CHAPTER V.

The Propagation of the Goldfish

THE PROPAGATION OF THE GOLDFISH

As previously stated, the goldfish is oviparous and the spawn is fecundated after extrusion. Figure 54. The almost transparent white or yellowish eggs are about one-sixteenth inch in diameter and when first extruded have a slightly flattened, lentel shaped appearance but upon fecundation assume a globular form. Fertilized eggs retain their translucent appearance, but the unfertilized eggs become opaque or milky. The hatching of the ova takes place in from three to seven days, dependent upon the season of the year and the temperature of the water; and consists of the germination of the yolk, the development of the embrio, and the final evolution of the alevin or tiny fry still attached to the yolksac, upon which it nourishes for some days after hatching. Figure 55 will explain the metamorphosis of the egg and the development of the fry, the greatly enlarged illustration being that of a June hatching of spawn of a mottled male and a red and white female Chinese Telescope goldfish; and is (1) the newly exuded unfecundated ova, full and lateral views; (2) the ova four and ten hours after fecundation, showing germination and formation of the membrane; (3) the development of the embrio and plasmic processes at the edge of the membrane, twenty-four and thirty-six hours after fecundation; (4) development of the alevin and yolksac, fifty and fifty-six hours after fecundation; (5) free-swimming alevin attached to the yolksac, four days old; (6) alevin five days old; (7) the same seven days old; (8) the fully developed young fry ten days old.

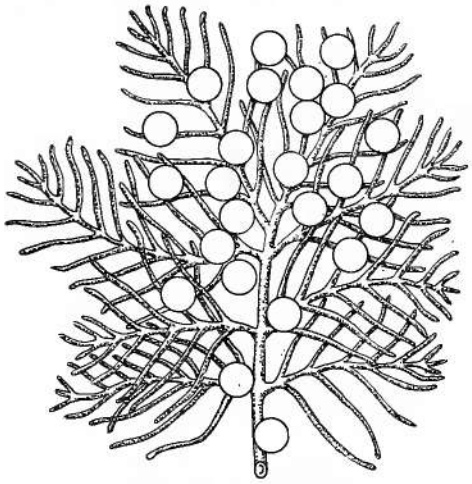


FIG. 54— Goldfish spawn attached to the leaf of an aquatic plant. Enlarged about two and a half diameters.

ARTIFICIAL IMPREGNATION. The author knows of no successful attempts at the artificial impregnation of the spawn of goldfishes, though this is successfully done with the eggs of the larger food fishes, and has increased the number of fertile eggs from 50% to 80% or 90% over the natural method of fecundation. Attempts in this direction would be most interesting, and there is no doubt of its being practiced by the Oriental breeders.

MATING. The mating season of the goldfish is during the warm spring and summer months, when the water is at 60° or over, and spawnings occur at frequent intervals, as with this species of Cyprinidæ all the

FIG. 55. Embriology of the Goldfish.

1. Newly exuded egg, not fecundated, wrinkled and unexpanded surface covered with vesicles. Full and lateral views.

2. Egg, four and ten hours after fecundation, showing germination and formation of membrane.

3. Development of embrio and plasmic processes at edge of membrane, 24 and 34 hours after spawning.

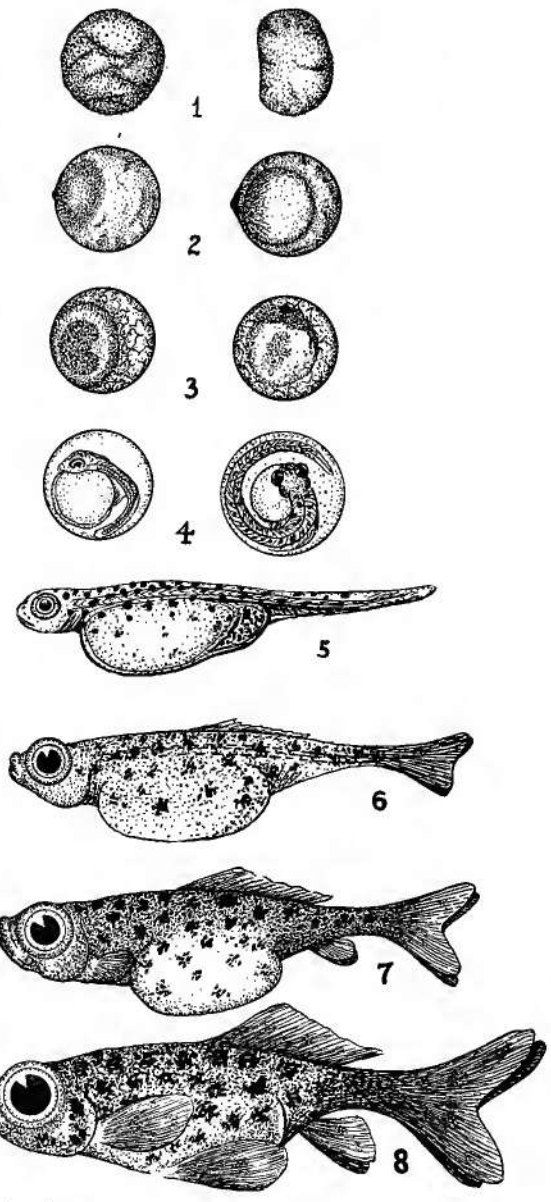
4. Development of alevin and yolk-sac, 50 and 58 hours after spawning.

5. Free-swimming alevin attached to the yolk-sac, showing skeleton, partly developed digestive organs and surface colors. Four days old.

6. Alevin five days old; dorsal and caudal fins partly developed.

7. Alevin seven days old; pectoral and anal fins developed.

8. The fully developed Telescope fry, ten days old.



Greatly enlarged. Actual size, No. 8, |——|

eggs do not mature at the same time. During this period the distinguishing characteristics of the male are developed and consist of wartlike protuberances or papillose tubercles on the operculæ and main rays of the pectoral fins, Fig. 10 (page 46), which have distinct sexual purpose. Another

means of discriminating the sexes is the appearance of the fishes near the anal region. The female shows a slight protuberance above the anus, the protrusion of the oviduct; while the male has a depression in this region as though a tiny piece of the flesh had been pinched out with the nails of the finger and thumb, Fig. 56. These latter differences are noticable at all times.

FIG. 56 Difference at anal region of female and male Goldfishes, for determining the sex.

The conduct of the male in pursuit of the female shows unmistakable evidence of courtship; swimming beside and around her, rubbing her sides and pressing on the ovaries with the head and tubercles, aiding her in depositing the spawn, often fairly forcing her on the spawning bed.

At this season the enlarged ovaries of the female give to her a decidely fuller and more distended appearance and also aid in the discrimination of the sexes, though the otherwise general conformation of body and fin may be alike. It is generally recognized, however, that the males of finely bred goldfishes incline to longer bodies than the females.

The female deposits the spawn, Fig. 54, on the leaves and roots of aquatic plants, its mucilaginous covering causing an adhesion thereto, where it is covered and fecundated with spermatic corpuscles by the male. To the breeder the preferable plants for spawning are Myriophyllum, introduced in loose bunches, and the Water Hyacinth whose finely spiked floating roots are well adapted to this purpose. Previous examination is advisable that they harbor no snails, insects, larvæ, or other enemies that may devour the spawn or injure the fry, if introduced with them into the hatching dishes. Preferably the plants should be placed in water for some time so that the larvæ will hatch and then thoroughly cleaned in a weak solution of Phenol-sodique before use for spawning.

When the fry has reached the stage of development that the yolksac entirely disappears, feeding is necessary and this consists of the tiny water plants known as Algæ, and of minute aquatic animalculæ which abound in quiet pools and still water, entomostraca of the genera Daphnia, Polyphema, Ceriodaphnia, Sida, Cyclops and Cyprus; also mosquito larvæ and those of harmless insects, of which more will be stated hereafter. Great care must be taken in the selection of this food that injurious insect spawn and larvæ, or the protozoa and fungi which produce diseases, and parasites are not introduced with it into the rearing tanks. This will also be treated of elsewhere.

If the breeding is undertaken in a small way, a fine net of cheese cloth and a jar containing a little pond soil and a water plant are required

to collect the animalculæ which constitute the entire requirements of the fry; but breeders usually employ a tank in which to store and propagate them under careful supervision.

When the fry have reached an age of about three weeks a few particles of clean, crushed earthworms, finely scraped liver or powdered prepared fish food may be occasionally fed, their diet being as described until they have reached an age of two or three months and are able to subsist on the food of mature fishes. Rice flour, oatmeal broth and finely powdered barley malt starch have also been fed to very young fishes with success; but the best results and most vigorous growth are obtained by feeding them their natural pond food two or three times daily; when this can be obtained it should be fed exclusively.

The common goldfish is easy to propagate but considerable experience, skill and knowledge are required to successfully rear fine specimens of the Japanese and Chinese breeds; of which the Comets, Fringetails, Fantails and Nymphs are more likely to reward the efforts of the amateur culturist than the very abnormally developed Telescopes and Celestials. There are but few breeders who have successfully done this on a commercial scale, though the requirements as to equipment are few and simple. A light, sheltered room, a greenhouse, conservatory, or in the open air during mild weather; a number of rearing tanks or other vessels of various sizes and depths of water; hatching dishes, jars or tanks; the proper aquatic plants and water supply; some few simple tools, patience, cleanliness, good eyesight, some little experience and a careful attention to minor details are required.

A prime factor in the successful propagation of the goldfish breeds is a judicious selection of the breeding stock, so that the desired characteristics of the parents may be transmitted to their young. The breeder should carefully select and mate those which most markedly exhibit the recognized perfections of strain, type, color and conformation, or such which are derived from known fine stock, as the constant tendency of the finely bred Japanese and Chinese fishes is toward reversion to the original stock or ancestral type; nor is this probably as much due to inbreeding as to the fact that the fishes, under the changed condition of existence, differences in treatment, climate, food etc., from generation to generation undergo a gradual variation from the direct parent stock, acquire a different form or become hybridized; and perfect specimens of the fine Oriental fishes are exceptionally rare. There is a general belief that all the methods employed by the Japanese and Chinese culturists, in developing and maintaining the pure strains and in producing the wide diversity of form, color and appearance of the different breeds are not known or fully understood by

the American breeder, goldfish culture being a comparatively recent industry in the United States, but has been a science in China and Japan for centuries and an occupation of very considerable magnitude, to which must be added the endless patience and perseverance which is characteristic of the Oriental. It is also known that they only retain those young fishes which are the most perfect of their respective kinds, as with all animals. even the most careful breeding will produce many variations from the parent stock, which in the goldfish leads to the hatching of imperfect fishes and "sports."

The breeding of the fine varieties is best conducted in tanks where the fishes may be kept under constant inspection and supervision, but the common goldfish multiplies rapidly in the pond; requiring only moderate attention, some little protection from natural enemies and sufficient food.

None of the early writers mention or illustrate the so-called scaleless goldfishes. These really are thin or transparently scaled fishes. The young of these breeds show a change from the dull to the bright colors almost as soon as the umbilical sac is consumed and when the fish is still very small. Under the microscope both the embrio and alevin show a mottled appearance different from the dull olivate color of the heavily scaled goldfishes. These thin-scaled fishes are the most sensitive to cold water and low temperatures, as they are derived from fishes bred in the warmer parts of China.

In breeding for color both parents should have the desired markings or have been derived from highly colored stock. To produce scaleless (transparently scaled) Japanese Fringetails a female Fringetail should be crossed with a transparently scaled male Chinese Telescope; as when the female is transparently scaled and the male scaled, a smaller percentage of the young will be transparently scaled. A scaleless (crossed) female Fringetail and a male scaleless Telescope will produce the telescopic eye and the Fringetail body and large fin development; and when both parents are scaleless (crossed) Fringetails, they are most likely to produce scaleless Fringetails with smaller and flat eye development than the Chinese Telescope, but larger than that of the common goldfish. These are the handsomest and most highly colored fishes, superior to the Scaled Japanese Fringetail stock.

Prof. John A. Ryder stated that experiments in shaking apart the cells produced by the first cleavage in the egg led to the development of two separate embrios from the same egg, as well as the production of monstrosities in both invertebrate and vertebrate animals. He mentioned experiments in producing double monsters by violently shaking the re-

cently fertilized ova of the pike, of almost entire broods of salmon composed of fry developed as double and triple monsters, each from a single yolk, by rough and careless handling or shaking of the ova during the early stages of their development; and the production of double monsters of the lobster and of birds by these and similar treatment of the eggs; which led him to the conclusion that the double-tailed goldfishes were produced by this or similar simple practices. The Orientals, by taking the eggs of the normal species and either by shaking or disturbing them in other ways produced some complete double monsters, some with two heads and a single tail, and some with duplicate caudal and anal fins. Of these the double monsters did not survive, but those with duplicated fins may have been kept alive and selections in breeding would continue the tendency to double fins.

It is known that crustaceans, batrachians, reptiles and fishes also have the power not only to reproduce lost parts, but of their regeneration in duplicate and triplicate, diverging from the point of mutilation. In tadpoles it has been observed that when the tail is cut off at right angles to the body, the new tip grows straight backwards in normal form, but when the cut is at an acute angle the development is, according to the inclination, either upwards or downwards; and that, if the growth of new material is interfered with across the narrow line of the stump, the growth will be to each side, producing a duplication of the part in diverging directions.

It has also been noted that this regenerative power diminishes in the higher animals, the last evidence being the reproduction of extremital parts; and that the rarity of the production of monstrosities, due to disturbance during the development, also diminishes, so that the continuation of these aberrations in successive generations becomes less frequent in the higher animal forms.

With fishes, however, the hereditary tendency to duplication of parts is a marked characteristic; and the goldfish and other Cyprinidæ tend to the retention of abnormalities; but which, in the natural state of pond existence would be lost, as fishes encumbered with duplicate fins, especially tails, would be less likely to reach maturity than those normally developed, though this sometimes occurs. Under the care of the breeder, however, these are fostered and by selection and careful propagation still further developed, until this tendency becomes a characteristic of the breed, and a considerable portion of the young continue the desired inherited peculiarity.

How this tendency is transmitted to the ova of the parent it is difficult to trace, but it is certain that the partially double bodies of the parents have some influence, and that the artificial interference with the ova or

with the normal processes of development, influences the first generation and these may transmit the effect and continue the peculiarity in the future generations.

Abnormal modifications in the goldfish breeds are not restricted to the fins, but affect the body, head and other organs, but in some respects the type is fixed, as in the number of scales in the lateral line and the number of transverse rows of scales on the body, though a displacement of the organs, a shortening of the body muscles and of the segments of the vertebra, is evident in the shortened body; to compensate for which the overlap of the scales and of their surface varies very considerable in the different breeds. Variations of the head consist most largely in a shortening, by compression, of the snout and of the position of the mouth, which in some breeds is modified to an almost vertical position. The form and position of the nostrils are also changed on the short snout.

The degenerative changes are not alone due to careful selection, but are also attributable to the restraint of an aquarium existence; the enforced disuse of the muscles producing an exaggerated growth of all the fins, as "the material saved from expenditure in muscular effort may be expended in growth in another direction, and culminates in a lengthening of all the fins, so that they are an actual hindrance in swimming."

The highly bred varieties have become entirely unfitted to existence other than in the aquarium under the fostering care of the breeder, and the young of such breeds, if they survive at all, revert more and more to the ancestral type with each succeeding generation when deprived of this supervision.

A sluggishness of habit has also been developed by the Oriental breeders, as both the descriptions of authorities on the propagation of the goldfish and the observations of fanciers prove; and with some of the highly developed varieties has been carried to such extent that harmless fishes of other species must be kept with them in the aquaria to agitate the water and prevent suffocation.

Some of the races are so monstrously developed and the displacement or the crowding of the swimming bladder so extensive that they cannot maintain their equilibrium in the water, but assume a position as though standing on their heads or tails, or partly or entirely reversed.

Professor Ryder prepared tables of measurements, in millimetres, of the three breeds of goldfishes obtained from Philadelphia breeders in March, 1893, which are here given in condensed form; but it should be stated that at this writing more varieties and even more wonderful developed fishes are sucessfully bred.

RACES	Total length of head and body.	Length of body.	Length of head.	Length of intestine.	Width of the trunk behind the body cavity, between it and the base of the caudal fin.	Length of caudal fin.	Distance from vent to caudal fin.	Ratio of head to length of intestine.	Ratio of total length to length of intestine.	Ratio of total length of head and body to the length of the caudal fin.
Common Goldfish.	90	62	28	364	15	36	25	1:13	1:4.45	2.5:1
Two long bodied Japanese long-tailed Goldfishes.	74	51	23	213	10	80	19	1:9.25	1:2.85	1:8.3
Three short-bodied Japanese double-tailed Goldfishes.	47	28	19	226	7	36	10	1:11.75	1:4.6	1.33:1

He also pointed out that "the large number of capillaries in the huge tail of fine specimens of the 'Kinyiki' and KIN-YU races indicate that the caudal fin may possibly serve in a very important way as an adjunct to branchial respiration", and that "the immense fins of the Japanese double-tailed goldfishes have been developed partially in physiological response to artificial conditions of respiration, that were not as favorable as those enjoyed by their wild congenetors", and, " that the dorsal, anal and caudal fins may be so modified as to minister in an important way to the needs of respiration." Also, "the fact that the very long fins are only fully developed at a very late period of the growth of the animal, is in harmony with the view that the hypertrophy of these organs is associated with a correlative degeneration of the muscles of the trunk, and possible use of these structures with their great amount of surface as respiratory organs, in the restricted and badly aerated tanks and aquaria in which they have been bred for centuries."

The very red color of the blood in the arteries and capillaries of the fins would indicate the correctness of this hypothesis.

The comparisons of the telescopic-eyed goldfishes are equally interesting. Professor Ryder states that " the eye-ball becomes greatly elongated in the direction of its optic axis. Sometimes the difference between the axial and equatorial diameter is as much as three millimetres, constituting an extremely myopic form of eye-ball. The form of the eye-ball in the common races is flat or hypermetropic in character. A gradual passage from the hypermetropic to the myopic form is shown in the following table, as based upon actual approximate measurements of the eye-balls of individuals of the three races. The size and shape of the globular lens is not appreciably different from that of the other races with smaller eye-balls. It would therefore, seem impossible for the image formed by the lens

of a distant object to be thrown on the retina at all, consequently the condition is one of near sightedness, or of an optical adjustment for very near objects. The conditions of life * * * would in their restricted quarters actually foster the development of near sightedness, and any variation in that direction would actually tend to be preserved. * * * The name telescope fish in allusion to the protruding eye-balls becomes a misnomer, as the form of the eye is distinctly myopic and short-sighted, and not hypermetropic or far-sighted, as required of an optical organ having telescopic capacity." The Chinese designation "Dragon-eyes," would better apply to these breeds of goldfishes.

RACES	Total length	Equatorial diameter of eye-ball	Axial diameter of eye-ball
Common Goldfish.	130	7	5
Double-tailed Japanese Goldfish.	55	5	4
Telescopic-eyed Goldfish. No. 1 - -	63	6	6
No. 2 - -	70	6	9

All measurements in millimeters.

Dr. S. Watase, in writing "On the Caudal and Anal Fins of Goldfishes" states that in his opinion, artificial selection has produced the abnormal forms of all the fins, and that in all goldfishes, irrespective of what breed, the tail fin is above all other parts subject to the greatest variation.

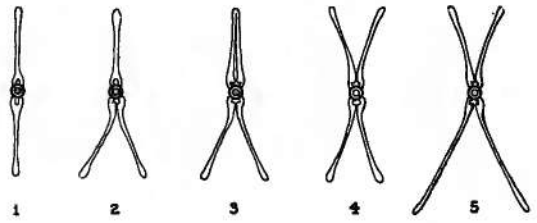


Fig. 57. Diagram of the vertebra and tail-rays of Goldfishes.
1 Single tail of the Common Goldfish.
2 Tripod tail of the Chinese and Japanese Goldfishes.
3 Webbed tail of the Chinese and Japanese Goldfishes.
4 Double tail of the Japanese Fantail Goldfish.
5 Double tail of the Japanese and Chinese Fringetail and Telescope Goldfishes.

It is found in one of the following states: 1, it has three lobes, one median and two lateral; 2, it consists of two separate halves (*paired*) giving rise to a four-lobed tail (the "*Yotsuo-wo;*") and 3, it is vertical and normal. In the first two classes, the lobes are more or less horizontally spread. The simplest transition state from single to double, is seen when the tail, normal in all other respects, has the ventral edge slightly furrowed by a median groove.

The greater part of it is vertical and median, but its lower portion occurs double, (the *tripod tail,*) which in some cases extends further upwards, (the *web tail.*) In other instances the furrow may reach the dorsal edge of the tail and thus divide it into two halves, which then expand right and left. These halves may or may not be connected at the median line, at the dorsal edge; in the former case, the tail is represented by a more or less horizontally expanded single piece, (the *dolphin tail;*) in the latter case it is distinctly paired, (the *double tail.*) Fig. 57.

Next to the caudal fin the anal fin undergoes a remarkable variation. It is either median and normal or distinctly paired. In the former case, especially when the caudal fin is also normal, the goldfish closely resembles the carp. In the double form of the anal fin, bony structures similar to those of the single fin are present in pairs. These double fins often make a flapping motion serving the same function as the ventral fins. Examination of the embrios of these breeds of fishes show that the double caudal and anal fins are laid out as two longitudinal folds or thicknesses along the ventral side of the post-anal section of the body, which diverge at a later period and form paired caudal and anal fins. The internal structures of these parts are also paired. In some of the breeds the anal fin is entirely absent and others have been developed which are devoid of dorsal fins, while the Egg-fish has neither dorsal nor anal fins.

Breeding. It is proposed to treat of tank culture first and later of the basin or pool and pond or lake culture, these latter terms being applied to the smaller brick or cement basins and pools or those with earthen or boarded sides, and the larger natural or artificial ponds and lakes.

When the breeding is conducted indoors or in a greenhouse the season is earlier than in the open air and spawnings may begin in February, while out-of-doors or in the pond, in a temperate climate, the fishes may not mature the spawn till April, May, or June, after which it may be continuous, at short intervals, until the advent of cold weather. Spawning is also dependent upon the temperature of the water and rarely begins until it has reached 60° F.

The period of rest between spawning varies with the fishes and may be but a few days or several weeks, dependent upon their vigor and the temperature of the water. Spawning may occur two days in succession, or at an interval of several days, if the weather becomes colder, to be resumed when the water becomes warmer. Of this the surest guide is the appearance of the female and the action of the male, and trials with the latter should be undertaken, the fishes being again separated if no spawn results in a day or two. An occasional change of males is also advisable. Stimu-

lating food and the frequent addition of well-aerated water also greatly aid the spawning. As soon as the spawn is deposited and fecundated, which usually takes place early in the morning, the plants to which it adheres should be placed in the hatching dishes or the parents removed from the tank or rearing trough, to prevent their devouring both the spawn and later the young fishes. The fry also prey on each other, and hatchings of different dates should be isolated until the fishes have acquired considerable growth and are of equal size; those of slower development and smaller size to be either put by themselves or with the next younger hatch; where their chances of obtaining food are improved, or the larger and more vigorous ones removed. In breeding fine fishes it will be noticed that the single-tail "sports" always make the most rapid growth, as they are better able to get about than their finer double-tailed brethren. They are also the natural cannibals and prey upon the smaller more perfect fishes.

The depth of water for hatching and for the fry should best not exceed 6 to 8 inches and when transfers are made, the dishes and their contents should be submerged and the fry permitted to make their exit at will. Change in the temperature of the water is also usually fatal and must be guarded against in making tranfers and at other times.

If there are no facilities for separating the parents and spawn, as in the small way in the house aquarium, a movable partition will serve; but it is best to hatch the spawn in separate vessels which can be placed in good but not too strong light, where eggs and fry will remain undisturbed. Shallow glass, porcelain or enameled dishes, fruit or candy jars, or other similar receptacles will fully answer the purpose, and are generally employed.

The relative size and vigor of the fishes regulate the number of males and females mated, to which individual judgment is the best guide. With the facilities at hand each female ready to spawn should be placed in a separate compartment with one, two or three males, dependent upon their size; but when the spawning has begun, selection of the finest male should be made, if he is of sufficient size, and the others removed to prevent too great exhaustion of the female. Care should also be exercised to prevent inbreeding by mating fishes of different strain or parentage. Where the number of fishes to be bred is large and of the same breed, it is advisable to select two or three males to one female, when she is the larger, three females and four males when of one size, and six females and four males when the latter are the larger fishes; but this, like much else relating to the culture of the goldfish is a matter of experience and applies more to the breeding of the ordinary than the finely bred varieties. A change of males is also advisable at different spawnings.

Should the rearing of the fishes be conducted in the open air, on a large scale or in pools or lakes, much that has been stated will apply; as with whatever method adopted the results are always more certain when the hatching is done in dishes or shallow tanks and the fry only transferred to the rearing ponds when sufficiently developed to find their own nourishment and too large to readily fall a prey to their numerous enemies. The temperature and condition of the water is thus under control, the spawn and fry better protected, feeding can be regulated, and a closer supervision had of all the details which lead to success.

Attention should also be given to the selection of such breeding fishes, especially with the common goldfish, which evince rapid growth and soonest develop color, as this may vary considerably, some fishes being very vigorous, growing to a length of 4 to 6 inches in a few months and assuming the desired colors when quite small, while with others this may have been delayed until the following season; and as these and other tendencies are likely to be transmitted to the progeny, a study of the parents is necessary to insure satisfactory results.

In pond or lake culture, where the fishes are turned in and permitted to breed at will, few precautions other than those of water supply, abundant food, protection from freshets and the larger predatory animals are possible; but when the breeding is done in prepared basins or pools, a very considerable supervision and control of the essential features are possible. A careful supervision, even from a business point of view, is advisable, as both the returns and the quality of the fishes are so greatly increased and better as to repay the additional care and labor involved.

Should the breeding stock have been sheltered indoors during the winter months, which with the facilities should be done, care must be taken not to transfer them to the open air tanks or basins too early in the spring as serious mortality may result. The fishes have lost much of their hardiness, and are liable to congested colds, affecting the gills and circulatory system. Such fishes should be placed in tanks or spawning beds protected by hotbed sash to moderate the temperature during the night and early morning, until they have once more become acclimated to out-of-door conditions.

Though spawning early in the season has a number of advantages from the commercial standpoint, as the young fishes may mature sooner and will be ready for sale when they command better prices, their enemies less numerous, as many of them will not yet have appeared, and thereby assure the arrival at maturity of a greater number, very early spawnings are usually not as robust and vigorous as those of later hatching.

Where the breeding is done in protected tanks, in the open air, it has been proven that better results are obtained by delay than by forcing, as these later fishes often outstrip the earlier ones in size and number of survivals at the selling season, which is usually after the month of September; but late spawnings are not advisable, as the young must then be carried over the winter.

The age as well as the probable maturity of the goldfish cannot always be determined by the size, the rate of growth not only varying with the individual but is also greatly influenced by the conditions under which it is, or has been, kept. When the surroundings are nearest the natural, growth and development are most rapid; indoors and in the small aquarium the conditions of existence are artificial and unnatural and may considerably stunt, dwarf or arrest development; but when transferred to larger tanks or basins in the open air, the growth is often surprisingly rapid, the increase in size being usually greater in a few weeks than during previous months in the aquarium or greenhouse.

The size, however, does not impair the fecundity of the fishes as those of small size and but eight (8) months old will spawn, though, naturally, developing less and apparently smaller eggs than the larger more robust fishes. Some individuals of the imported varieties are dwarfs and never attain a size over three inches; these are particularly desirable for small aquaria. They are fertile and breed as well as larger fishes. Aquarium rearing almost always dwarfs the fishes, but they are usually of finer appearance than those reared in the pond, for reasons already given.

Under favorable conditions, the goldfish attains to maturity during the spring and summer following that in which it was hatched, and large, vigorous fishes will spawn 1500 to 2000 eggs in a season. It has been established that fishes of the finer toy breeds under two years old have more rounded fins than older fishes, whereby their age may be determined. Also that fishes under four years old are the best for breeding, producing a larger number and more robust young.

Though, as stated, any well-lighted room will serve for the culture of the goldfish, especially a properly constructed and equipped greenhouse, having out-of-doors facilities for the young fishes, on a mercantile basis the industry is usually conducted in the open air, either in specially equipped hatching and rearing establishments or in basins and pools fitted for the purpose. There are a number of small and larger plants of this kind in the Eastern Section of the United States, principally devoted to the culture of the common goldfish; but some of the breeders have turned their attention to the more profitable industry of rearing the finer breeds and

with varying success, as the results of a season's labors depend upon many conditions not yet fully understood but which longer experience may remedy. Success with directly imported Japanese and Chinese goldfishes is equally uncertain; the mortality before arrival, from diseases, contracted during transit and before acclimatization, being in such proportion as to make this also a precarious business venture. Importations are made during the most favorable season, the late fall, winter and early spring months, but the results are usually such as soon to discourage many enthusiasts who otherwise would become profitable customers. The survivors in the home aquarium are so very few that American bred fishes of the choice imported breeds are more desirable and command higher prices, as the percentage of fatalities of imported stock is so considerable as to prevent a profitable venture.

The greatest discouragement to the breeder is the failure to raise a large proportion of the fishes hatched. This may be due to easily explained reasons or possibly caused by mistakes made in remote stages of the development of the eggs or of the parent fishes; and when the fry perish in unusual numbers, it is not sufficient to seek the cause in recent occurrences but all the conditions of feeding and care of the parents as well the young should be considered and corrections made in the future. At best, the survivals are usually small in proportion to the number hatched and even the most experienced breeders do not expect a greater survival than 20 to 25 per cent. of the most promising hatches which have arrived at an age of two or three weeks, after which he should separate the finer developed fishes from the less desirable ones, and of these rarely over 5 per-cent. will be fishes which will be considered perfect in conformation and development by the expert fancier.

The least touch will affect the mucous membrane of the alevin and may lay the foundation for a future fungus development, and the fry from very young fishes or those which have not received a sufficient supply of oxygen by overcrowding, or those of parents which have not had a frequent change of water to act as a stimulant some little time before spawning, are usually weaklings and do not survive. Young fishes should be handled with a spoon and never taken out of the water.

The constantly growing demand for goldfishes is such that extensive cultivation is certain to be remunerative. In the Eastern States, at some seasons of the year, the supply is often exhausted and dealers complain that fishes are hard or impossible to get; which applies to both the common and the fine breeds and assures a ready market to breeders having the facilities for keeping their stock until times of greatest demand, usually at the Christmas season and in the spring when the breeding fishes are sought.

As it is the purpose of this volume to treat the subject not from the business point of view only but to interest the amateur and professional breeder alike, it is desirable to describe the breeding methods separately beginning with the simplest. The suggestions given should be modified to suit the conditions.

AQUARIUM AND TANK CULTURE. This method is usually employed by amateurs and fanciers with limited facilities, and undertaken as a pleasant diversion. The requirements are an open space, good light, one or more tanks, sawed-off barrels or similar clean and seasoned vessels of varying depth of water, which have been thoroughly scalded, scoured, frequently watered, filled and left standing for one or more months, and on which a growth of algæ has formed, success always being surer the longer they have been in use for this purpose. They should be placed in a bright and sunny location, accessible to water; clean potted plants placed therein and permitted to stand to accumulate oxygen and the minute animal life which is not only beneficial in removing the refuse, decayed particles of plants and excrement, but also serves as food; care being necessary in the establishment, seasoning and maintenance of the spawning and rearing tanks, which often require more than one season's use to be in perfect condition. When let into the ground they maintain a more equitable temperature, but set above the ground are not so accessible to some of the enemies, frogs and cats among the number. It is advisable to cover the tanks with wire screens as a protection from the larger enemies.

As elsewhere stated, either the parent fishes may be placed into the tanks to spawn and then removed, or the plants to which the spawn adheres placed therein and permitted to hatch, the former being the better method as then none of the eggs will be lost.

BASIN AND POOL CULTURE. Basins and pools may be built of bricks laid in cement or mortar and lined with cement, of cement concrete, or on a good clay bottom with the sides of boards backed by well puddled clay. Their proportions should be such that a careful observation of the entire contents is possible and when based on a factor of 4 or 5 feet many advantages will be manifest; that is, a breadth of 4 feet and a length of 4, 8 and 12 feet; or a breadth of 5 feet and length of 5, 10 and 15 feet, so that glass sashes, wire covering, etc., are interchangeable, the capacity and the number of fishes for each size easily kept in mind, and the available space well occupied by this systematic arrangement.

An easily constructed basin is one of circular form with sloping sides, as the earth may be evenly excavated, the bottom leveled off, and brick or concrete sides built directly against and upon them. The action of frost

is also less severe on circular than rectangular basins and a basin of this kind is more likely to be lifted off the bottom than to break the sides by the pressure, and is easily repaired by filling in the bottom crack with liquid cement. All tanks should be seasoned before the fishes are introduced by a thorough soaking and frequent changes of water, to remove all traces of soluble lime or acid substances.

When not in use, it is a mooted question whether they should be kept dry in winter or partially filled with water to equalize the pressure of the frozen ground. Good results have been obtained by filling with water and floating logs in them to relieve the sides of ice pressure, while freezing will destroy fungus and disease spores.

GREENHOUSE CULTURE. Experience has taught breeders of the goldfish that the principal purpose of the greenhouse is the wintering of the breeding fishes, keeping over young fishes for better prices when the general supply is exhausted, and for spawning, hatching and rearing of the fry during the early weeks of the spawning season, when the possibility of late frosts may endanger them out-of-doors, though early spawning is not to be generally recommended.

Another purpose of the greenhouse is the facilities it affords in continuous growth of the young during the winter months, as aquaria and small household tanks tend to arrest development; also for the preservation of the necessary aquatic plants over winter. Young fishes, however, thrive best in the open air.

Compartment tanks and cement basins, should be arranged to place as many as possible in the available space, and to permit of ready access and inspection. When the weather has become settled, the rearing should be done out-of-doors. Great care must be exercised in seasoning these receptacles.

The illustration, Fig. 58, is a greenhouse for goldfish propagation designed by the author, which may be erected in a back yard or garden. All the sash of the sides and roof are hinged, to permit of raising or removal in warm weather for the free circulation of air, a prime essential to success. The spawning and hatching tanks are arranged at the sides, to permit of a central aisle, and the overflow connections led to the drainage by pipes with union joints. The water supply is by a hose. The rearing tanks are shown adjoining the greenhouse but may be located within convenient distance and should be provided with portable glass sash as covers on cold nights and mornings and with wire screens to keep out enemies. If the screens are of galvanized iron, they should be thoroughly cleansed and seasoned, to remove the acid.

All the openings are protected by screens, those of the roof by gauze netting and the sides by $\frac{1}{4}$ inch-mesh wire screens to exclude obnoxious

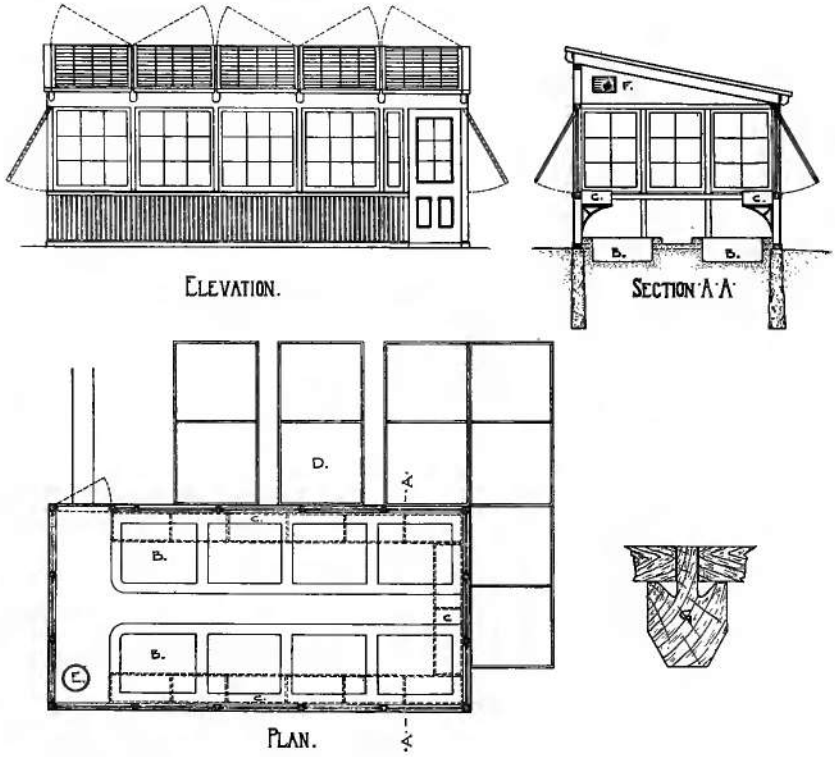


FIG. 58 Elevation, plan and section of a Greenhouse for Goldfish propagation.

A-A Line of section.
B Cement basins, 3′ 9″ x 3′ 0″ x 1′ 4″.
C Shelves and Hatching tanks, 2′ 10″ x 1′ 6″ x 1′ 2″.
D Rearing tanks, 4′ 0″ x 8′ 0″ x 1′ 3″.
E Oil or gas stove.
F Ventilator.
G Detail of Roof supports to prevent dripping.

insects but to permit small flies, gnats, mosquitoes and other harmless insects to enter and deposit their eggs, the larvæ serving as food for the young fishes.

Heating arrangements other than a portable odorless oil stove or a small coal stove are not required, and these need only be employed in the most inclement weather; experience having proven that goldfishes thrive best when not kept in too warm temperature, 45° to 50° F. being better than higher, and if no rapid changes take place those just above freezing are not injurious, except to the transparently-scaled Chinese breeds developed in a warm climate. Warmer water is necessary during the breeding season.

The sash of the greenhouse should be arranged to open in the direction of the prevailing summer winds.

The principal reasons for failure to rear many young fishes, apart

from improper feeding and other evident causes, are too much light, particularly strong sunlight, which should be guarded against. Daily ventilation is also required, especially when the heating apparatus is in use.

POND AND LAKE CULTURE. Figs. 59 and 59A. With this method, the rearing ponds should not be of the same depth of water, but vary from 3 or 4 feet near the outlet to a few inches at the inlet, that the fishes

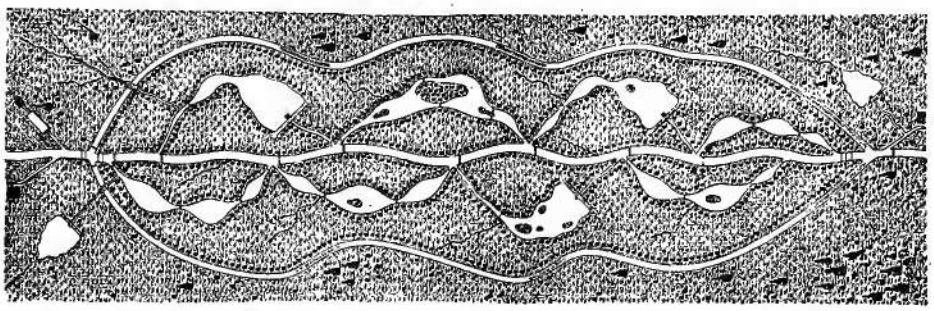


FIG. 59 Plan of a Fish Farm.

may seek any desired depth and relieve themselves of the water pressure, but constructed that they may be entirely drained when necessary, and free from obstructions that they may be seined. Each should have independent inlet and outlet, but also arranged to connect in series, when desired. Ponds should not be formed in streams, but at a safe distance and the water led to them through sluices which can be closed in case of freshets or too muddy water.

Each season the ponds should be drained, thoroughly cleaned and the upper layer of soil removed from the bottom. It is also advisable to leave them exposed to frost for a time to exterminate insects and other enemies.

One or more small isolated emergency ponds, containing a plentiful growth of plants and arranged for draining, should be established; into which fishes may be placed in case of mishap, serve as reserve ponds for temporary storage, utilized for fishes of retarded growth, or for the separation from the general stock of selected future breeders.

A small basin dug into the soil or having a soil bottom, thickly grown with aquatic vegetation, to supply the water with oxygen and for the propagation of the live food, should be arranged between the water supply and the rearing ponds; and if the water is derived from a spring it should not be too near the ponds, that it may not be of too low temperature and also in flowing over stones or artificially constructed ripples absorb a large quantity of air, as spring water is deficient in oxygen. The water of a shaded cold-water brook is preferable, river or pond water is not as desirable on account of its rising temperature in the hot summer months.

Ponds dug into the earth or constructed by dams are less expensive than those built of bricks or concrete, but the latter are more easily supervised, as the perpendicular sides offer a clear view of the contents and protection from the direct rays of the sun during hot afternoons. However constructed, shrubbery and shade trees should be planted along the banks and a luxuriant growth of water plants encouraged in them, restricted to localities where they will be under control. For this purpose Cabomba, Myriophyllum, Giant Anacharis and *Ludwegia mulerttii* are best and will find a ready market; but floating bunches of watercress will root and thrive on the surface, furnish oxygen and offer convenient hiding places and shade for the fishes and homes for the small aquatic fauna constituting the natural food; having the additional advantage of ready removal when desired. No plants other than these and lilies should be introduced or permitted to grow. Sagittaria will not grow out-of-doors. All sod should be removed from the bottom and the sides at the water level to prevent the injurious decay of vegetable matter.

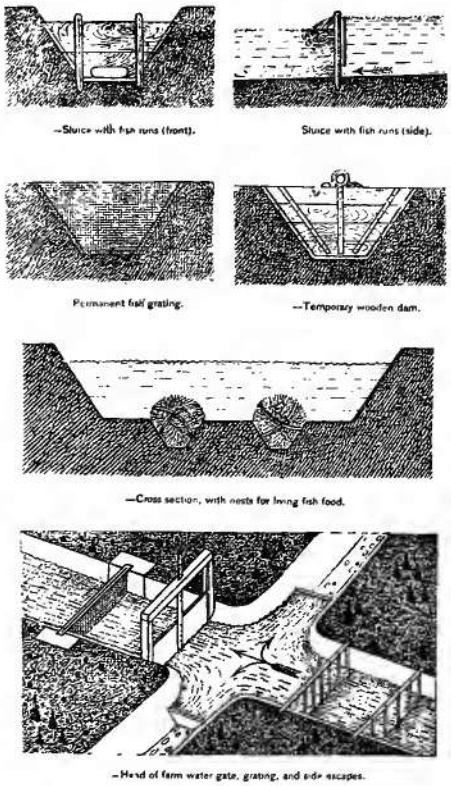


FIG. 59A Sectional views of Sluices and Ponds.

Feeding tables in the water are not advisable as they may become foul from decaying matter, culture places for parasites and safe retreats and lurking places for enemies which shun the light of day. The fishes soon learn to congregate in the desired localities at the regular feeding time and will keep the bottom clean and clear of food, if not overfed.

Let it here be again noted that goldfishes of the fine breeds become more course in large bodies of water than those reared in small tanks and basins.

SPECIALLY EQUIPPED GOLDFISH BREEDING ESTABLISHMENT. The illustration, Fig. 60, is an ideal arrangement for a large artificially constructed breeding establishment for fine fishes. Its location would best be in the country near an abundant supply of clear, moderately cold-water,

derived from a constant spring or shaded brook; the best site being a sunny location, a natural valley or a hollow, sheltered by hills or woods in the direction of the prevailing cold winds.

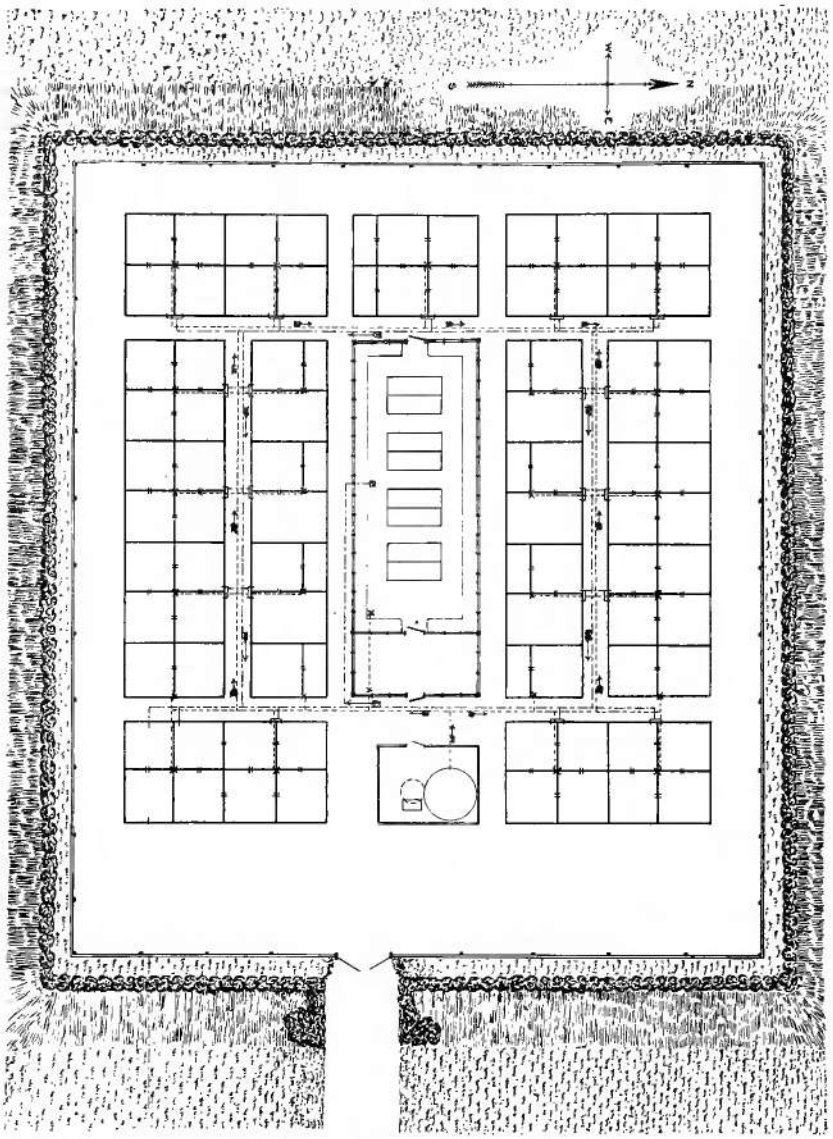


FIG. 60 Arrangement for a large Fish-culture Establishment for the propagation of the Goldfish.

A central greenhouse is surrounded by rearing and breeding basins; a shed containing the water collecting tank and a pump; the water supply and drainage system is indicated, and the premises surrounded by a board fence, sheltering embankment and shrubbery.

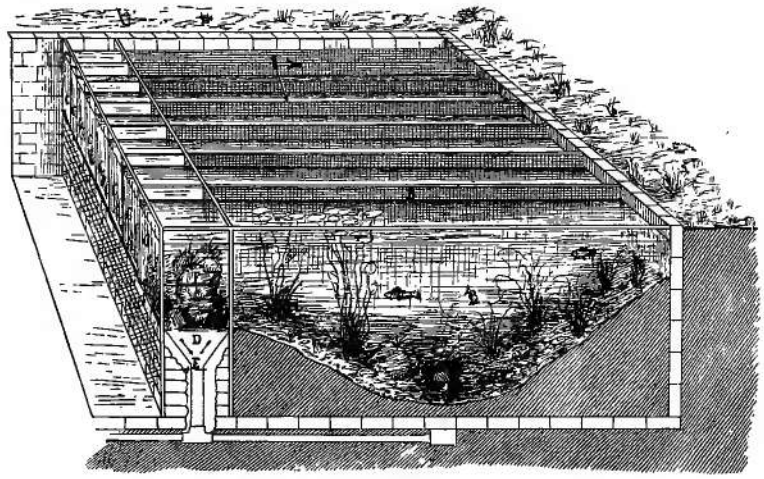
An establishment of this size with sufficient breeding fishes, after a

successful season, should produce many thousands of goldfishes of both the common and the highly prized Oriental breeds, for which there would always be a constant and remunerative demand. The Paradise Fish, Ide and Tench could also be cultivated.

POND AQUARIA. Vol. VII of the Bulletins of the U. S. Fish Commission, 1887, gives two excellent suggestions for pond aquaria which are here reproduced and no better explanation can be given than to quote the accompanying article by Mr. Wm. P. Seal:—

"With this idea in view I offer the following suggestion for the consideration of those interested in the establishment of large aquaria, hoping for further development through interchange of ideas.

The plan or principle herein suggested might be termed not inaptly Pond-Aquaria, it being essentially a combination of the pond and the aquarium; the aquaria being constructed on the margin of the pond or reservoir used, as shown in the accompanying illustration, Fig. 61; the



POND AQUARIA.

FIG. 61 Pond Aquarium.

idea being to have a water-pen or pond-garden (A) extending back from each aquarium front, and to be surrounded by a wire or other fence or partition (B) of sufficiently small mesh to prevent the escape of the occupants, but large enough to allow the smaller fry, which would furnish them with food, to pass through freely. (C) represents the glass fronts. (D) the upper or perforated aquarium bottom, which allows the escape to a lower funnel-shaped bottom (E) of all sedimentary deposits. (F) represents rocky eminences containing pockets, in which could be planted aquatic vegetation at depths adapted to their needs. The whole creating a close approximation of natural conditions. An arrangement of wire gates would keep fishes in close confinement for short periods for observation, or would keep some, while others were allowed to roam at will in their domain.

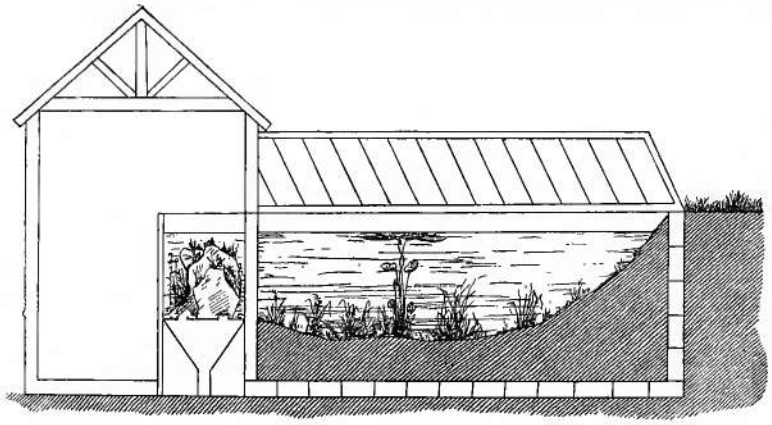
Fig. 61A represents a cross-section of the same, showing building over the aquaria, and greenhouse roof to pond-gardens.

The advantages of some such plan will, I think, be apparent to all who have experience on the subject at least. It is simply imitating nature more closely and getting rid of artificialities.

The conditions would afford natural vegetation, sunlight, mud, sand, and rocks, with abundance of room in which to move about freely and seek for natural food.

By such a plan also the necessity for circulatory apparatus is dispensed with, the circulation caused by the movements of the fishes, changes of temperature and evaporation, together with the aeration or oxygenation affected by the plant life being ample, as in the pond.

It might be argued that, with so large a space, fishes would keep hidden from view. The experience of the writer has been that when the fear of danger is removed and animals become confident of an ability to escape at will when threatened by danger they lose their timidity and



INCLOSED POND AQUARIA.

FIG. 61A Section of Enclosure for a Pond Aquarium.

become both bold and curious, and are more easily and satisfactorily viewed than when under the influence of fear in close confinement. The deer, the most timid of animals, when confident of safety, becomes perfectly content, and without desire to escape except to seek its kind for company.

The experience of the writer in the care of fishes and reptiles and other animals as well, is to the same effect."

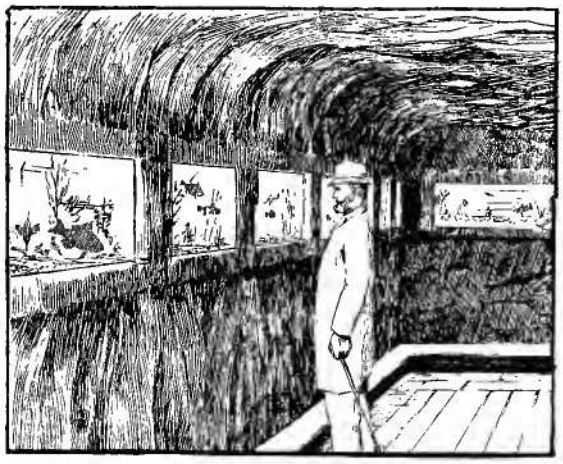


FIG. 62 Grotto at the Central Station of the U. S. Fish Commission, at Washington, D. C.

AQUARIUM GROTTO. The same authority describes the aquarium grotto attached to the Fish Commission building at Washington, of which the herewith reproduced illustrations give an adequate idea. Figs. 62 and 63.

WINTERING GOLDFISHES. In the household the fall, winter and spring months are the seasons when the aquarium is the most appreciated, and considerations for wintering are for the surplus fishes and breeders, or for

such as have been kept in outdoor tanks and basins in favorable weather but which must be otherwise accommodated during the rigors of cold weather. The best success is had when fine fishes are kept only about four months in household aquaria, after which they should be placed out-of-doors.

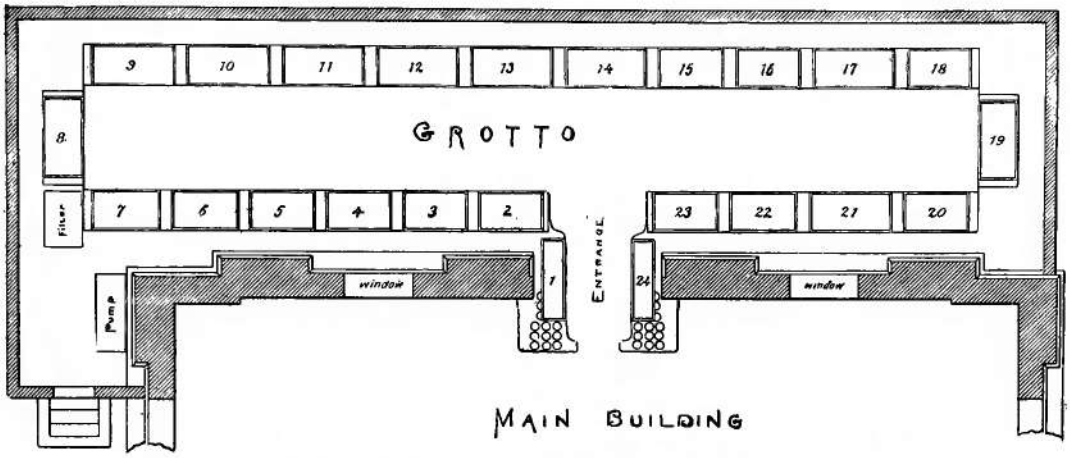


FIG. 63 Plan of Grotto at the Central Station of the Fish Commission, at Washington, D. C.

The ordinary goldfish will survive out-of-doors, if the ice is broken to admit air. The tanks should be of sufficient depth so as not to freeze solid, and straw or other materials should be packed about them for protection. A board cover, with straw spread over it, should also be provided, to moderate the cold. An approved method is to permit an inch of ice to form, after which a hole should be cut and sufficient water removed to make a space of two inches between the ice and the water, and the hole closed with a cloth and a board. If the sides are protected, the cold will not cause a further freezing, and the air space will prevent suffocation. The top of the tank may also be covered, after which the fishes will be in comfort until the advent of spring. Feeding is only necessary at long intervals.

The fine breeds should be wintered in a greenhouse or in the cellar. Tanks or similar vessels will serve, but the best receptacles are fibre wash-tubs. These should be set upon supports near a window, for occasional ventilation, but no plants introduced unless the light is such that they will grow. The fishes should have ample water, five gallons per fish, if possible, and once a week a pail or two of water should be siphoned from the bottom around the edges, where the excrement will accumulate, and a like quantity of fresh water added, which has been moderated in temperature. Feeding should be light, once a week, and but a small quantity of nutritious food given. Fishes so wintered will remain in fine condition,

the only danger being a possible lack of aeration in the absence of plants, which should be guarded against by the occasional partial change of water.

Where there are facilities for water supply and drainage an excellent plan is to arrange an overflow pipe and a constant very small inflow of fresh water. A sheet of glass suspended vertically over the tank, to which a very small hose is attached, will occasion a constant dripping to both aerate the water and moderate its temperature. A very considerable constant water supply has been found to be objectionable, as the low temperature of the water direct from the mains in winter is injurious to the finer goldfishes, which have been bred and kept in a warm climate and lack the hardiness of the common goldfish. Snow water is usually fatal to the finer breeds.

Goldfishes are sometimes kept over in tubs in moderately warm cellars without any attention or food, and though they have survived, this is an inadvisable practice and an unnecessary cruelty.

Wintering in large aquaria and tanks is best, and should be adopted wherever the facilities are to be had. Any unoccupied light room will serve, and temperatures above freezing are not injurious, except possible to the transparently scaled fishes, if no sudden changes occur. Under these conditions aquatic plants can usually be kept in growing condition to supply the required oxygen. The water should be occasionally partially changed.