animals, whilst it is well known that carp possess a much greater power of digestion and ability to extract than land animals. In using my standard of food this would only prove the calculations not exact, by increasing the profit, but not by diminishing it; and this would cause, not an increase, but a decrease of the standard nutritive substances.

These and similar thoughts rise in my mind in connection with this subject; but I am of opinion that all such considerations may be left to the investigation of specialists.

More than a hundred observations made in the piscicultural establishment of Mr. Kuffer, in Munich, have satisfactorily proven that the quantity of my standard was entirely sufficient. Mr. Kuffer daily feeds 100 to 125 kilograms of trout with only a few handsful of roe and fish entrails in addition to a bleak about 10 centimeters in length to each trout. Thereby he has, for more than twenty years, obtained a daily increase of 1 kilogram for each 100 kilograms live weight. In seeking to ascertain the weight of the dry substances and the nutritive matter contained in them per 500 kilograms live weight, in this kind of food and in the above quantities, one will come very near to the figures of my standard of food. In making similar experiments, principally with cheap, lean portions of meat which are generally used for feeding fish—following herein the rule laid down by a well-known authority, Livingston Stone (see Von dem Borne *Fischzucht*, first edition, p. 73), according to which 2.5 kilograms of meat produce 0.5 kilogram of fish flesh—one will arrive at similar results. The quantity of albumen contained in the above quantities agrees with my calculations that 1 kilogram of meat-flour produces exactly 1 kilogram of fish-flesh. All similar analyses of food which have come under my notice in a number of piscicultural and scientific journals, and which have produced particularly favorable results, have confirmed the practical correctness of my standard of food.

That the standard proportion of nutritive substances, Nh : Nfr=1 : 0.5, can only be obtained when pure meat-flour is fed, will become clear when one remembers that, according to Professor Wolff, the proportion of nutritive substances in meat-flour is only 1 : 0.4, and that consequently it needs an addition of some food containing hydrate of carbon in order to produce the desired proportion. That a mixture of food showing the required proportion may be obtained at a comparatively small expense will be seen from the following facts:

In the food used at Plau the kilogram of albumen is said to have cost 84 to 88 pfennigs [21 or 22 cents]. This must be considered dear; yet it cannot be owing to my standard of food, but to an irrational method of mixing the food. Nevertheless, in spite of this great expense, the results show a very considerable profit. It required 0.496, or, in round figures, 0.05 kilogram of albumen, costing 44 pfennigs [11 cents] to produce 1 kilogram of fish flesh. Calculating the price of 1 kilogram of carp at 100 pfennigs [25 cents], we get a net gain of 56 pfennigs [14 cents] per kilogram, which can only be accounted for by the method of feeding employed. If, however, the meat-flour had only been mixed with some binding soil, such as clay, which was frequently done in olden times, our calculations would be as follows: the price of meat-flour varies from 11 to 18 marks [$2.61 to $4.28] per hundred weight; supposing it to cost 18 marks [$4.28], the kilogram would cost 36 pfennigs [9 cents], and counting 4 pfennigs [1 cent] for preparation and soil, the cost would be 40 pfennigs [10 cents]. As we have seen above, 0.664 kilograms of meat-flour produce an increase of 1 kilogram. The kilogram of fish

flesh, therefore, cost 0.664 × 40, which is 26.56 pfennigs [about 6 cents]. In the market it would bring at least 100 pfennigs [25 cents], and in former times it would have brought at least 120 pfennigs [30 cents].

Let us now take a second mixture. Suppose that we feed to 500 kilograms of carp per day, 4.807 kilograms of fish-flour and 1.411 kilograms of wheat-flour of the second quality. This contains 2.174 kilograms of albumen and 1.247 kilograms of hydrates of carbon, inclusive of fat; this latter substance reduced to the value of respiration (*Respirationswerth*). We now get 1:0.56 as the proportion of nutritive substances, which agrees with my standard. The cost of this mixture, including its preparation, which simply consists in adding water, making a tough paste, and trying it, would be as follows:

	Cent.
4.807 kilograms of fish-flour at 30 pfennigs [7½ cents]	36
1.454 kilograms wheat-flour at 44 pfennigs [11 cents]	16
	52

One kilogram of albumen, with the hydrates of carbon belonging to it, therefore, costs 96 pfennigs [24 cents]. If this produces 2.2 kilograms of carp flesh [at 43 pfennigs per kilogram] we get, supposing the price of carp to be 100 pfennigs [28 cents] per kilogram, a net gain of 57 pfennigs [14 cents] per kilogram of increase.

If we were to base this calculation on the result given in my manual, which is that 1 kilogram of albumen, with the corresponding quantity of hydrates of carbon, produces 1.428 kilograms of carp flesh, the cost of the kilogram would be 56.8 pfennigs [14 cents], and the net gain per kilogram of increase would, therefore, be 31.2 pfennigen [about 8 cents].

A third mixture of food is as follows: 2.890 kilograms of meat-flour and 1.451 of wheat-flour, containing 2.174 kilograms of albumen and 1.341 of hydrates of carbon, inclusive of fat, with a proportion 1: 0.7 of nutritive substances; the kilogram of albumen, at the above mentioned prices, would cost 72 pfennigs [18 cents]; the net gain per kilogram of carp flesh produced by food would, therefore, be 67.3 pfennigs [17 cents]. The proportion of nutritive substances is somewhat larger than in my standard, but may still be considered suitable.

A fourth mixture is as follows: 2 kilograms of wheat bran, and 9 kilograms of fresh blood, containing 1.971 kilograms of albumen and 1.012 kilograms of hydrate of carbon, inclusive of fat; the proportion of nutritive substances is therefore 1 : 0.594. Counting a kilogram of wheat bran at 20 pfennigs [5 cents] and a kilogram of blood at 5 pfennigs, this food costs, in round numbers, 85 pfennigs [21 cents], and the kilogram of albumen, in round numbers, 43 pfennigs [about 11 cents]; the net gain per kilogram of increase is therefore 80 pfennigs [20 cents].

Respecting this mixture, it may be mentioned that in the old *Oesterreichisch-Ungarische Fischerei-Zeitung* 1880, p. 139, it is stated that, during seven summer months an increase of 1.5 kilograms per fish was ob-

tained.* The mixture was prepared in the following manner. A paste was formed by the bran and blood, which was rolled into large balls. These balls were placed under the water near the banks of the pond, at a depth of about 30 centimeters, in places exposed to the sun. In the main pond the carp were therefore always fed in the same places, and the carp soon showed a preference for being fed in these places. Small aquatic animals also get their share of this food, and as they in their turn serve as food for the carp, nothing is lost; which also is true of most articles of fish-food.

A fifth mixture would be as follows: 1 kilogram of sprouting malt, 0.5 kilogram of wheat bran, 1 kilogram of meat-flour, 6 kilograms of blood; containing 2.040 of albumen and 1.048 kilograms of hydrate of carbon, inclusive of fat. In this the proportion of nutritive substances is 1 : 0.51.

The expense would be about as follows: 1 kilogram of sprouting malt, 10 pfennigs [2½ cents]; 0.5 kilogram of wheat bran, 10 pfennigs; 1 kilogram of meat-flour, 36 pfennigs; 6 kilograms of blood, 30 pfennigs; total, 86 pfennigs [21½ cents]. The kilogram of albumen would, therefore, be 43 pfennigs; yielding a net profit of 80 pfennigs [20 cents] per kilogram of increase.

If we were to base this calculation on the results above mentioned, as given in my manual—1 kilogram of albumen with the corresponding quantity of hydrate of carbon produces 1.428 kilograms carp flesh—the net gain per kilogram of increase would be: In the second mixture 31.2 pfennigs [about 8 cents]; in the third, 50 pfennigs [12½ cents]; in the fourth, 60 pfennigs, and in the fifth, also, 60 pfennigs. In considering the profits calculated in the above, we must remember that the market price of 100 pfennigs [25 cents] per kilogram of carp flesh is very low, whilst the cost of the food has been set rather high. Blood may be obtained from slaughter-houses for a few pfennigs a bucket, and often it is freely given away. It follows further that even if the results of the standard of food given by me were smaller than those mentioned above—which I am firmly convinced, however, will never be the case—there would still be considerable profit.

I could increase the number of recipes for food very considerably, but I think that those given will be sufficient to prove that mixtures of food can be produced with the proportion of nutritive substances given in my standard. As this proportion is very close, some articles of food containing a good deal of nitrogen should be added to all mixtures. As the most profitable of such articles of food, and those most readily taken

* Unfortunately, neither the quantity of the mixture nor its proportion is given; nor is it stated what was the productiveness of the pond; we, therefore, are not able to ascertain how much of the 1.5 kilograms obtained must be ascribed to the productiveness of the pond. It may be supposed, however, that the quantity of food is less than in the mixture mentioned just above, which corresponds with my standard of food. It must also be remembered that the fish were not fed every day.

by the carp, we will mention fresh and dry blood, with a proportion of nutritive substances Nh : Nfr = 1 : 0.1; lean horse-flesh with a proportion of 1 : 0.1; fish-guano or fish-flour, of 1 : 0.1; thick milt, of 1 : 0.2; dry refuse from starch factories [gluten], of 1 : 0.3; and meat-flour, of 1: 0.4. Of substances lacking in nitrogen we may mention potatoes, with a proportion of nutritive substances of 1 : 10.6. If we add to a food, or mixture of food, containing a proportion of nutritive substances of 1 : 0.5, about the same weight of potatoes, and to one of 1 : 0.2 about half the weight of potatoes, or to a certain weight of meat-flour, the fourth part of this weight in potatoes, or to a certain weight of fish-guano the same weight of potatoes, we shall come very near to the required proportion 1 : 0.5 of nutritive substances.

Such a mixture will become suitable for food, if boiled potatoes are mashed, then mixed with the articles of food, and mashed again repeatedly. During cool weather, or kept in a cellar, this food will keep for several weeks. When it is to be used, it is best taken out with a shovel or spade, broken into small pieces, and thus fed to the fish. Mixtures of meat-flour, fish-guano, horse-flesh, and similar substances, with potatoes, will, however, when thrown into the water, only hold together for a few minutes. These mixtures are only specially adapted to young fry, and they should be placed in the flat grassy edges of the ponds where the particles of food cling to the grass, and are found by the young fish. For larger fish these mixtures are not well suited, whilst solid food substances are not adapted to young fish. If one adds to such a mixture corresponding quantities of blood, thick milk, gluten from starch factories, worms, snails, or beetles, a tough paste may be made which will remain in the water for some time without dissolving. It may then be fed to the fish at once. If one wishes to keep it for some time, long strings are formed of this dough or paste by pressing it through the apertures of a sieve; these strings are cut in pieces of about the size of a pea, and are either dried in the sun and air, or baked. They are then well adapted to fish that are two years old or older.

Mixtures of fish-guano, meat-flour, dry meat chopped fine with flour or bran, are prepared by putting the first-mentioned substances in a barrel or any other suitable vessel and pouring boiling water over them till they will not absorb any more, whereupon the flour is added, and the entire mass is well mixed and kneaded. This food may be used as soon as it has grown cold, but it may also be kept for several days without any danger of its spoiling. This mixture may also be dried in the air, or be baked, when it will keep for a considerable length of time.

It will be well, especially when meat-flour is used, which does not contain any salt, to add a little salt—say about 10 kilograms coarse salt to 100 kilograms of food.

The necessity of maintaining the proper proportion of the nutritive substances, and to this end of using mixed food for carp, will exist in

all cases where artificially introduced food forms the exclusive food of the carp.

This is the case, for example, where feeding is intended to aid in stocking a pond with more fish than its natural conditions of food will allow, if a certain weight of carp is to be obtained. In this case, the food to be introduced would, so to speak, be the only food for the fish above the number naturally belonging to that pond. The case would be similar wherever fish are to be kept in a walled basin.

The more nitrogen the food contains, all the more profitable will the feeding be, for if more hydrates of carbon are fed to the fish than the proper proportion of the nutritive substances demands, these and the money spent for them is wasted, as they either pass from the body without being of any special use, or are used in the vital process without creating any flesh.

Wherever artificial feeding is merely to increase the productiveness of a pond, one may more or less, or even entirely, abandon the idea of mixing food for the purpose of widening the standard proportion of the nutritive substances (*i. e.*, of adding, in food not containing much hydrogen, the necessary hydrates of carbon to the food containing much albumen), as in nearly all organic matter the quantity of hydrates of carbon far exceeds that of the proteine, so that the fish can easily satisfy their demand for such hydrates of carbon from the natural resources of the pond.

The mixing of food, however, will be necessary, if it is not to be immediately eaten by the fish, in order to put the food in suitable shape, so as to prevent its losing its strength by being soaked in the water. Such preparation will also be necessary when it is to be kept for any length of time. For the sole purpose of meeting the last-mentioned object, it will suffice to mix the food with clayey or loamy soil. Thus, *e. g.*, by mixing a suitable quantity of water with meat-flour and some soil, an evenly mixed tough paste is produced, which is shaped into balls of the size of a pea or a filbert, or into small cubes, which are dried in the air. Food thus prepared only soaks very gradually in water, and takes a long time to dissolve entirely; which, however, happens but rarely, as the fish will devour it as soon as it has become somewhat soft.

It is not advisable to form this and other mixed food into thin cakes, similar to the Jewish Easter bread, which are broken and thrown into the water, as they will sink to the bottom, where it is difficult for the fish to get at them, and, sinking deeper into the mud, are finally lost. This is my own observation. For young fry, meat-flour, malt, bran, &c., may be scattered on the grassy banks of the ponds.

In designating those articles of food which contain the largest quantity of nitrogen, as the most profitable, I take it for granted that a person is exclusively limited to the *buying* of food. Wherever this is not the case, where other agricultural industries are carried on in connec-

tion with pond-culture, such as stock-raising, distilling, brewing, &c., which furnish a large quantity of refuse matter suitable for fish-food, which could hardly be put to any other use but feeding carp, it will be understood that this matter will be principally used as food, other substances, containing much nitrogen, only being employed to produce a food containing the proper proportion of nutritive substances. As the farmer in feeding his cattle is often obliged to make the best of what food he possesses, and to make lengthy calculations to obtain the proper mixture of food without having to buy much, thus, also, the pond-culturist will often be obliged to have recourse to the same plan.

In cases where the refuse matter above referred to cannot be sold, it may be counted at a much smaller price than it could be bought for, and in spite of the great waste of hydrates of carbon, the feeding of such matter will yet be profitable, whilst if food containing hydrates of carbon had to be bought, the profits would all be taken away by the high price of the proteine which would be needed.

Artificial feeding will be particularly advisable in ponds which do not contain much natural food, whilst in highly productive ponds, which at certain times are planted, or which receive the excrements of grazing cattle, &c., and which, as experience shows, if not too thinly stocked, may produce a very large quantity of fish, it will not prove profitable; at least I have never been able to observe any special effect of artificial feeding under such circumstances. The cause of it may be found in the circumstance that the stomach of the fish filled with the heavy food furnished by the pond, which requires a longer time for digestion, cannot receive any more food, and that, consequently, the fish does not feel any desire for it.

It cannot be denied that the regular feeding of fish in ponds has its peculiar difficulties, and requires much labor, especially when the ponds are large. But, if labor can be had, the expense should not be shunned, for the results will certainly pay for the labor and outlay, and the profits, as calculated in examples 2 and 3, will certainly not be diminished. At times it will even be possible to give the carp much food without incurring any great expense.

In the neighborhood of many, probably of most, ponds, cattle are grazing, and their excrements will be found in considerable quantity. It will neither be a difficult nor time-consuming labor to gather these excrements, which quickly dry in the sun and become the abode of many beetles, maggots, &c., in a wheelbarrow, and throw them into the ponds. It will be still better to gather these excrements only in summer, and keep them in heaps, sheltered from the rain, using them during the months of August, September, and October, when nature does not produce much suitable fish food.

The most profitable way will be to gather these excrements and throw them into the principal ponds about this time, when their fish are to be sold, and should have the greatest possible weight, and the expense of

feeding will thus quickly be repaid. Experience has shown that the quantity of food in the ponds decreases as the weather grows cooler, and in September one cannot count on more than about 10 per cent. of the total increase. If the carp, therefore, cannot be sold during that month, it is to be feared that in October the fish lose in weight—at any rate do not increase in weight. During the months above referred to, recourse should be had to artificial feeding.

Besides excrements of cattle, the flesh of dead animals can, in most cases, be easily procured, or blood and scraps of meat can be bought from the butchers at a cheap price. Such matter simply thrown into the water near the bank of the pond serves either directly as food for the fish, or maggots and worms form in it, small aquatic animals gather round it, and ample food is thus provided for the fish. With regard to dead animals it should be observed that large animals should not be thrown into the water whole, but cut in medium sized pieces, so as to avoid the danger of poisoning the water and thereby injuring the fish. Such pieces of flesh should always be about 20 to 30 centimeters under the surface.

Pieces of flesh, or small dead animals may also be placed free on poles stuck in the bottom of the pond. The maggots forming in such decaying animal matter will then fall into the water and become a prey to the fish.

Wherever there are distilleries, the slops from them may be thrown into the water near the bank of the pond, and will form a cheap and good food. Thus it was stated in No. 8 of the *Deutsche Fischerei-Zeitung*, 1878, that by feeding 60 liters of slops per week, in a pond measuring 500 cubic meters, from April 10 to November 9, 104 carp weighing each, on an average, 0.25 to 0.50 kilograms, reached an average weight of 1.375–1.625 kilograms.

Potatoes that are a little rotten, and other roots, may also be used for food.

In years when cockchafers are plentiful, they may be gathered and thrown into the pond, thus furnishing the carp with a favorite and strengthening food, and ridding the country of an insect which often becomes injurious to vegetation. Whenever there are breweries in connection with farms, their refuse, such as spoiled malt, husks, malt which has commenced to germinate, refuse from the barley, &c., may also be profitably employed as food for carp. Such matterial, when used in this way, will yield greater profits than when used for feeding cattle.

If there are clover fields or meadows near the ponds, the carp may be supplied with ample natural food by cutting grass, clover, or lucern, during the months between May and August, chopping it fine, pouring water on it, and then distributing it in small stacks in sunny places near the banks of the pond, so that it may be thoroughly warmed. On the following morning water should be again poured on these stacks, and, without being disturbed in any way, they should be again exposed to the

rays of the sun, which quickly heats them and produces putrefaction. During the following night already numberless beetles and other insects will creep into the steaming stacks and deposit their eggs. After three days the stacks are fairly alive with insects and their larvæ, and the stacks are then thrown, just as they are, into the water near the banks. They must, however, be entirely covered with water to the height of 20 to 30 centimeters. The exhalation from this decaying vegetable matter acts like a bait upon the carp. They eagerly seek it, devouring the insects contained in it, and also particles of the decaying matter. The places where the grass has been thrown into the water become gathering places for many other small animals, which breed there, and thus supply ample food for the carp. These places should be kept up. As grass can generally be had near the banks of ponds, this food is cheap and can be obtained with very little trouble.

Placing branches of pine, spruce, or juniper (branches of deciduous trees are injurious on account of the tannin contained in the leaves) in the water of ponds, especially those having but little vegetation, will also serve to increase the number of insects, as they become the breeding and hiding places of many of them. By lifting these branches from time to time out of the water, and shaking them, the insects contained in them are scattered in all directions and become an easy prey to the fish.

The feeding of carp will be all the more profitable, the more extensive the scale on which it is carried on, and the more the food agrees with the scientific principles of feeding animals.

If one restricts one's self to use substances for food in the manner indicated, which otherwise would not be of much use, which cannot be obtained regularly in sufficient quantities, much nutritive matter will—even if the results of this method of feeding are favorable—pass from the body of the fish without affording any use. Such irregular feeding can only be recommended in ponds containing larger fish; whilst in ponds where fish are raised, it would disturb the whole system of cultivation, and therefore prove injurious.

In order to reach the greatest possible results with the smallest possible quantity of food and at the least expense, or, at least, to approximately reach certain definite results of production, it is indispensable that the carp, like domestic land animals, should be supplied with a suitable quantity of food containing nutritive substances in proper proportion. As, so far, no other standard of food has been given but mine, as this has not been seriously attacked by any one, and, as in a general way it has been tested by my own experience, I see no reason why I should not conscientiously recommend it as a reliable guide in feeding carp.

Wherever it is the intention to reach certain definite results, especially when the feeding is to take place in feeding-ponds, the feeding process, if carried on in the wrong place, or in an improper manner, will

often do more harm than good; and in this case a guide for feeding carp, even if ever so imperfect, holding perhaps the same relation to it as the theory of the value of hay to the well-developed theory of feeding cattle, cannot be dispensed with.

With regard to the entire farming operation the feeding of carp can be made to subserve the following purposes:

I. To cause the fish in the growing-ponds to gain as much as possible in weight during the time immediately preceding the sale, viz, during the months of September and October.

If it is not the intention to catch a certain minimum weight of fish, it will be sufficient to give the fish, from time to time, food which may be on hand, and is otherwise useless; but even in doing this, certain regular periods should be observed, as it will invariably retard the growth of the fish if they are not fed on those days on which they have been accustomed to be fed.

If, however, it is the intention to reach, approximately, a certain definite minimum weight, food should be given in accordance with the standard. An example of this way of feeding is given on page 218 of my *Lehrbuch der Teichwirthschaft* (Manual of Pond culture).

II. To obtain young fry having the greatest possible weight.

The main question here is also whether a certain definite weight is to be approximated, or whether the object is merely to obtain heavier fry than could be obtained without feeding.

In the first case it will not be necessary to adhere strictly to the standard of food.

But if the young fry are, for example, to be advanced so much during the year of their birth as to reach a weight which otherwise they would not have reached till the second year, this object cannot be attained by feeding the fry in the hatching-ponds unless the quantity of fry is extraordinarily small, but the young fry must during the first year be transferred to special growing-ponds, and in them brought up to the desired weight, artificial food being used, according to the quality of the fry and the quantity contained in the pond.

If feeding has to be resorted to, the quantity of food should be adapted to the end in view by observing the feeding-rules.

III. To bring fry that have not attained the normal weight* during one year to the weight required for its transfer to the feeding-ponds during the following year.

Even in piscicultural establishments conducted on rational principles it may happen, in exceptional cases, that the fish of one or the other pond do not reach the normal weight aimed at for that particular year,

* By normal weight I mean the minimum weight per fish which the carp must reach in a year, so as to be ready for transfer during the following year, and so as to reach at the end of the entire period of raising the minimum weight aimed at for that period. This normal weight will therefore vary considerably, according to circumstances.

or that a part of the fish in one pond do not reach the same weight as the other fish in that pond. The cause of such uneven growth must generally be found in the circumstance that the fish with which the pond was stocked differed much in weight. Thus a difference of 50 grams, which would hardly be noticed with the naked eye, would, for example, in two-year old fish, which generally grow 150 per cent., result in a difference of 125 grams. For instance, if fish had been placed in the pond weighing from 250 to 300 grams, the former would reach a weight of 625 and the latter of 725 grams, showing a difference easily recognized with the naked eye. In fish, whose power to grow differs very much, this difference will be still more easily discerned.

Such irregularities should be corrected at once, as otherwise they may injure the system for years. In a well-organized and rationally-conducted piscicultural establishment it will not be possible to remedy the evil by diminishing the number of fish in each pond, because it is the object to raise every year an equal number of fish of equal weight, and therefore under otherwise equal conditions the number of fish in the different ponds must remain the same.

There are, therefore, only two ways, either to raise the young fry in ponds, outside of the farm proper, such as I have recommended in my manual, and which I have designated as "ponds at disposal" (*disponible Teiche*) (See p. 308, &c.), or to resort to artificial feeding.

It is self-evident that, for this purpose, the fish should be placed in one or several ponds without mixing them with other fish, either greater or smaller. If, for instance, one has in a growing-pond of the first class (calculated to raise, during a period of four years, fish of 1,260 grams weight) some fish which have not reached the necessary weight of 260 grams, but perhaps only 160 grams, the most rational plan would be—in case the natural method indicated above cannot be followed—to feed the fish, which have been retarded in their growth, so much during the following year as to cause them to reach the weight of 625 grams necessary for their transfer into another pond.

If, thereby, contrary to intention, a greater weight than the normal weight is obtained, this will, of course, do no harm whatever. Only one should then take the precaution to follow one of the fundamental principles of fish culture, viz, to keep fish of the same weight together and see to it that they do not mingle with those of different weight, as, in that case, the larger fish might injure the smaller ones; the only result will be that one will have some fish which exceed the normal weight, which, however, will be an advantage, as it will increase the price of such fish, and will therefore add to the income of the pisciculturist. As a general rule a minimum weight is agreed upon in the contracts for the sale of fish, and the buyer will generally be pleased to see some of the fish exceed this weight. In case the difference between the weight obtained and the normal weight is not very great; if, *e. g.*, one has, in a feeding-pond of the first class, fish weighing between 200 and

260 grams, it would seem advisable to omit the artificial feeding in the growing-ponds of the second class, because there will then be a greater probability that in these ponds they will reach the weight of 625 grams under natural conditions of food. If this expectation should not be realized one should make up for lost time in the sale-ponds; but, if it is realized, the expense of feeding the fish has been saved. But, as we have already remarked, a difference of 50 or 60 grams will hardly be recognizable.

IV. To make the period of raising as short as possible. If artificial feeding is to be introduced for the purpose of shortening the period of raising, which would be impossible under natural conditions, especially in ponds whose natural power of production is not very great, it is imperative that the feeding process should be carried on according to scientific principles; only in this way will it be possible to feed the fish without heavy expense, and to approximate a certain definite weight. This will apply principally to a three-years' period of raising.

If the period lasts four years, the feeding process should be so regulated, that—approximately, at least—in the feeding-pond of the first class a weight of 260 grams is reached during the second summer, a weight of 635 grams in the feeding-pond of the second class during the third summer, and a weight of 1,260 grams in the sale-pond.

One ought, of course, to be satisfied if these weights are only reached approximately. This ought to be self-evident, but I desire to make special mention of it so as to preclude the possibility of making any mistakes; and I would say still further that this does not only apply in certain special cases, but may safely be laid down as a general rule.

Above everything else, regard should be had in artificial feeding to the laws of natural growth, or rather to the power of growth possessed by carp during the different years of their life, for any violation of the laws of nature will be punished sooner or later by nature herself. Even in the artificial regulation of the growth of carp, the laws of nature should be closely observed.

The natural power of growth varies very much during the first year; it is 150 per cent. during the second year, 100 per cent. during the third, 50 per cent. during the fourth, and 33⅓ per cent. during the fifth year.

I must confine myself to giving these figures, as it would lead us too far to give the reasons therefor; possibly I may be privileged to give them in some future article.

Feeding should also be adapted to the productiveness of each pond, as shown by experience. The food should be adapted to the difference between the productiveness and the result aimed at.

During a three-year's period it will be better to raise the weight of the young fry to 260 grams during the year of birth than to raise the weight to 510 grams during the second year, which weight would have to be reached in order to keep up with the natural power of growth.

In following the first-mentioned plan, a good deal of food will be

saved, because, if properly aided, the power of growth is greatest during the year of birth. If, however, the desired weight has already been reached during the year of birth, one will also need less food during the second year, because the advance from 260 to 635 grams can be made, in most cases, in tolerably good ponds, without having recourse to artificial feeding. As the case is similar in the sale-ponds, it will be most profitable, if there is a sufficient area of growing-ponds to justify the taking of the young fry from the hatching-ponds during the year of birth, and placing them in the feeding-ponds, to place in the feeding-ponds during the year of birth. If there are not enough feeding-ponds, nothing can be done, of course, but to place the young fry in the feeding-ponds during the second summer, and endeavor to raise some of them to the necessary weight for the last pond (510 grams of a final weight of 1,260 grams is to be reached); in this case, however, the expense of feeding will be greater than in following the first-mentioned method.

A similar method of feeding has to be followed, if, with an equal number of fish, a greater weight is aimed at than the productiveness of the pond can produce. In this case only one way remains—artificial feeding; in *all* ponds, if the difference between productiveness and the demand is very great; if this difference is not very great, it will be sufficient to introduce artificial feeding in some of the ponds. The quantity of food should, in that case, be in proportion to the difference between the productiveness of the ponds and the weight to be reached.

V. To stock a pond with a larger number of fish than its productiveness and the object aimed at allow.

There will be nothing irrational in stocking one or more ponds with a larger number of fish than their productiveness will allow, if the ponds belonging to an estate are so large that the natural distribution of fish in different ponds, according to their age, cannot be properly kept up, and if, therefore, it becomes impossible to keep only fish of the same age in one and the same pond.

The extent of the different ponds may necessitate a larger area for the growing-ponds than properly belongs to them; or, on the contrary, it may happen that the sale-ponds are too large in proportion to the growing-ponds.

In the first case it would seem best to stock the growing-ponds according to their productiveness, in such a way that the fish in these ponds, at the end of their second year of growth—for the sake of clearness we will give an illustration by figures—reach the weight of 635 grams (which would correspond to a final weight of 1,260 grams). This latter weight, however, cannot be reached in the sale-ponds by the fish from the growing-ponds, because their area and productiveness are not sufficiently large for this purpose. This difficulty can only be overcome by giving so much food to the extra number of fish in the sale-ponds as to increase the weight to 1,260 grams. If, however, the sale-ponds are too large in proportion to the growing-ponds, it will be best, for the

purpose of deriving the full benefit from the sale-ponds, to stock the growing-ponds in proportion to the capacity of the latter; which, of course, would give them an extra number of fish, and then to raise this extra number of fish to the required weight by artificial feeding.

By not employing artificial food in the above-mentioned cases, the given pond area would not yield its fullest possible produce, which, of course, could not be considered a rational method of pisciculture. The cause of it is this, that for certain given conditions there is only one final weight which can be considered the most rational, and which will yield the greatest possible revenue; it is that weight which will insure, every autumn, the most quick and profitable sale of the carp.

VI. To change the weight of carp of a former period as quick as possible to the normal weight of carp in the succeeding period, thereby shortening the period of transition.

The transition from one period to the other always requires several years till it is fully accomplished. During these years the yield of the fisheries will be either greater or smaller than in former years. If greater, this result will be brought about by the circumstance that, compared with former years, larger and heavier fish get into the sale-ponds. The catching of a larger number of fish does not, therefore, increase the revenue, as it is caused by the stock from preceding years; if smaller, the cause of this must be found in the circumstance that in some years the final weight is not reached, and the fish, therefore, cannot be sold till the following year.

These irregularities are rather annoying, and the transition, if it is to be accomplished without any disturbance or delay, requires great attention. It is, therefore, to the interest of the pisciculturist to shorten the period of transition as much as possible, and this can only be done by artificial feeding. It is better, however, not to feed than to feed in the wrong place, as will appear from the following.

To shorten the transition from one period to another—as a general rule, from a longer to a shorter one—it is above everything else necessary to do away, as soon as possible, with the differences of weight of the fish, which they have reached in the years of growth of the former period, and gradually to cause them to reach those weights which are aimed at in the new period.

If pisciculture has been carried on systematically during the preceding years, it will be easy to ascertain which fish have to be fed artificially for this purpose. But, if this has not been the case, the first thing to be done is to arrange the stock on hand according to weight, to ascertain the number of fish of each weight, and put these data down, so as to get the necessary facts in the case.

For such a transition, however, neither the young fry, nor a portion of the same, should be fed artificially, but the required weight can, and must, at once be reached by a proportionate stocking of the ponds.

Unless one puts down these data in some sort of tabulated form, one

is very apt to make a mistake in the feeding, and instead of quickly reaching the weights required for the new period, and thus finishing the transition and perfecting the new period during the first year, this result will be still more delayed than would have been the case if artificial feeding had not been employed.

I will endeavor to illustrate this by an example from my own practice. Suppose a six years' period is to be changed to a four years' period, with a final weight of 1,250 grams. For this purpose there would be required for the sale-ponds, 12,700 fish—1,300 weighing at least 600 grams each per hectare; for the growing-ponds, of Class II, 12,700 fish—216 weighing at least 250 grams each per hectare; and for the growing-ponds of Class I, 12,700 young fry, 325 per hectare.

There are on hand from the preceding period:

		No. of fish.
Young fry:		
At 0.029 kilogram		18,760
Fish:		
At 0.113 kilogram	845	
At 0.143 kilogram	1,721	
At 0.169 kilogram	2,031	
At 0.181 kilogram	2,121	
At 0.249 kilogram	2,252	
At 0.280 kilogram	2,177	
At 0.341 kilogram	2,353	
At 0.467 kilogram	2,859	
		16,259
Fish:		
At 0.602 kilogram	1,683	
At 0.664 kilogram	1,900	
At 0.712 kilogram	2,712	
At 0.780 kilogram	2,722	
At 0.021 kilogram	3,497	
		12,514

(It should be observed that, in this case, there were actually about fifty different weights which, for the purpose of simplification, are here already distributed in groups, the average weight of which has been taken.)

If the six years' period had been preceded by a systematic course of pisciculture, the carp should, in this case,—where the weight of the young fry, when placed in the growing-ponds, was about 30 grams, and the final weight reached 1,280 grams,—have reached the following weights during the intervening years: in the first year of growth 155 grams, in the second year 342.5 grams, in the third year 635 grams, and in the fourth year 967.5 grams. I have to give these figures without the detailed calculations on which they are based, as this would lead us too far; but any one who has worked a six years' period will hardly doubt their correctness, as his experience will teach him that they are at least approximately correct, even if he should be inclined to smile at the idea of calculating such things with mathematical accuracy.

In supposing that in consistent and systematic pisciculture there are variations in these weights, *e. g.*, during the first year of growth from 120 to 200 grams, in the second from 300 to 400, in the third from 600

to 700, and in the fourth from 900 to 1,000, I think (at least my experience teaches me this) that one would go too far. In spite of this, however, we have very distinctly divided classes of fish before us, which at once suggest a six years' period.

If a four years' period is aimed at, with a final weight of 1,250 grams, the weights—all other conditions being the same—will be as follows: 274 grams at the end of the first year of growth, 640 at the end of the second, and 1,250 at the end of the last year.

As it can hardly be expected that those carp which do not have the minimum weight of 600 grams will in the sale-pond reach the final weight in a single year, all fish having less than 600 grams must, in the four years' period, be placed in the growing-ponds. The stock on hand for the sale-ponds is only 12,514 fish, whilst it should be 12,700.

In the growing-ponds of Class II no carp should be placed which do not weigh at least 0.250 kilogram a piece. Of those weighing from 0.249 to 0.467 kilogram there are on hand 9,541 which will certainly reach a minimum weight of 0.600 kilogram for the next year's stock for the sale-ponds. The number aimed at is 12,700. In order to reach this number we must, therefore, endeavor to bring 3,159 of the lighter carp up to 0.640, or at least 0.600, kilogram, which will not be very difficult to accomplish.

In order to raise the stock of the sale-ponds to the required number, 12,700, it will be necessary, as has already been stated, to raise the required number of carp weighing 0.467 kilogram by artificial feeding to the final weight. There will then still be 3,358 fish, varying in weight from 0.43 to 0.181 kilogram. The best plan will be to sell them; unfortunately there will not be many customers for such light weights. In the case before us a very large number, however, may be used to supply voids in some of the ponds. If there are ponds at some distance, or if a summer-course has been included in the system, these extra fish can, in some outside ponds, by feeding, be raised to the weight of the other fish. It would not do to place them in the growing-ponds, as fish placed in these ponds should have the same normal weight as the stock of such ponds.

If one has no ponds of one kind or the other at one's disposal, all that can be done is to overstock a suitable area of the growing-ponds of Class I and Class II, in order to obtain ponds for raising these extra fish, and to neutralize this overstocking by artificial feeding. If the transition from one period to the other is to be hurried it will be better not to use any artificial food at all than to feed artificially in the wrong place. In the case in question several thousand young fry have, by feeding, in one year been raised to a weight of 0.500 kilogram, and the feeding of the heavier fish has been omitted in order to enter the new period as soon as possible. Thereby the perfecting of the transition is considerably delayed.

If, instead of aiming at 0.500 kilogram, the feeding had only aimed

at about 640 grams, this would still have been a rational system, because then the fish would have been sufficiently matured for the sale-ponds. But if they only weigh 500 grams they cannot be placed in the sale-ponds with any hope of success, unless one intends to adopt, at least for one part of the fish, a five years' period; and, on the other hand, these fish are too heavy for growing-ponds of Class II.

In the case in hand I had expressed my doubts (in view of the natural power of growth and the quantity and quality of the food) that the 500 grams would be reached, and these doubts have proved to be well founded. From a later communication it appears that in one pond only 390 [490?] grams were reached, viz: 404 grams with 17,000 fish, and 550 grams with 100 fish; and in a second pond, on an average, 681 grams, viz: 500 fish weighing 666, and 420 fish weighing 857 (?) grams; after 608 fish out of the total number of 1,150 had been removed. There is no doubt that even if the normal quantity of fish had been removed, no greater weight would have been obtained than in the first pond.

Here the unequal growth is a striking feature. In my opinion the matter is sufficiently explained by the circumstance that the fish were not of a pure breed, but were a mixture of mirror carp, leather carp, and hybrids of other carps, and that the fish, when placed in the pond, very probably differed considerably in weight. Another, and not less weighty reason, seems to be the circumstance that the fish did not all derive the same benefit from the food thrown into the ponds. As the food used softened very slowly, and was inconvenient for the carp to take, the fish could not be induced to come and be fed in flocks, as they are generally wont to do, and take the food at once; but they only occasionally seemed to come and see whether there was anything for them to eat. It can easily be imagined that, under these circumstances, some fish came often, and others but rarely. At least my own personal observations have taught me this. If, on the other hand, one waits till the fish all gather—and it is known from long experience that, if fish are accustomed to be fed daily at the same time and place, they will acquire the habit of flocking together at the accustomed time—and then throws the food into the pond, so that it is immediately eaten by the fish, they will all get very nearly an equal share. Those which get more in the beginning, will, when they have had their fill, go away and let others get some food. It will therefore be best, in order that all the fish may get their share, not to throw all the food into the pond at one and the same time. Nor should the food be thrown in in small pieces, one by one, for then only the stronger and swifter fish would have a chance to get anything; nor all in a lump. If these rules are observed, artificial feeding will result in tolerably even growth of the fish. Feeding fish has to be learned like everything else, and experience will be the best teacher. Any one may easily convince himself of the truth of the above remarks.

To return to the transition from one period to the other, it may be expected that the fish in the sale-ponds will reach the final weight, and the young fry the weight of about 270 grams, required for the intended four years' period; in the growing-ponds of Class II, however, a great many carp should be placed which probably, under ordinary circumstances, will not reach the weight of 640 grams required for their being placedin the sale-ponds; and it would therefore be doubtful whether they would reach the final weight during the following year. There will be, at any rate—

	No. of fish.
At 0.181 kilogram	2,121
At 0.169 kilogram	2,031
At 0.143 kilogram	1,721
At 0.113 kilogram	845
Total	6,718

It will be evident that if these 6,718 fish had been over-well fed, they would have reached the weight of 640 grams, and the four years' period would have been perfected already during the following year; for then the growing-ponds of Class I would have received young fry, those of Class II fish weighing on an average 270 grams, and the sale-ponds fish weighing 640 grams; whilst, owing to the feeding of the young fry, the transition was delayed, and thus this one year, at any rate, was lost.