THE CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN.

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B. B. F. 1904—17

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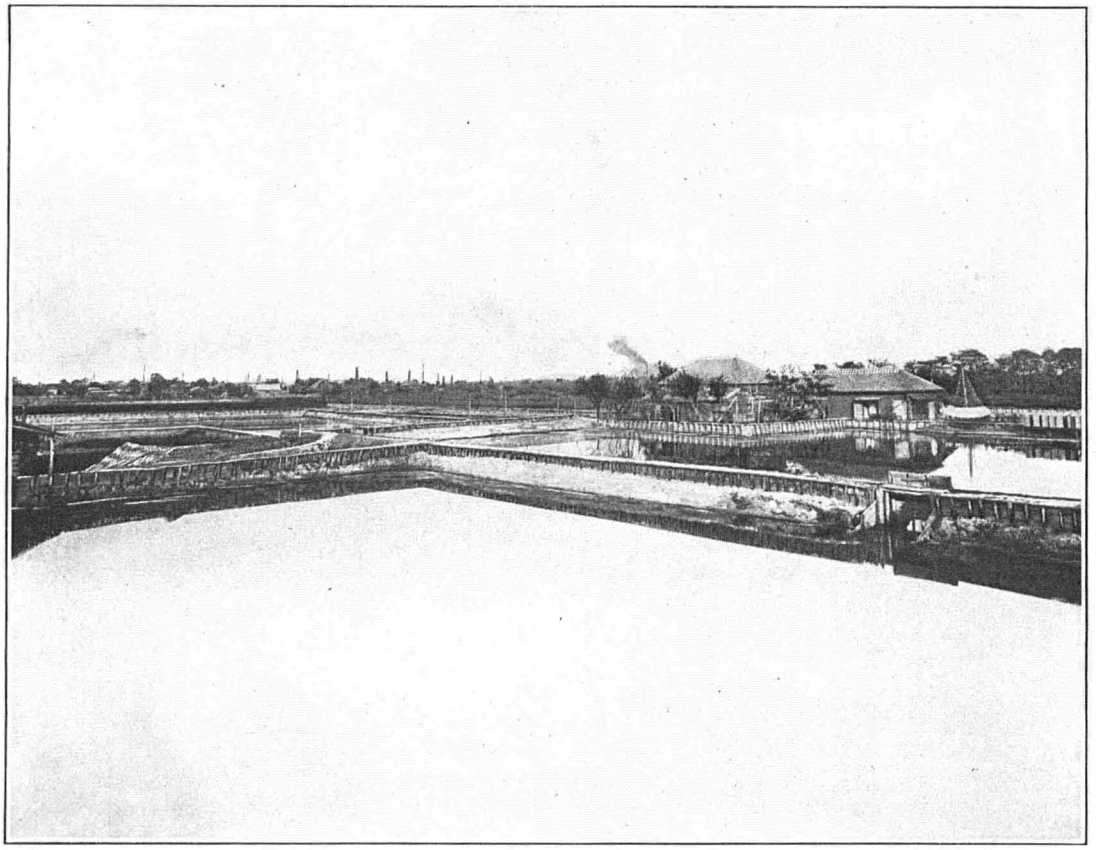
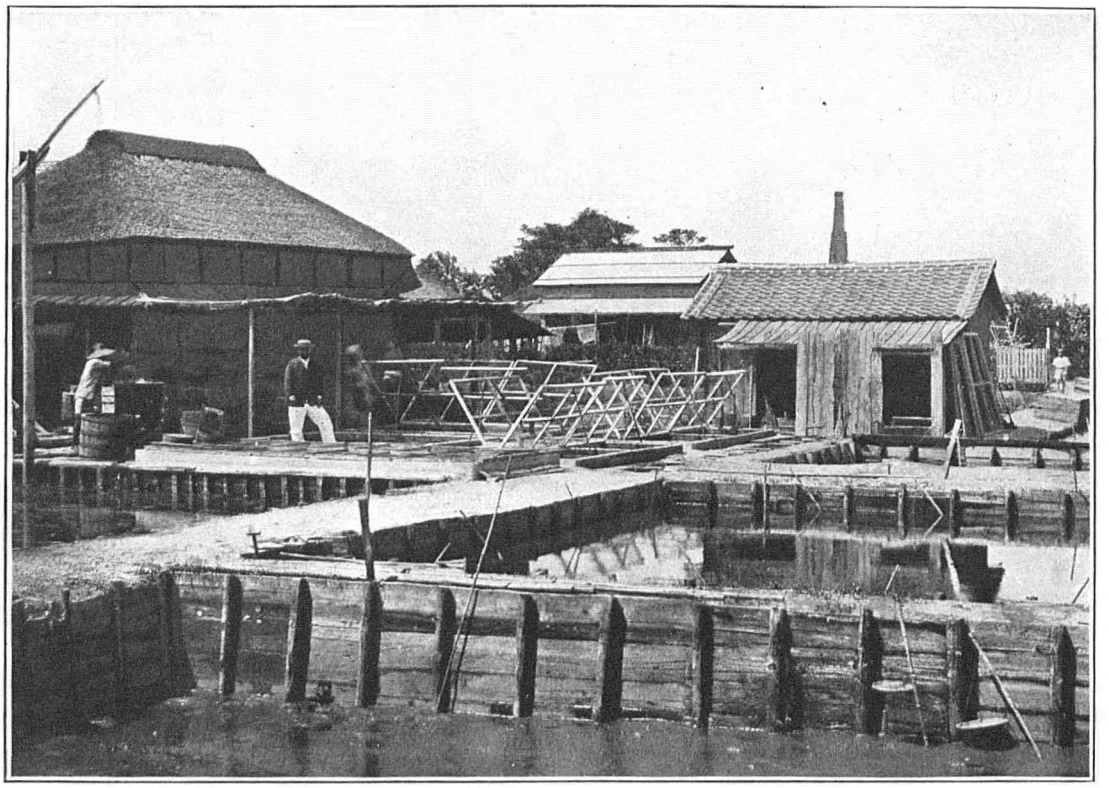


1. VIEW OF A TURTLE FARM, FUKAGAWA, TOKYO, JAPAN.



2. VIEW IN A GOLD-FISH BREEDER'S ESTABLISHMENT.

THE CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN.[a]

By K. MITSUKURI, Ph. D.,

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While the pasturage of cattle and the cultivation of plants marked very early steps in man's advancement toward civilization, the raising of aquatic animals and plants, on any extensive scale at all events, seems to belong to much later stages of human development. In fact, the cultivation of some marine animals has been rendered possible only by utilizing the most recent discoveries and methods of science. I believe, however, the time is now fast approaching when the increase of population on the earth, and the question of food supply which must arise as a necessary consequence, will compel us to pay most serious attention to the utilization for this purpose of what has been termed the "watery waste."

For man to overfish and then to wait for the bounty of nature to replenish, or, failing that, to seek new fishing grounds, is, it seems to me, an act to be put in the same category with the doings of nomadic peoples wandering from place to place in search of pastures. Hereafter, streams, rivers, lakes, and seas will have, so to speak, to be pushed to a more efficient degree of cultivation and made to yield their utmost for us. It is perhaps superfluous for me to state this before an audience in America, for I think all candid persons will admit that the United States, with her Bureau of Fisheries, is leading other nations in bold scientific attempts in this direction.

Nor is it simply from the utilitarian standpoint that more attention is likely to be paid in future to the cultivation of aquatic organisms. Far be it from me to depreciate in any way beautiful modern laboratory technique, but I think all will agree the time is now gone by when science considered that when the morphology of an animal has been made out in the laboratory all that is worth knowing about it has been exhausted. We have been apt to forget that animals are living entities and not simply a collection of dead tissues. But we are now beginning to realize that in order to arrive at the proper understanding of biological phenomena we must, in addition to laboratory methods, observe living animals in their natural environment or study them by subjecting them to accurate scientific experiments. To show the efficiency and intricate nature of the new methods, I need only refer to the important results obtained by Professor Ewart, of Edinburgh. And America has also already started a zoological experimental farm, under the able directorship of Professor

[a]Read before the International Congress of Arts and Sciences, held at the Louisiana Purchase Exposition, St. Louis, Mo., August 21–25, 1904.

Davenport. From this standpoint the cultivation of various organisms becomes an important and necessary aid to scientific researches, and it is partly for this reason that I venture to call your attention to some of the more successful of culture methods practiced in Japan.

Japan, I need hardly remind you, consists of an immense number of islands, large and small. In proportion to its area, which is nearly 160,000 square miles, its coast line is immense, being, roughly speaking, 20,000 miles. This is broken up into bays, estuaries, inlets, and straits of all sorts and shapes, with an unusually rich fauna of marine organisms everywhere. In addition, the country is dotted with lakes and smaller bodies of fresh water. Put these natural conditions together with the facts that the population, in some districts at least, has been extremely dense, and that until within comparatively recent times hardly any animal flesh was taken as food, and even at the present day the principal food of the general mass of people consists of vegetables and fish—it would be strange indeed if the cultivation of some aquatic organisms had not developed under these circumstances. And such is actually the case. For instance, the oyster culture of Hiroshima and the algæ culture of Tokyo Bay are well-known industries which have been carried on for hundreds of years. Within recent times there has been a development of a number of such enterprises, some of which are interesting even from the purely scientific standpoint. It is my intention to call your attention to the more important of these culture methods, giving preference to those which are peculiar to Japan, and which might be interesting not only from the economic aspect but as a means of scientific investigation.

THE SNAPPING TURTLE, OR SOFT-SHELL TORTOISE, "SUPPON."

Trionyx japonicus Schlegel.

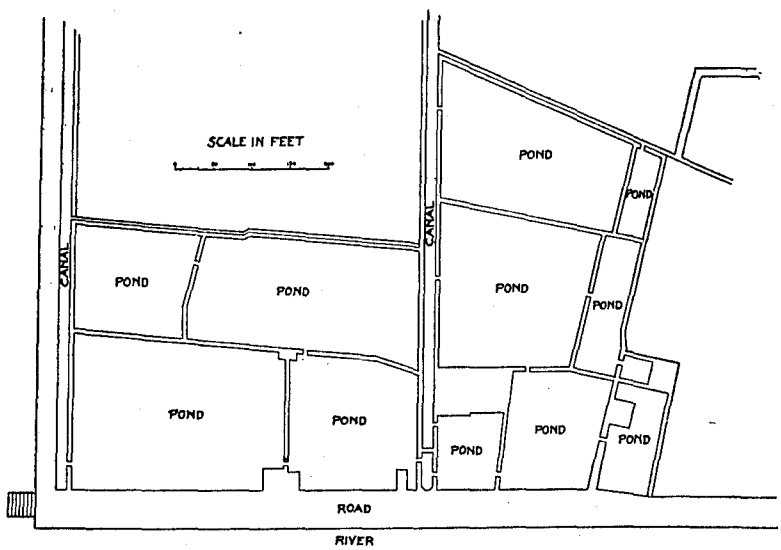
The place occupied among gastronomical delicacies by the diamond-back terrapin in America and by the green turtle in England is taken by the "suppon," or the snapping turtle, in Japan. The three are equally esteemed and equally high priced, but the Japanese epicure has this advantage over his brothers of other lands—he has no longer any fear of having the supply of the luscious reptile exhausted. This desirable condition is owing to the successful efforts of a Mr. Hattori, who has spared no pains to bring his turtle farms to a high pitch of perfection and is able to turn out tens of thousands of these reptiles every year. As his are, so far as I am aware, the only turtle farms in the world which are highly successful, a description of his establishment and methods will, I think, prove interesting and serve as a guide to those who may have similar undertakings in view. In passing I may remark that I have known Mr. Hattori these twenty years and have spent a number of summers on his original farm, collecting, with his kind consent, ample materials for my studies on the development of Chelonia. In return, Mr. Hattori is kind enough to say some of the facts and suggestions I have been able to give him, based on my embryological studies, have been of service in carrying out improvements.

The Hattori family has lived a long time in Fukagawa, a suburb of Tokyo, which lies on the "Surrey" side of the Sumida River, and which, having been originally reclaimed from the sea, is low and full of lumber ponds[a] and until recently of paddy

[a] Ponds in which lumber is kept soaked in water.

fields. The occupation of the family was that of collecting and selling river fishes such as the carp, the eel, and the crucian carp, and of raising gold-fishes, in addition to the ordinary farmer's work. As far back as in the forties of the last century, the high price commanded by the "suppon" seems to have suggested to the father and the uncle of the present Hattori the desirability of cultivating it, and this idea, once started, seems never to have been lost sight of, although lying in abeyance for a long time.

In 1866 the first large turtle was caught, and from then on additions were made by purchase from time to time, so that in 1868 there were fifteen, and by 1874 the number reached fifty, which were all very healthy, with a good admixture of males and females. In 1875 these were placed in a small pond of 36 tsubos[a], with an island in the center which was intended for the turtles to lay eggs on. They, however, seemed to prefer for this purpose the space between the water edge and the



CUT 1.—Plan of a turtle farm.

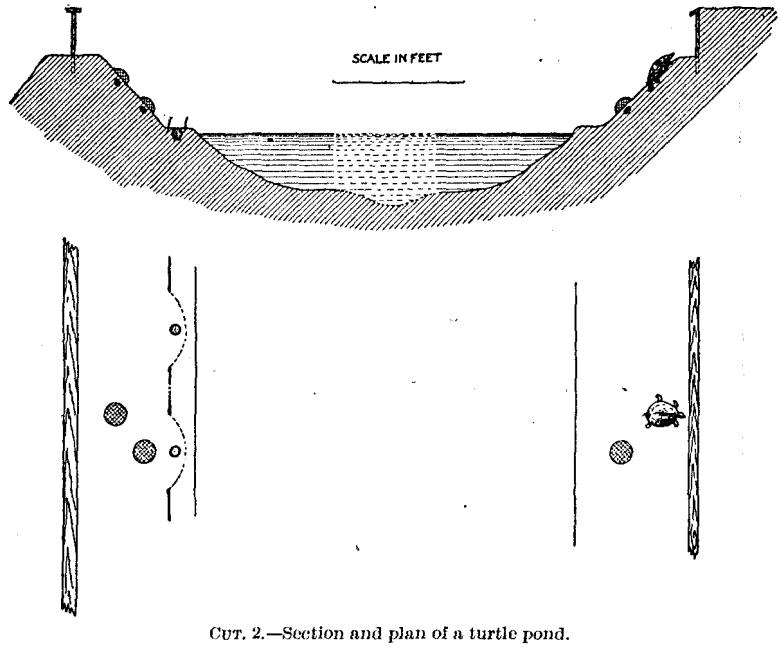
outer inclosure; hence, to suit the tastes of the reptile, the pond was hastily modified into a form very much like the one in use at the present day. That year over one hundred young were hatched, but, unfortunately, they were allowed to enter the pond in which the adults lived, and all but twenty-three of them were devoured, making it evident that some means were necessary to protect them from their unnatural parents. Thus was gradually evolved the present system of cultivation.

In general appearance a turtle farm is at a first glance nothing but a number of rectangular ponds, large and small, the large ones having a size of several thousand tsubos. The ponds are undergoing constant modification, being united or separated just as need arises, so that their number may vary considerably at different times. Cut 1 gives the plan of the Hattori turtle farm at Fukagawa as at present laid out. There pass through the farm two small canals which communicate on the one hand

[a] One tsubo, an area 6 feet square, is the unit in the measurement of small land surfaces.

with the river across the road, and on the other with the ponds, so that the water can be drawn into, or emptied from, each of them at will.

All the ponds, whether large or small, are constructed very much on the same plan. They are limited on their four sides by plank walls, the top of which may either be on the level of the ground (see the right side of the section, cut 2) or may be more than a foot above the ground when two ponds are contiguous (the left side, cut 2). In either case the plank wall has a cross plank of some width at right angles to it on its top, and is also buried some inches in the ground. The former arrangement is, of course, to prevent the tortoises from climbing over the wall, and the latter to prevent them from digging holes in the ground and making their escape in that way, while at the same time it serves to exclude the moles. On the inner side of the plank wall there is more or less of a level space, and then a downward incline of



CUT. 2.—Section and plan of a turtle pond.

3 or 4 feet. At the foot of this incline and directly around the water's edge there is another level space which enables people to walk around the pond. From the edge of the water the bottom of the pond deepens rather rapidly for a space of some 3 feet and there reaches the general level of the bottom, which is about 2 feet below the level of the water. The greatest depth of a pond is about 3 feet and is always toward the water gate by which the pond communicates with the canals. The bottom is of soft, dark mud, several inches thick, into which the tortoises are able to retire to pass the winter.

On a turtle farm one or more of the ponds is always reserved for large breeding individuals, or "parents," as they are called. The just-hatched young or the first-year ones must have ponds of their own, as must also the second-year ones; those of the third, fourth, and fifth years may be more or less mixed.

In order to give a connected account of the raising of tortoises, we might begin with a description of the pond for large breeding individuals, or "parents," and with an account of egg-laying and hatching.

The "parents' ponds" does not differ in any remarkable way from the general plan of a pond given above. Usually one of the largest ponds is chosen, and it can be distinguished from the others, because one or two of its slopes are usually kept up very carefully, while the other slopes or those of other ponds are apt to be worn by rain and wind and to become rugged. These well-kept slopes are invariably on the warmer sides, where the sun pours down its midsummer rays longest, and are carefully worked over in the spring so that the tortoises will find it easy to dig holes in them. In the breeding season these sides are seen to be covered with wire baskets which mark the places where the eggs have been laid.

Copulation takes place on the surface of the water in the spring. Egg deposition begins in the last part of May and continues up to the middle of August. Each female lays during that time two to four deposits, the number differing with individuals and with years.[a] The process of egg deposition is very interesting. A female comes out of the water and wanders about a little while on the banks of the pond in search of a suitable locality in which to deposit eggs. Having finally chosen a spot, with her head directed up the bank she firmly implants her outstretched fore feet on the earth, and during the whole operation never moves these. The process of egg deposition, which takes altogether about twenty minutes, may be divided into three portions occupying about the same length of time, namely: (1) digging a hole, (2) dropping eggs in it, and (3) closing the hole. The digging of the hole is done entirely with the hind legs. Each with its nails outstretched is moved firmly from side to side—that is, the right foot from right to left and the left from left to right, and the two are worked in a regular alternation, while the body is swayed a little from side to side, accompanying the motion of the legs. The force put in the lateral pressure of the feet is so strong that the earth that has been dug out is sometimes thrown off to a distance of 10 feet or more, although the largest part of it is heaped up around the hole. Digging seems to be continued as long as there is any earth within the reach of the legs to be brought up. The result is a squarish hole with the angles rounded off, and although its size differs with the size of the female, it is generally about 3 to 4 inches across at the entrance, with the depth and width inside about 4 inches or more. When digging is finished eggs are dropped from the cloaca into the hole, which naturally lies just below it. The eggs are heaped up without any order, but, there being no chalazæ, the yolk is able to rotate in any direction, and the blastoderm, having the least specific gravity, always occupies the highest spot of the yolk in whatever position the egg may happen to be dropped. The eggs are generally spherical in shape, although sometimes more or less oblate. Their diameter is in the neighborhood of 20 millimeters, the largest being as large as 24 millimeters, the others smaller according to the size of the females. The number of eggs in one deposit varies from 17 or 18 up to 28 or more, the smaller individuals producing the smaller number.

[a] See my notes: "How many times does the snapping turtle lay eggs in one season?" Zoological Magazine, Vol. VII, p. 143, 1895. Tokyo.

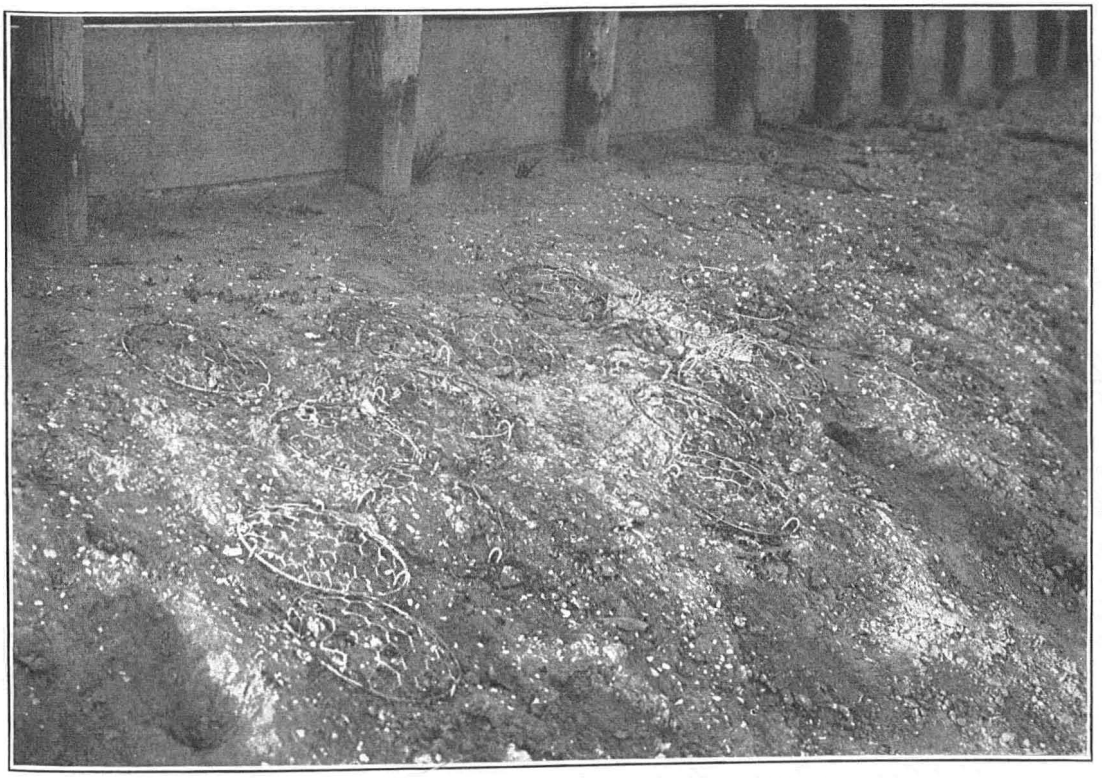
When the eggs have all been deposited, the turtle's legs are again put in requisition, this time to fill up the hole, which is done by alternate motions as before. The earth about the hole is used at first, but search is made for more loose earth for a little distance, as far around as the legs can reach with a slight motion of the body either to the right or left without moving the front legs. Toward the end of the process the loose earth is trampled down. When the hole is well filled up to the level of the ground, the turtle turns around and goes immediately down into the water, not casting even one backward glance.

I have noticed an interesting contrast between the behavior of *Trionyx* and of *Clemmys* during the egg deposition. If one wants to watch a *Trionyx* depositing eggs, one has to crawl on all fours behind the plank wall of the pond and peep through a hole, being careful not to show himself. The moment the snapping turtle sees anyone, it stops in whatever part of the egg-laying process it may be engaged and plunges straight into the water. Utterly different is the behavior of *Clemmys*. When once it begins the process of egg-laying it is never deterred from carrying it out, no matter how near or how boldly one may approach. Whenever I watched a *Clemmys* working away in the direct midsummer rays with its carapace all dried up and with its eyes alone moist, I could not helping comparing it to a slave of duty fulfilling his fate with tears in his eyes. What causes such a difference of behavior in the two species? What is its significance? What difference in the nervous system corresponds to it?

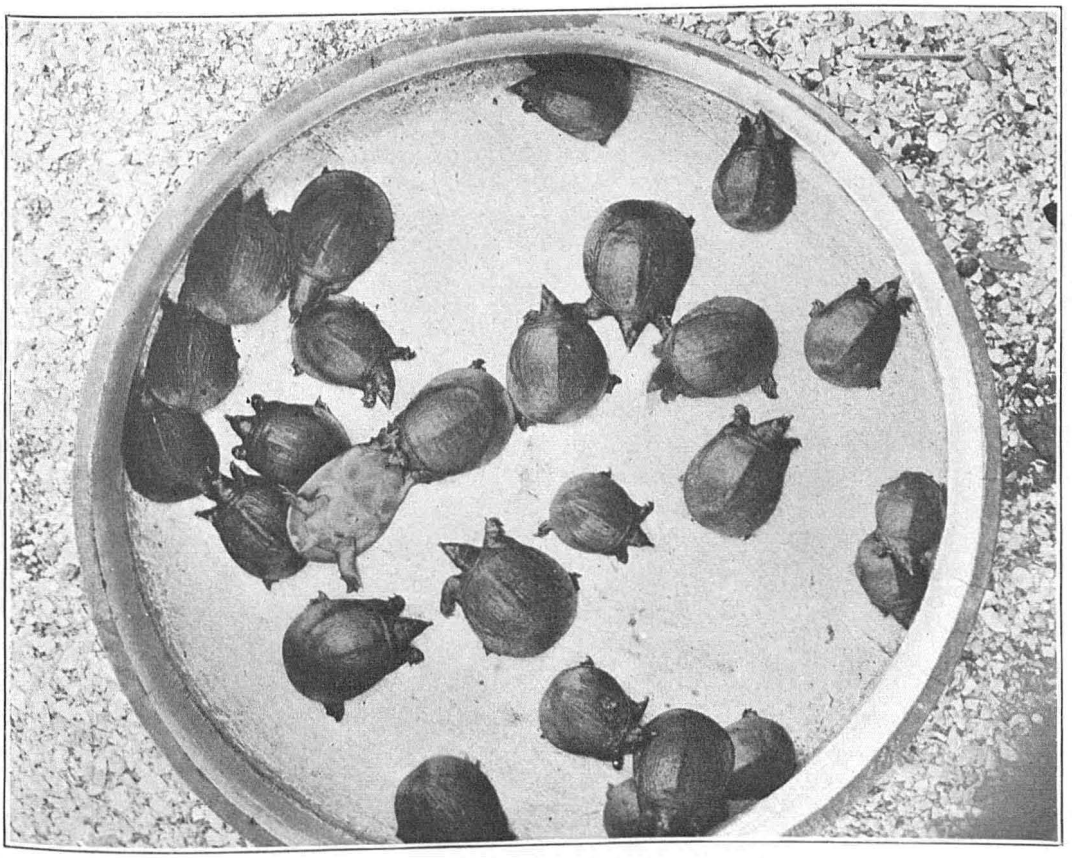
The traces of a spot where the snapping turtle has laid eggs are (1) the two marks made by the forepaws holding on to the earth during the whole operation, and (2) a disturbed place some distance back of the line of the forepaws where the hole has been made. The three marks are at the angles of a triangle. I have noticed a very interesting fact in regard to these traces. When a young female is depositing her first eggs, she is very clumsy, the hole being badly made and the filling in of it very imperfect, so that often a part of it remains open. Old females are extremely neat in their doings, and one can determine at once the age and size of the female by the skill displayed and by the distance between the three marks of egg deposition. This shows that although the elaborate actions necessary in egg laying must be, in the main, due to instinct, each individual has to add its own experience to the inherited impulses and is able thus only to accomplish the desired end with perfection.

In Hattori's farm a person goes around the "parents' pond" once a day or so and covers up with wire baskets all the new deposits made since the last visit (pl. II, fig. 1). Each basket may be marked with the date if necessary. This covering serves a twofold purpose—the obvious one of marking the place, and in addition that of keeping other females from digging in the same spot. When hundreds, or even thousands, of these baskets are seen along the bank of a "parents' pond," it is a sight to gladden the heart of an embryologist, to say nothing of that of the proprietor.

The hatching of the eggs takes, on an average, sixty days. The time may be considerably shortened or lengthened, according to whether the summer is hot and the sun pours down its strong rays day after day, or whether there is much rain and the heat not great. It may become less than forty days or more than eighty days. By the time the last deposits of eggs are made in the middle of August, the early ones,



1. EGG DEPOSITS OF TRIONYX COVERED WITH WIRE BASKETS.



2. SECOND-YEAR YOUNG OF TRIONYX.

Reduced $\frac{1}{5}$.

which were laid in May or June, are ready to hatch; and inasmuch as if small tortoises that have just emerged from the eggs are allowed to get into the "parents' pond" they are devoured by their unnatural fathers and mothers, a special arrangement has now to be put up to prevent this. Figure 1, plate III, and the left side of the plan in cut 2 are intended to show this arrangement. Long planks about 8 inches wide are put up lengthwise around the edge of the pond, leaving perhaps 1 foot margin between them and the water. Two successive planks are not placed contiguous, but a space of about 3 feet is left between every two, and closed by a bamboo screen put up in the shape of an arc of a circle, with its convexity toward the pond. Thus the slope or the bank where the eggs have been deposited is completely cut off from the pond itself. In the center of every pocket-like arched space made by a bamboo screen an earthenware jar is placed with its top on the level of the ground, and some water is put in it. This elaborate arrangement is for the reception of the young tortoises, which, as soon as they break through the egg shells—those belonging to the same deposit generally coming out at the same time—crawl up to the surface of the ground by a hole or holes made by themselves, and go straight down the incline toward the pond, as naturally as the duckling takes to the water. They are stopped, however, in their downward hydrotaxic course by the planks put up, as stated before, around the pond, and they crawl along the length of the planks and sooner or later drop into the jars placed in the recesses between every two planks. A man going around once or twice a day can easily collect from these jars all the young hatched since the last visit.

The young just hatched are put in a pond or ponds by themselves and given finely chopped meat of a fish like the pilchard. This is continued through September. In October *Trionyx* ceases to take food, and finally burrows into the muddy bottom of the pond to hibernate, coming out only in April or May. The young are called the first-year ones until they come out of their winter sleep, when they are called the second-year young. At first the same kind of food is given these as that given to the first-year young, but gradually this may be replaced by that given to older individuals, namely, any fish meat or crushed bivalves, etc. Figure 2, plate II, shows a lot of the second-year young in August. From the third to the fifth year, inclusive, the young need not be kept in ponds strictly according to age, but may be more or less mixed, if necessary. The young of these years are also the best and most delicate for eating and are the ones most sold in the market. In the sixth year they reach maturity and may begin to deposit eggs, although not fully vigorous till two or three years later. How old these snapping turtles live to be is not known. Those 1 foot and more in length of carapace must be many years old. The following table gives the average size of the carapace and the weight of the young:

Age.	Length in centimeters.	Breadth in centimeters.	Weight in grams.
Just hatched	2.7	2.5	.....
First year	4.5	4.2	23
Second year	10.5	8.8	169
Third year	12.5	10.5	300
Fourth year	16.0	13.5	563
Fifth year	17.5	15.1	750

One of the most important questions in turtle farming is that of food supply. The profit depends largely on whether a constant supply of healthful food can be obtained cheaply and abundantly. In the Hattori farm chief dependence in this respect is laid on the "shiofuki" shell (*Mactra veneriformis* Deshayes) which occurs in enormous quantities in the Bay of Tokyo. These shells are crushed under a heavy millstone rolled in a long groove in which they are placed, as shown in figure 2, plate III. Other kinds of food given are any dried fish scraps, silkworm pupæ, boiled wheat grains, etc.

A curious part of the ecological relations of a turtle pond is this: It would be supposed that putting other animals in the same pond with the snapping turtles would be detrimental to the welfare of the latter, but experience has proved just the contrary. It is now found best to put such fishes as carp and eels in the same ponds with the turtles. The reason, I am told, is that these fishes stir up mud and keep the water of the pond always turbid, and this is essential to the well-being of the turtles, as is proved when the messmates are taken out of the pond. Dirt and mud then settling down, and the water becoming clear and transparent, the turtles, which are extremely timid, will not go about searching for food, and thus very undesirable results are brought about.

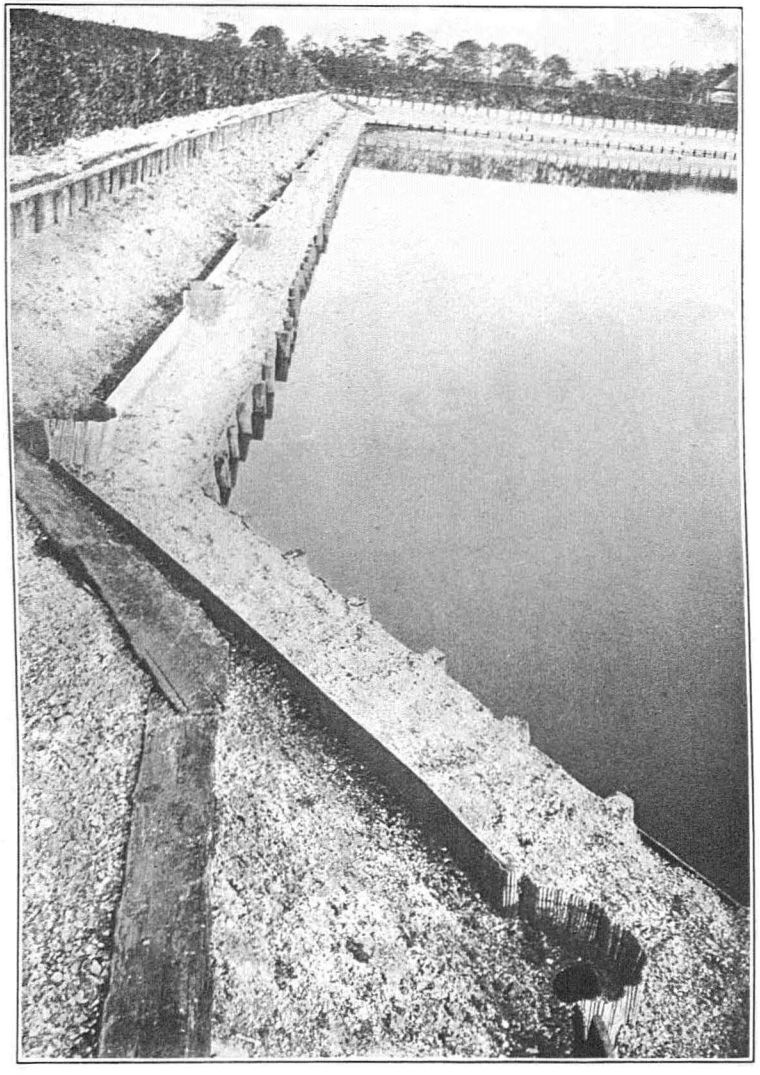
The business of turtle raising has thrived well. When I first became acquainted with the turtle farm, now over twenty years ago, it was a small affair with only a few small ponds, and the eggs hatched out in one year were, all told, not much over 1,000. Now the enterprise embraces three establishments: (1) The original farm at Fukagawa, Tokyo, now enlarged to 7 acres; (2) the large farm at Maisaka, near Hamamatsu, province of Totomi, over 25 acres, whither the main part of the business has been transferred; and (3) the second farm in Fukagawa, about 2 acres in extent. These three establishments together will yield this year (1904) about 4,100 egg-deposits, which means 82,000 eggs, counting 20 eggs to a deposit on an average. Probably 70,000 young will be hatched from these, and deducting 10 per cent loss before the third year, there will be about 60,000 "suppon" ready for the market in three years. The turtles sold in a year in Osaka, Tokyo, Nagoya, and a few other towns weigh about 2,000 kwan (=16,500 pounds), and are worth about 6.50 to 7.50 yen (1 yen=$0.50) per kwan.

There are several minor turtle farms besides those mentioned above, but as they are all modeled after those under Mr. Hattori's management, they need not be described further.

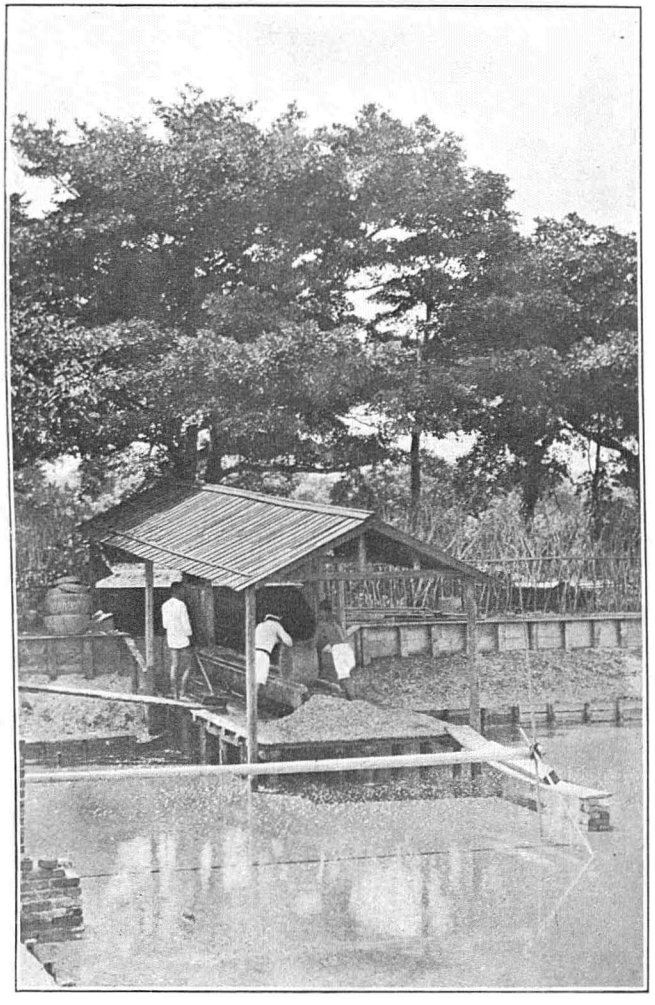
THE GOLD-FISH.

Carassius auratus Linnæus.

The gold-fish is the characteristically oriental domesticated fish. Its beautiful bright coloration and graceful form, with long, flowing fins, appeal most strongly to one's sense of the beautiful. It also is intensely interesting from the scientific standpoint, and proves a source of endless surprises to the biologist, for it is a plastic material with which skillful breeding can, within certain limits, do almost anything. Our gold-fish breeder seems to have understood the principle of "breeding to a point" to perfection, and I have often been interested in hearing some



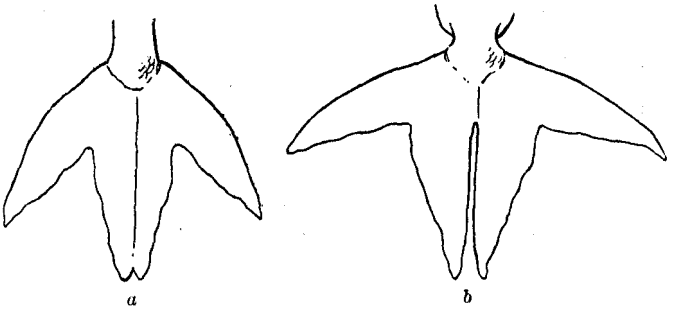
1. ARRANGEMENT FOR COLLECTING YOUNG TURTLES JUST HATCHED.



2. CRUSHING SHELLS FOR FOOD OF TURTLES.

of them talk in a way which reminded me of passages in the "Origin of the Species" or other Darwinian writings. This must be considered remarkable, for these breeders are, as a general thing, without much education, and have obtained all their knowledge from the practical handling of the fish.

The history of the gold-fish is lost in obscurity. Like so many things in Japan, it seems to be an importation from China. There is a record that about four hundred years ago—that is, about the year 1500—some goldfish were brought from China to Sakai, a town near Osaka. The breed then brought in is said to be that now known as the "wakin." There must also have been several later importations and the Japanese must have improved vastly on the original forms, as in so many other cases of things introduced from foreign countries. Several varieties have thus resulted, but before proceeding to describe these I may say a few words about gold-fish in general. A characteristic of the gold-fish, no matter of what variety, is that the black pigment with which the body is uniformly colored when first hatched from the egg disappears in a year or so and gives place to bright colors, which are of various shades between carmine and vermilion red and which may be either spread all over the body or variegated with white in various degrees. A fish that is entirely white fetches no price in the market, and is mercilessly eliminated in the first year. A fish with the white body variegated with red around the lips and on the opercula and all the fins is considered to have the best coloration. The dorsal fin is either single or absent. The tail may remain simple, as in ordinary fishes, but should best split open and spread out horizontally, when it is therefore three-lobed (cut 3, *a*), but quite as frequently it may be split in the median lines, when it is four-lobed (cut 3, *b*). The anal fin may also very often split open and become paired.[a]



CUT 3.—Diagram of the tail of a gold-fish. *a*, Three-lobed; *b*, four-lobed.

There are five well-established varieties of the gold-fish in Japan, and in addition one or two which have not become so common as yet. I will go over these varieties briefly (compare pls. IV and V):

1. The "wakin" (literally "Japanese gold-fish"). This has a shape nearest the normal form of a fish. The body is slender and long, closely resembling that of the common crucian carp. The tail may be single, vertical, and normal, but should, to be a good form, split open and become either three-lobed or four-lobed. This may, in short, be characterized as the bright-colored variety of the common *Carassius auratus* with or without the modified tail.

2. The "ryukin" (literally "Loochoo" gold-fish), also called the "Nagasaki". The first name may possibly denote whence the variety came originally. The body

[a] For further details see S. Watase: "On the Caudal and Anal Fins of Goldfishes." Journal Science College, Vol. I, p. 247, Pl. XVIII–XX.

is strikingly shortened—this being one of the points to which the variety was bred—and has a rounded, bulged-out abdomen. The tail and all the fins are long and flowing, the former being as long as or even longer than the body. This, in my opinion, is the most beautiful breed. A "ryukin" 2 or 3 years old, slowly swimming with its long, flowing, graceful fins and tail, full of quiet dignity, I can liken to nothing so much as to Japanese court ladies of olden times, dressed in long robes and walking with quiet grace and dignity.

3. The "ranchu," also called "maruko" (literally, round fish), "shishigashira" (literally, lion-headed), and sometimes "Corean goldfish." This is distinguished by its rather broad head, its extremely short, almost globular body, the short tail, and the absence of the dorsal fin. Some individuals of this variety develop in the second year, or at the latest in the third year, a number of peculiar wart-like protuberances all over the head, making it look as if it had a low coxcomb or some skin disease. Such fish are called the "shishigashira," or "lion-headed." This variety is seen often swimming upside down, a fact with which the absence of the dorsal fin probably has something to do.

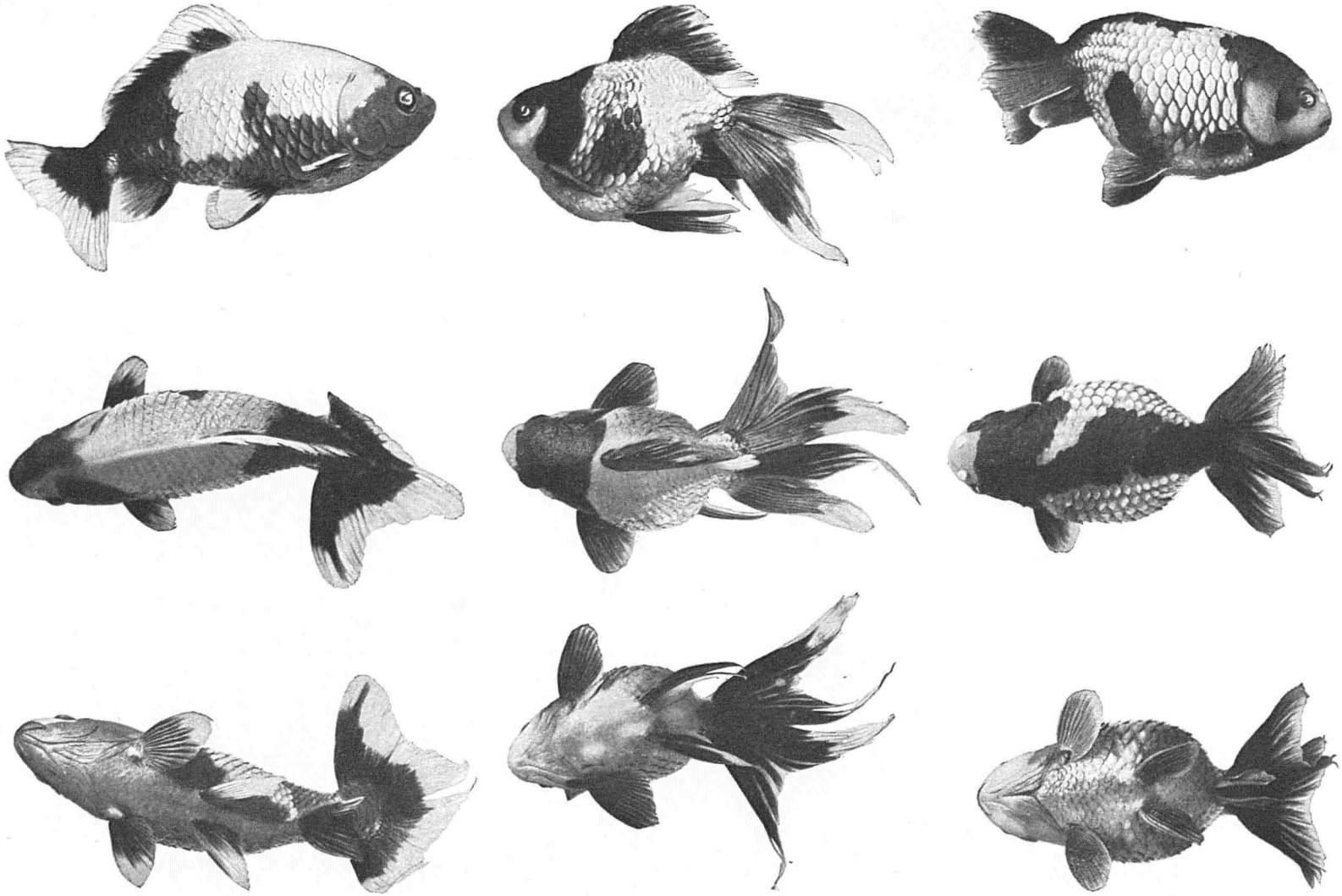
4. The "oranda-shishigashira" (literally, Dutch lion-headed). The adjective Dutch is known to have nothing to do with the place of origin of the fish, but was attached to the name to denote something novel. This variety was produced in Osaka in the forties of the last century by crossing the "ryukin" with the "ranchu." Therefore, it possesses a body more or less like that of the "ryukin" with the dorsal fin, but from the second year or thereabouts the head begins to develop the wart-like protuberances described under the "ranchu."[a] When fully developed, this breed is, to my mind at least, anything but beautiful. It is cultivated near Kyoto or Osaka, while the "ryukin" is reared most in Tokyo.

The above four breeds are common and can be seen in almost any gold-fish seller's. There are some other rarer or newer varieties:

5. The "shukin." This is a breed only recently produced by my friend, Mr. Akiyama, a skilful gold-fish breeder of Tokyo, and also produced independently in Osaka. It was obtained by crossing the "oranda-shishigashira" with the "ranchu." It is "lion-headed"—that is, has warts on the head—has the globular body of the "ranchu" without any dorsal fin, but it has a long flowing tail. It may be characterized as a long-tailed variety of the "ranchu."

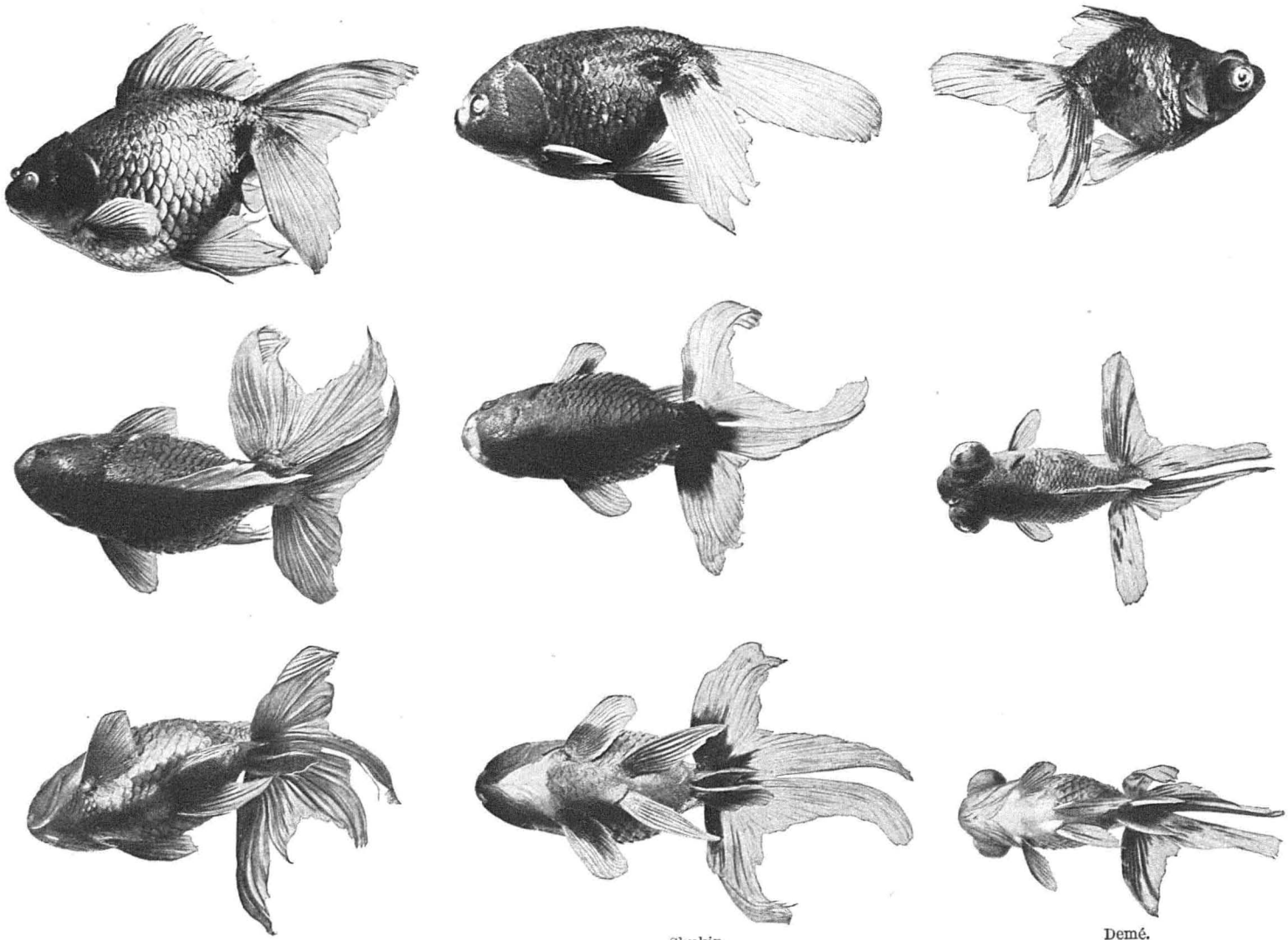
6. The "demé" (literally "protruding eyes" or "telescope fish"). Contrary to what is stated in many American and European books, the telescope fish is only a recent introduction into Japan. In fact, it was brought to Japan at the end of the late Japan-China war (1894–95). As is well known, in this variety the large eyeballs have started out of the skull and protrude sideways from the head, which thus somewhat resembles (although only superficially) that of the hammer-headed shark. The body is short; the color is yellowish, or at least not usually bright red, and often has black spots or irregular black patches scattered over the body. It should be stated that the first-year young have the eyes in the normal position, the protrusion occurring gradually in the course of growth and not through any artificial devices. These

[a] I am sorry that these are not very well brought out in the accompanying photographs. They are seen better in plate VI.



Wakin. Ryukin. Ranchu.

VARIETIES OF GOLD-FISH (LATERAL, DORSAL, AND VENTRAL VIEWS).



Oranda shishigashira.

Shukin.

Demé.

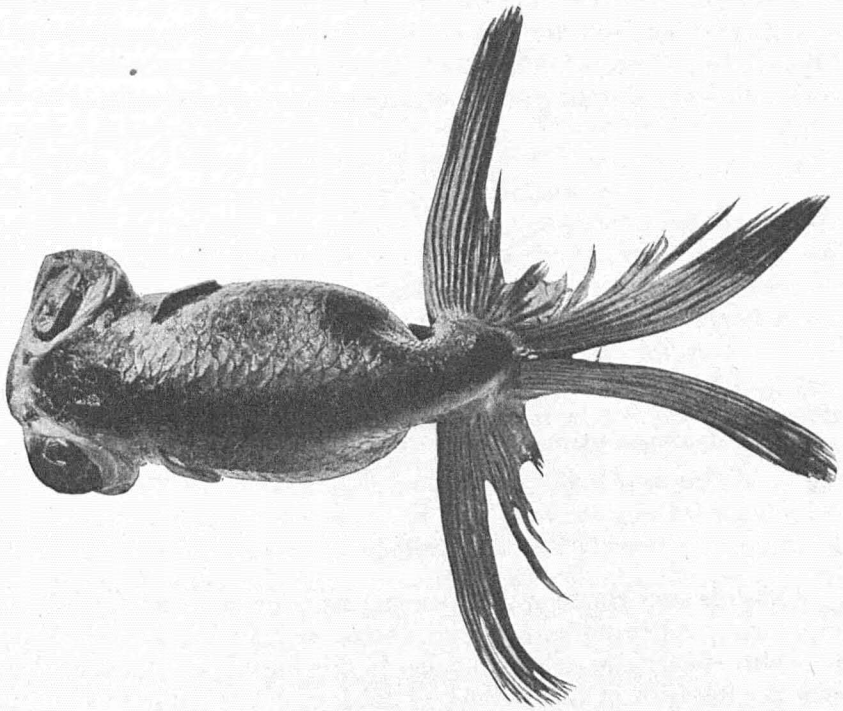
VARIETIES OF GOLD-FISH (LATERAL, DORSAL, AND VENTRAL VIEWS).

VARIETIES OF GOLD-FISH (FROM JAPANESE PAINTINGS).

Lower left, wakin; lower right (group of three), demé, ryukin, ranchu; upper left (two), ranchu; upper middle and right, oranda shishigashira.

fish, when fully grown, are apt to strike their eyes against the sides of the ponds, tubs, etc., in which they are kept, and to injure them so that they often become blind. In nature, therefore, such a protuding eye must be a distinct disadvantage, and would never have been produced except by artificial selection.

7. The "demé-ranchu" (cut 4). This variety is not yet naturalized in Japan, having been imported from China only within the last two or three years. Of all the extraordinary and odd-looking fishes, it certainly is far in the lead in many respects, and is interesting as showing how far man can proceed in modifying nature. It is a telescope-fish with a short globular body resembling the "ranchu," and, like it, without the dorsal fin. The eyes have assumed a most extraordinary position. The ordinary telescope-fish is odd enough, with the eyes protruding, but in



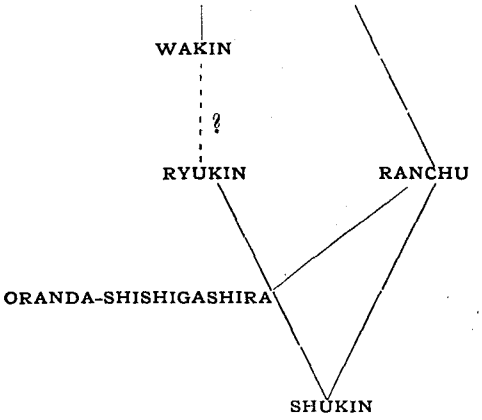
CUT 4.—The "demé-ranchu."

this variety dislocation has gone one step further. The eyes have not only started out of the head, but have turned upward 90 degrees and have their pupils looking straight skyward. For this reason I should be inclined to call this "astronomical telescope-fish." As a fish, it is so monstrous that it gives one almost uncomfortable feelings.

It is an interesting fact that in the forms without any dorsal fin, many young show more or less traces of that fin. Sometimes there may be only the first spine, at other times only a few spines, at still others a little bit of a fin, etc., showing that the fin must have been bred off comparatively recently.

There can be no doubt that of these varieties the "wakin" is the most primitive, as can be seen from its shape, as well as from the fact that it is much hardier than the

others, and therefore easier to rear. The "ryukin" is next the "wakin" in its nearness to the original *Carassius*. It is still like an ordinary fish, although its shortened body and long flowing fins show that changes have already gone very far. The "ranchu" seems further removed from the original type, as its globular body and the absence of the dorsal fin well testify. The relations that these three varieties hold to one another are involved in obscurity. Some think that the "ryukin" is a cross between the "wakin" and the "ranchu," but I think that this can hardly be so. I am inclined to think that the "ryukin" must have been bred from ancestors somewhat like the "wakin" by careful selection, and that the "ranchu" is the offshoot of another branch which must have separated from the "wakin" stem very early. The cross between the "ryukin" and the "ranchu" is the "oranda-shishigashira," and this crossed again with the "ranchu" is the "shukin." An interesting fact is that in the first cross both the dorsal and the tail fins are long, but in the second cross the dorsal fin is lost, while the tail is not only retained but remains long. Expressed in a diagram, the supposed genealogy would be as follows:



The gold-fish is very common in Japan and more or less reared in all parts, but the main centers of cultivation are Tokyo, Osaka, and Koriyama (a small town near Nara, where almost every household engages in this business). Each of these places has its own peculiarities in the method of raising, but the differences are, on the whole, in minor details only. In Tokyo gold-fish breeders are all located in low-lying parts of the city, where ponds, a sine qua non of this business, can be easily made.

One establishment is very much like another, the principal differences being in the number and size of ponds. Figure 2, plate 1, gives a view of a typical one. There is always a number of shallow ponds, as shown in the foreground of the photograph. (In the particular place where this photograph was taken I think I counted ten.) Fortunately, water had been drained off the nearest pond and one can see its construction and depth without further explanation. The shallow dishes slung by three strings from bamboo poles stuck in the muddy bottom of the pond, seen in the photograph, are the dishes in which food is given to the gold-fish. Besides these shallow ponds there is always a large number of shallow square cement basins of various sizes, some as small as 3 feet by 3, others as large as 12 feet by 12, with

intermediate sizes of all sorts. (In the figure, a man with a hand-net is standing in the midst of these basins.) They are very shallow, being not more than a few inches deep, can be easily drained or filled, and can be shaded or exposed to the sun at will. In the figure, the wire-gauze coverings are seen half lifted up, to the right of the man with a hand net. To the left of these basins there is the main house with the thatched roof, where the proprietor lives with his family. Under the rush shade in front of the house there is seen a large number of trays piled up one above another, and also a number of pails for carrying fish about. Under the shade is standing the mistress of the establishment—somewhat out of focus. Farther beyond are two young girls, not clearly seen, sorting some undesirable fish out of a lot of the first yearlings. A man is drawing water from the well with a sweep. A smaller house to the right is the place where fish food is prepared. A visit to such an establishment would delight the hearts of not only children, but grown-up persons who love bright colors and graceful forms, for the ponds are full of brilliantly colored fish of all ages and sizes. Here are huge fourth-year "wakin," there graceful second-year "ryukin," off there fine "ranchu". Ornamental little carps, little tortoises, and tiny fish called "medaka" (*Aplocheilus latipes*) are also generally found in the gold-fish breeders' establishments.

The process of rearing gold-fish is in its main outline as follows: Large gold-fish that are 3 or 4 years old, with good forms and healthy in every respect, are carefully selected for the purpose of breeding. This takes place any time between the last part of March and the middle of June, the usual time being in April and May. At this season the color of the fish becomes more brilliant than ever, and small, low warts that can barely be felt with one's finger are said to be produced on the opercula of the male. Both sexes crowd together, causing great commotion in ponds in which they are kept. Plenty of a waterweed ("kingyomo," or "matsumo," *Ceratophyllum demersum* Linnæus), or bundles of fine roots of the willow tree are placed in the pond, and on them the gold-fish lay their eggs. It is an interesting fact that gold-fish breeders are able to control, within a certain limit, the time of deposition of eggs. If the fish are given plenty of food beforehand and then the water of the pond in which they are kept is renewed, or if they are placed in another pond, they will deposit eggs in a day or two. On the contrary, if they are underfed and kept in the same stagnant water, they will desist from depositing eggs sometimes altogether.

The eggs take eight to nine days to hatch. The young for the first few days are given the yolk of hen's eggs, boiled. Food is usually given them on shallow earthenware plates, slung by three strings from a bamboo pole (fig. 2, pl. 1), for the youngest these plates being kept at the depth of a little over 1 inch below the surface of the water. For the next two or three weeks the young are given various kinds of fresh-water Copepoda. These the gold-fish breeders prepare beforehand in a separate pond, for they have the knack of producing these water fleas in any quantity they need at any time they like. After Copepoda, succeeds the ordinary food of the gold-fish, such as fresh-water earthworms, boiled cracked wheat, etc. It is essential for the growth and health of the fish that they be kept as warm as possible; hence, the shallow earthenware dishes from which they are fed are kept at first—that is, when the fish are first hatched, and, therefore, in the hot season—only a little over an inch

below the surface of the water. With the growth of the young and the approach of the colder weather they are gradually put down lower and lower, until in the winter they are down nearly 10 inches, such a depth being naturally warmer than nearer the very surface of the water.

Among the young fish all sorts and conditions of the body and the fins are found—that is, all forms intermediate between those closely resembling the normal crucian carp with a long slender body, the unsplit tail and anal fins, etc., and those which are extremely modified, as shown in the varietal types described above. If a lot of young contains a large percentage of those with the unsplit tail, it is considered, from the commercial standpoint, a failure, for these latter are only a fraction of the split-tailed in price. In some experiments I have tried it was found that in selecting for breeding the adults which have the split anal fin give, on the whole, better results than those with a single anal. It is needless to say that all undesirable ones are early eliminated.

All the young just hatched are dark in color, the bright colors coming only later. A great deal of experience and skill is needed in making the gold-fish change its color from black to red. If a person who is not an expert tries his hand at raising a lot of young gold-fish he will find to his sorrow that the fish remain black and do not assume bright colors, while those which may be from the very same lot of eggs, but have been under the care of a professional breeder, may have all donned the beautiful hues. The essential points to be attended to in bringing about this change seem to be (1) that the young fish should be given plenty of food, (2) that they should be exposed to the sun's rays and be kept as warm as possible, and (3) that the water of the pond in which the young are kept should be changed occasionally, although sudden transfer from warm to cold water in the middle of the day is to be avoided. The change of color begins in about sixty to eighty days from the time of hatching, and by the middle of August the fish should all have lost the dark pigment and acquired bright colors. I am told a curious fact—that the fish which change their color earliest are apt to be white or variegated white and red, while those that change later are apt to be uniformly red. What can be the significance of such a fact? I am also told that by the middle of August of the second year, all the individuals, however obstinate, change their color. It is worth while determining whether, even if the young are left to themselves and not given the care which they receive at a breeder's, they will change color by the summer of the second year.

White is commercially worthless and is ruthlessly weeded out. It is also said that to improve the brightness of the color, the fish should be somewhat underfed—that is, should be given about 80 per cent of the ordinary feed. In Koriyama they have the trick of bleaching out white spots in the red, by applying some mixture. The result, I think, is not worth much.

I have by no means exhausted the subject of the gold-fish; in fact, I doubt whether anyone can write all the minute details of the art of gold-fish raising. But I think I have said enough to show how full of interest gold-fish breeding is, not only from the commercial or æsthetic point of view, but from the purely scientific standpoint. A most casual glance shows it to be full of problems which have ever attracted the serious attention of biological investigators.

I have just now no available statistics in regard to the output of gold-fish, but the number produced must be millions upon millions. It shows the power of children in the nation, for they are par excellence the customers of these establishments. It is said that in the old régime, even in years when a famine was stalking in the land and hundreds were dying from starvation, there was a tolerable trade in gold-fish, proving the truth of an old proverb: "Crying children and landlords must not be disputed." Landlords are not now tyrannical as of yore, but children have not abated their power in the slightest degree, and that they do not get the moon seems simply to be due to the fact that it involves an impossible feat for their parents.

THE CARP.

Cyprinus carpio Linnæus.

Closely connected in some respects with the culture of the snapping turtle and of the gold-fish is that of the carp. As stated before, the carp is put in the same pond with *Trionyx;* and the raising of the ornamental varieties is generally undertaken by gold-fish breeders. There are several breeds, among which the red carp ("higoi"), the "hokin" (literally "gold-cheeked," with the operculum of the gold or silver color) and the "goshiki-goi" (literally "five-colored," or variegated) are the most common. Travelers in Japan must have noticed in ponds belonging to various temple grounds these ornamental carps, which often reach the enormous size of 2 feet or more, and which children delight in feeding.

The ordinary carp itself has been very extensively cultivated from olden times in Japan in ponds, reservoirs, and various other bodies of water, and the business has been considered profitable, as the fish commands a comparatively high price.

Around or near Tokyo, especially in the district called Fukagawa, there have sprung up within the last twenty years a number of carp-culture establishments. They carry out at the same time and in the same ponds the culture of the eel and of the gray mullet ("ina" or "bora," *Mugil oeur* Forskål), the three fishes going well together and being consumed to a great extent in the city of Tokyo. It is estimated that there are in this small district alone 225 acres devoted to carp culture, producing annually 405,000 pounds of the meat of this fish, valued at 30,000 yen at the wholesale price, and furnishing a large part of the supply for Tokyo and its neighborhood. I ought to add that Mr. Hattori, who is the proprietor of the turtle farm, was largely instrumental in developing the industry in this region.

Some of these establishments are very interesting. Figure 1, plate VII gives a view in one of them—a very large establishment, with an area of 75 acres, and a large number of ponds, the largest of which are about 5 acres in extent.

The carp is reared from the egg in these establishments. In May of every year large adult individuals are carefully selected for breeding, and, as in the case of gold-fish, eggs are made to be deposited on the water weed ("matsumo") or bundles of fine willow roots, where they hatch in about a week. The young are about 5 millimeters in length, and undergo the same course of feeding as the young gold-fish. The rate of growth depends very much upon the extent of the crowding in the ponds. It is found that for individuals 14 to 16 centimeters long the best rate of distribution is about two for every "tsubo" (6 feet square). Skilful culturists can push the

fish, if necessary, to the length of 30 centimeters in the first year, and to 50 centimeters in two years. They are put on the market any time after the second year.

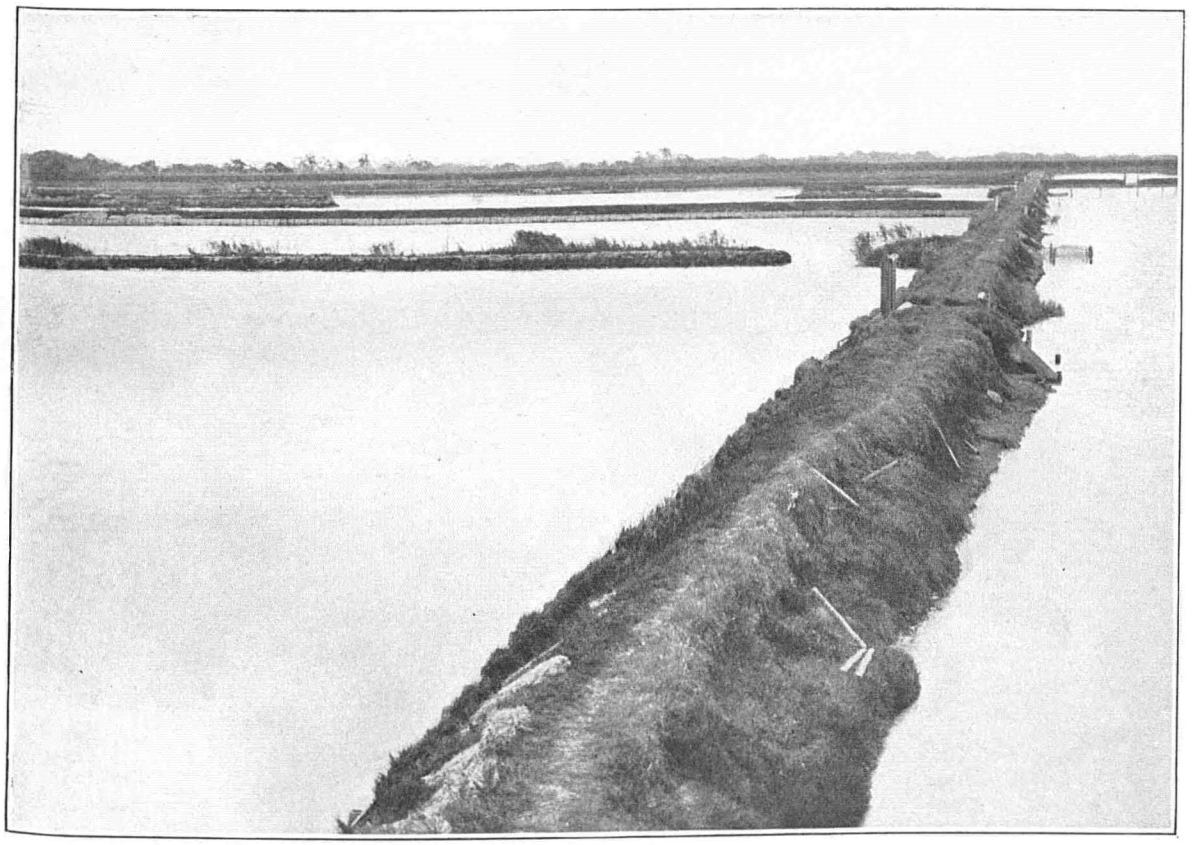
Carp culture is carried out extensively in parts of Japan other than Tokyo, especially in mountainous parts where sea fishes can be transported only with difficulty, and the industry is spreading more and more every year into all parts. One interesting reason for this is found in the circumstance that wet paddy fields in which rice is grown, and which occupy such a large portion of the cultivated area in Japan, are found in many low-lying districts to be excellent for the raising of the carp. The rice plant not only does not receive any serious injury from it, but is benefited because many insects are devoured by the carp. In the prefectures of Nagano (province Shinano) and of Gifu (province Mino) carp culture has progressed very far in this way. In Nagano, which is also noted for silk-worm raising, abundant food for the carp is found in the pupæ of the silkworm, taken out of the cocoons when these are reeled. This gives a bad flavor to the meat of the carp, however, which has therefore to undergo the process of purifying culture before it suits the taste of the fastidious. In one village in Shinano (Sakurai Mura) the agricultural society which represents the whole village undertakes to utilize 250 acres of paddy fields in the village in this way and annually raises 25,000,000 young fish to be sold and raised in the eastern provinces. In Mino, in the prefecture of Gifu, these communistic enterprises have gone further. There land is partitioned off into what are called "embankment areas"—that is, areas inclosed within a circle of embankments against the overflowing of large rivers. In one of these areas, called the Takasu embankment area, all the villages within it, with a total of 75,000 acres of paddy fields, have combined in the business of carp culture, and although the enterprise is still in its infancy, succeeded in realizing 48,000 yen in 1902. The example is being followed in other areas.

THE EEL.

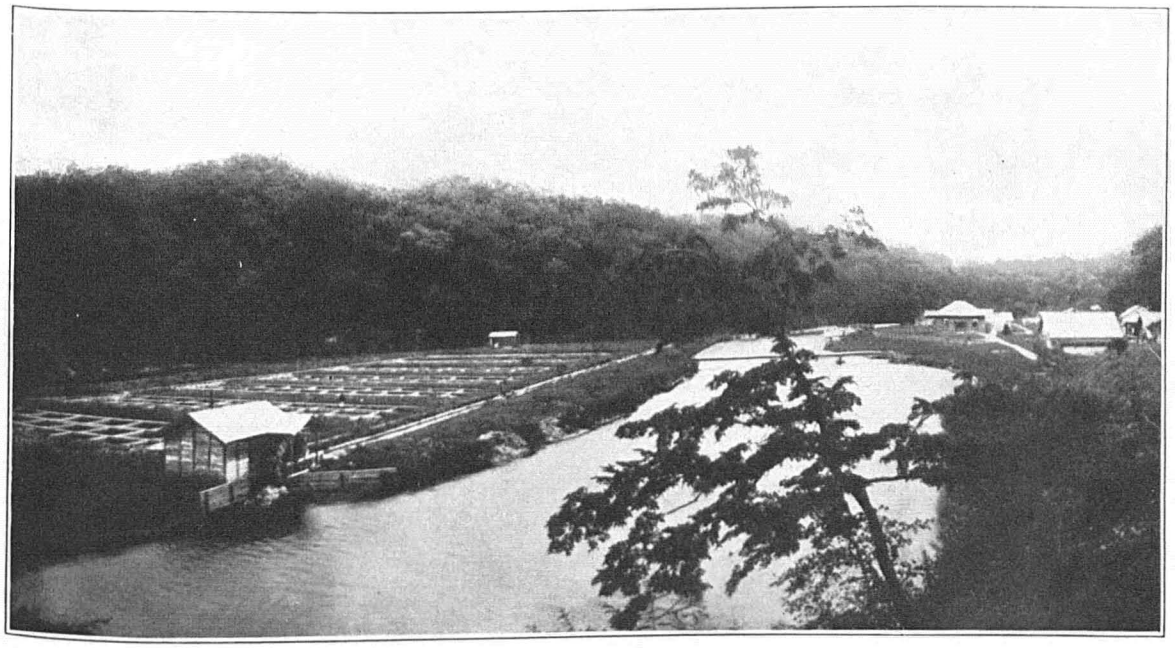
Anguilla japonica Temminck and Schlegel.

As has already been mentioned, in the piscicultural establishments in Fukagawa, Tokyo, and in the neighborhood of Maisaka, province Totomi, the snapping turtle, the carp, the eel, and the gray mullet ("ina"), especially the last three, are often cultivated together in the same ponds. That the eel finds itself one of this trio is due largely to the efforts of Mr. Hattori, the expert pisciculturist. He experimented long as to the best way to make eel culture a paying business, and succeeded so well that this is now the most profitable of the three fishes named.

The process is as follows: In April little eels that are brought to the Tokyo market from all the districts around the capital (Tokyo, Ibaraki, Chiba, Kanagawa, etc.) are bought. They are probably in the second year of their growth and are about 15 to 25 centimeters in length and weigh 3 to 20 grams. They are put in the same ponds with the carp and the gray mullet in varying ratios, although the total weight of the fishes put in should not exceed 610 grams per 1 tsubo (6 feet square). They are fed abundantly with the same kinds of food as the carp—that is, crushed molluscs, earthworms, etc. It is a wonderful sight when they are fed. They come crowding from all parts of the pond to the spot where food is given them, and literally thousands are seen



1. VIEW IN CARP-CULTURE ESTABLISHMENT AT SUSAKI.



2. CHITOSE SALMON HATCHERY.

crowded in hopeless tangles. They climb in their eagerness some distance up almost vertical wooden walls, and, looking at them, one begins to understand how eels are able to make their way into ponds and lakes which appear inaccessible to any fish coming up from the sea.

By July they weigh on an average 40 grams and are ready to be sent to the market. When they were put in, in April, they were worth 0.80 yen per kwamme (3.75 kilograms). Three months' culture has raised their value to 1.50 to 2 yen per kwamme, giving thus a large margin of profit. They are all sold by April of the next year, when the largest reach the weight of about 110 grams. The ponds are then ready to receive the next lot.

Eel culture, as I have said, has been mainly developed by the efforts of Mr. Hattori, and all the piscicultural establishments which are more or less directly connected with him are engaged in the business. These are in Fukagawa, Tokyo, and in Maisaka, province Totomi, where the industry is being very widely taken up. I believe that there are also some who have engaged in the business before or without any relation to Mr. Hattori, but I am sorry I can not gather any facts about these at present.

THE GRAY MULLET, "INA."

Mugil oeur Forskål.

This is one of the commonest fishes in the estuaries, river mouths, etc., of Japan. It penetrates in large numbers brackish ponds or any other brackish body of water, where it may grow to a large size and may be gathered in by the proprietor without his having spent any labor on it. Mr. Hattori tells me that from the culturist's point of view fear is not that there may be too few, but that there may be too many, of this fish that will get into culture ponds. The young are caught in April with a net in the sea or river near the establishments. At that time they are no more than 4 to 5 centimeters long. They are divided into two lots, according as they are to be sold that year or the next. Those that are to be sold that year are given plenty of space, not more than one or two per tsubo being put in ponds, and are fed abundantly. By September they attain the length of about 25 centimeters and weigh 225 to 860 grams, and are sold for 0.50 to 0.80 yen per kwamme. They are all sold by the end of the year.

Those that are to be sold the next year are not allowed to grow larger than 20 to 25 centimeters before April. This is accomplished by giving them not too much food and by keeping them in ponds or streams where there is a good circulation and current of water. It is found that those with plenty of fat will not live through the winter. They are all sold off by the end of the second year, for beyond this they do not keep well. They reach the length of 33 to 40 centimeters and 450 to 750 grams in weight, and fetch 0.70 to 1.10 yen per kwamme.

I should say that practically there is no limit to the demand in the Tokyo market for this fish or the eel. They can be sold in any quantity. The same is true more or less in other parts of Japan.

THE SALMON AND TROUT, "SAKE," "MASU," "BENIMASU."

Oncorhynchus keta (Walbaum); *O. kisutch* (Walbaum); *O. nerka* (Walbaum).

The salmon that is most widely distributed and most abundant in Japan is the "sake" or dog salmon (*Oncorhynchus keta*). It ascends all the rivers of Hokkaido and the northern half of Honshu down to near the Bay of Tokyo, and is one of the most important wealth-producing fishes in Hokkaido. In olden times, when the annual catch was not as great as at the present day, there does not seem to have been any necessity for artificial culture. Still there were some attempts at the propagation of the fish. For instance, on the Sammen River, in the province of Echigo, salmon fishing was prohibited in a branch of the river and the salmon which entered it were caught only after they deposited eggs and by the daimio to whom the district belonged, thus securing an income for him and some safety for the salmon eggs. It was a very imperfect method, but still an attempt at propagation, and is even at the present day practiced at the same place.

The modern method of salmon culture is taken bodily from the American method, so I can communicate nothing that is new in America. As early as 1876 a Mr. Sekizawa, then an officer of the home department, inspected and carefully examined salmon and trout culture in America, and on his return started experimenting on them, which was largely imitated in the hope that these delicious fishes might be easily increased and propagated. But these undertakings were mostly on too small a scale and no important results came of them, except that Chuzenji Lake at Nikko was stocked with some American trout about this time and has since become tolerably full of fish.

Meanwhile the salmon fishery in Hokkaido was going on upon a destructive scale, and matters came to such a pass in the eighties of the last century that a need of artificial propagation was strongly felt, and an expert of the Hokkaido government, Mr. K. Ito, was sent over to America to examine into the system of salmon culture there carried on. On his return Mr. Ito established, in 1888, a hatchery at Chitose, on one of the upper branches of the Ishikari River. It was modeled after the hatchery at Craig Brook, Me. By the efforts of Mr. Ito and his successors and by the able superintendence of Mr. Fujimura, the hatchery, which has been enlarged several times, has now become the center of salmon culture (pl. VII, fig. 2). It comprises an area of over 30 acres and hatches annually 8,000,000 to 14,000,000 "sake" eggs, besides a much smaller number of trout ("masu") eggs. All the hatched fry are liberated in the Ishikari River system.

Besides the central hatchery at Chitose there are seventeen smaller hatcheries scattered all over Hokkaido, maintained by private fisheries associations with some government aid. All of these hatch between 1,000,000 and 5,000,000 eggs, while the largest of them, at Nishibetsu, may go up as high as 8,000,000. We may therefore assume that something like 35,000,000 to 50,000,000 eggs—being 37,000,000 in 1903—are annually liberated in Hokkaido.

Besides those in Hokkaido there are some five hatcheries on the main island—Honshu—supported by the five northern prefectures (Niigata, Akita, Miyagi, Awomori, and Ibareki). All of these establishments, however, are small, the largest (Niigata) hatching only a little over 2,000,000 eggs.

At Chitose and Nishibetsu, in Hokkaido, a small number of the "masu" (*O. kisutch*) are hatched, and on Lake Shikotsu, near the Chitose hatchery, there is a small branch hatchery. Here the eggs of the landlocked "beni-masu" (the Ainu "kabacheppo"—landlocked *O. nerka?*) are hatched. This fish was originally found in Lake Akanka, in the eastern part of Hokkaido; from there transplanted to Lake Shikotsu, mentioned above; from there again to Lake Onuma near Hakodate, and still farther to Lake Towada, in the Akita prefecture on the main island.

There is one interesting fact which is perhaps worth mentioning. Of the salmon fry that were liberated in the spring of 1896, 30,000 were marked by cutting off the operculum. Of these some are said to have come back in the winter of 1901–2, and two grown to the size of 2.3 and 2.4 feet are specially mentioned. In the winter of 1902–3 some twenty (according to Mr. Fujimura) were heard from, and five specially recorded. In the winter of 1903–4 some forty (according to the same authority) were heard from, and several were no doubt specially examined, but the records are not just now available. Thus the salmon liberated in one single year are returning during several years in succession, the earliest recorded being five years and a half after being set free. In the years 1897–1901 a certain number of the young fry were marked by cutting the adipose fin, and these are already being reported. All the certain recorded cases have come back to the same Ishikari River system.

I need hardly say that salmon and trout culture is still in its infancy in Japan. The dog salmon is considered by the Americans as not delicate in flavor, and we should not confine ourselves to its cultivation, but should make efforts to introduce the finer salmon and trout of America. At the same time we should undertake the culture of other members of the Salmonidæ native in Japan, such as the "shirauwo" (*Salanx microdon*), the "ayu" (*Plecoglossus altivelis*), etc.

PISCICULTURE IN FORMOSA.

In Formosa, recently acquired by Japan, the native Chinese engage in the culture of various species of fishes, such as the carp, the gray mullet, the crucian carp, etc. Of these, two stand out prominent. One species belonging to the Clupeidæ and called in Chinese "sabahi" (*Chanos salmoneus* Bloch and Schneider) is abundantly cultivated in the southern parts. Although a sea fish, it is able to accommodate itself easily to fresh water. The fish are at first put, when small fry, into ponds not more than 4 feet square, and are fed with hen's eggs. When grown to a larger size, in twenty to thirty days, they are put in larger ponds, given plenty of food, and when they reach the size of 10 inches or more are put on the market. The other fish much cultivated is called "lenhi" (*Hypophthalmichthys molitrix* Cuvier and Valenciennes), belonging to the Cyprinidæ. These are brought from China in November and December, when 9 to 10 inches long. They are kept in ponds and abundantly fed, and may reach the size of 3½ feet, but are sold from the time they become 1 foot long. This fish is cultivated in all parts of Formosa.

THE OYSTER.

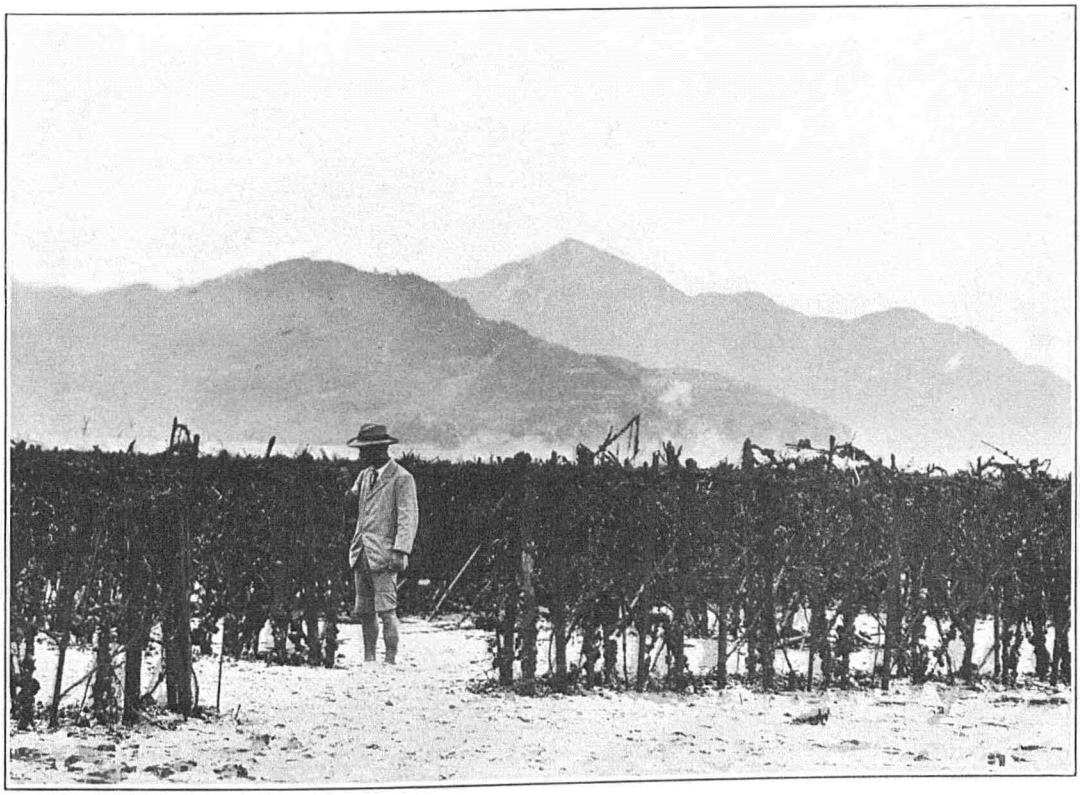
Ostrea cucullata Born.

The oyster has probably been longer under cultivation by man than has any other mollusk, and it is also the most extensively cultivated. As to the former point, I need only refer to Roman pictures delineating oyster rearing, and as to the latter to the extensive enterprises carried on at the present day in Europe and America. In Japan also the luscious mollusk received an early attention, and its culture is becoming more and more extensive. The first place where this was done systematically appears to have been the neighborhood of Hiroshima, a town about in the middle of the length of the Inland Sea and on the north side of that waterway. There is a record preserved there showing that the art of oyster raising was well understood certainly one hundred and eighty years ago, and the practice is no doubt much older. There were several reasons why it should prosper here, among which may be mentioned (1) that the sea about there is as quiet as a lake; (2) that the differences of level between the high and low water marks are comparatively great, being 10 to 15 feet, thus exposing a very wide area adapted for oyster cultivation; (3) the bottom of the sea is rather firm there, being composed of finely ground granite; (4) lots were early divided and leased to individuals, thus securing the utmost exertions of those lessees; (5) monopoly was acquired by the people of this region in selling oysters in Osaka, thus ensuring a large market.

I made in 1894 a careful inspection of the oyster industry of Hiroshima at the request of the department of agriculture of the Japanese Government and wrote a report on it (in Japanese). This has been, in its main outline, together with some valuable additions of his own, put in English by Prof. Bashford Dean, of New York (U. S. Fish Commission Bulletin for 1902, pp. 17–37, pls. 3–7), and the reader may be referred to it for details. I shall, however, touch here, though briefly, on various systems carried out around Hiroshima, for they are, after all, the most complete of any known in Japan.

The simplest method among them is practiced in a village called Kaidaichi, a few miles east of the city of Hiroshima. When the tide is in this bay is a quiet, placid piece of water; one sees nothing unusual unless he looks deep below the surface and notices long lines of bamboo fences. When the tide is out the scene takes on an entirely different aspect. One sees that the entire area, only so recently covered by the water and over which one glided in a boat, seems to be cut up into lots looking very much like town lots, with streets intersecting. Two examples of these lots are given in cuts 5 and 6. The lines in the figures indicate bamboo collectors on which the oyster spat becomes attached and grows, the full lines representing those that were put up any one year, and the dotted lines those of the year previous. Figure 1, plate VIII, shows how these bamboo collectors and oyster fields look. From a distance the sight reminded me of nothing so much as vine trellises in the Rhine vineyards. The spat that is collected on these bamboo fences is left to grow on them until the winter of the next year—that is, only a little more than a year from the beginning. Then the bamboo collectors are taken down, the oysters are beaten off and are then ready to be sent to the market.

The oysters are necessarily small, for unfortunately there is no place in this bay to allow their further growth, as the bottom is too soft and they would become

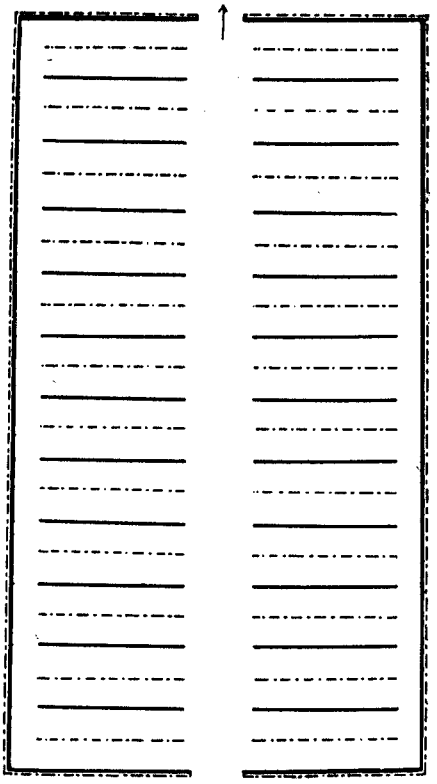


1. OYSTER FARM IN KAIDAICHI.

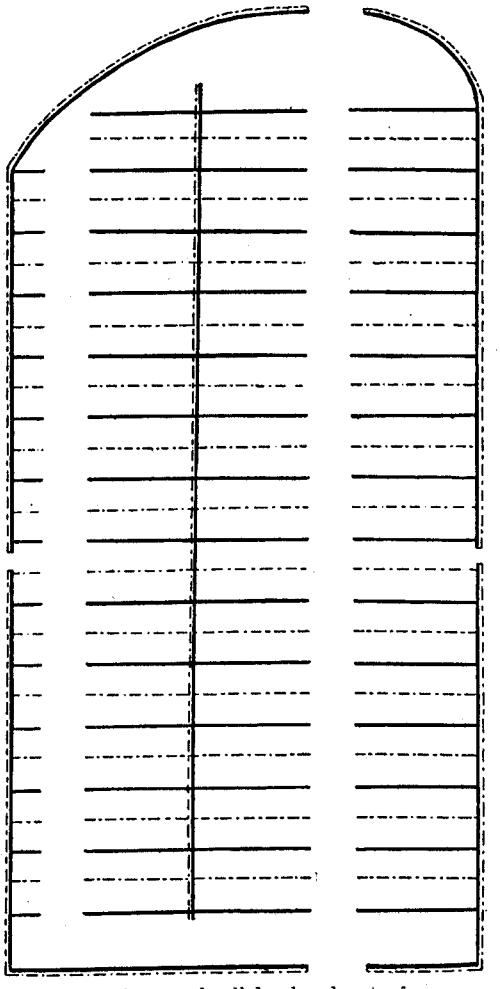
2. OYSTER GROUNDS AT KUSATSU, SHOWING LIVING GROUND (FOREGROUND) AND MATURING GROUND (INCLOSURE IN THE DISTANCE).

buried in mud. This, then, is a very simple system—to collect the oyster spat on bamboo fences, to let it grow on them until a little over a year old, and then to send the oysters to the market.

The method known as the Kusatsu system is practiced in the village after which it is named as well as in all other villages that lie to the west of Hiroshima. Four or five bamboo sticks about 4 feet long are made into clusters and stuck firmly into the



CUT 5.—Typical oyster farm, Kaida Bay.



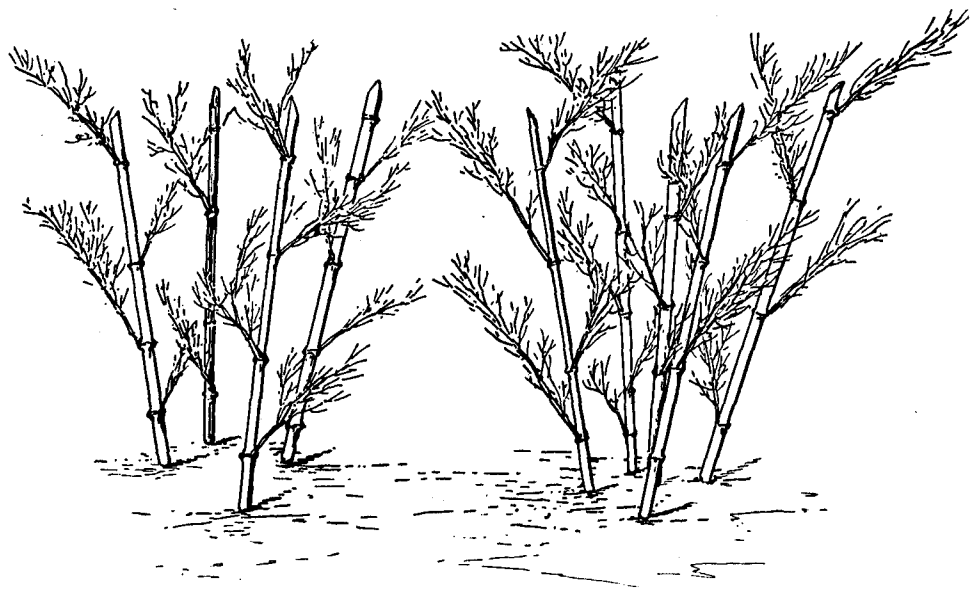
CUT 6.—Diagram of well-developed oyster farm.

The black lines in figs. 5 and 6 represent newly arranged bamboo collectors, the dotted lines the collectors of the second year.

bottom so that about 3 feet is left above ground (cut 7). These clumps are arranged in long rows, generally over 1,000 feet in length, each row being in reality double, with clumps in each of these two subordinate rows set alternately. On these clumps the oyster spat is collected, and the young oysters are allowed to grow on them until April of the next year. At that time the old collectors have to give place to the new set of collectors to be ready for the spat that will soon be shed. Young oysters

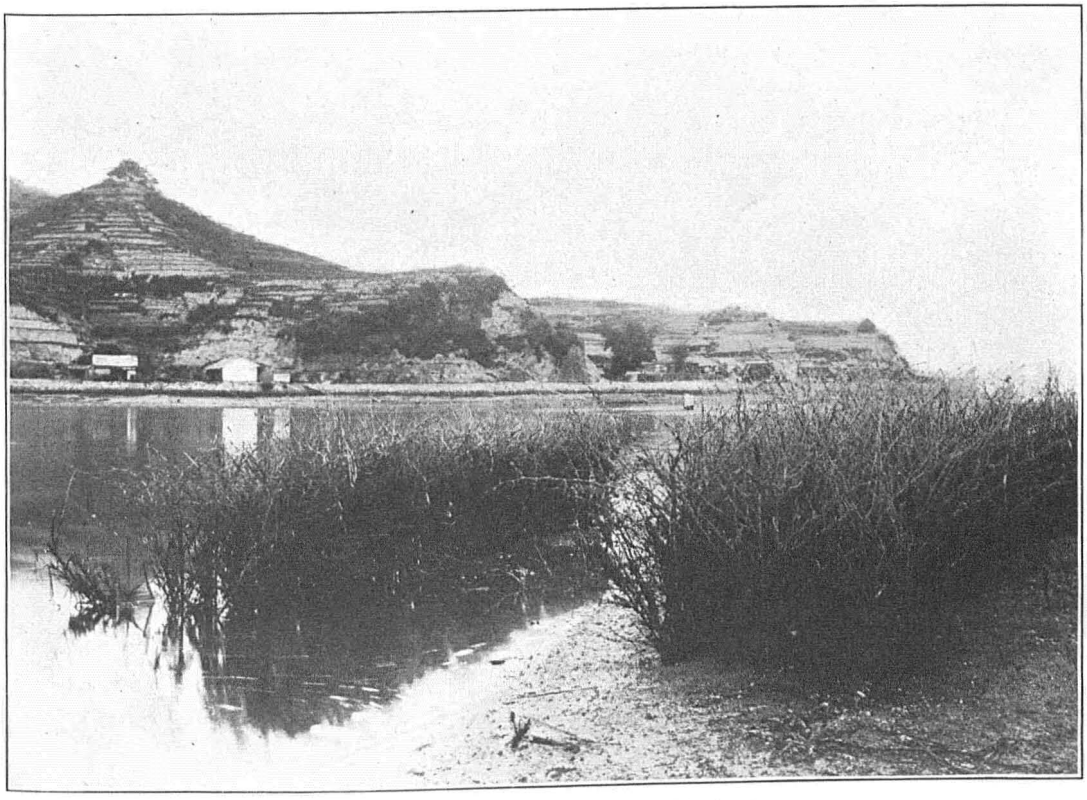
are therefore struck off the collectors at that time and taken to the place called "ike-ba" (literally living-ground), where they are placed directly on the rather firm, gravelly sea bottom, and allowed to grow there until the cold season of the third year. These "ike-ba" may be some distance from, or quite near, the spat-collecting ground, according to the circumstances of each collector and how and where he can get a good bottom for the purpose. Finally, toward the cold season of the third year the oysters are removed to the "miire-ba," or maturing-ground, which is to receive all that are ready for the market. This ground must, of course, be quite near the culturist, and easily accessible. Figure 2, plate VIII, shows oyster grounds at Kusatsu, and conveys a good idea of their extent.

At Nihojima, about 2 miles east of Hiroshima, the nature of the oyster grounds has necessitated the development of a most elaborate system of oyster culture. Here the main part of the grounds is in a sheltered inlet, or rather in an enlarged

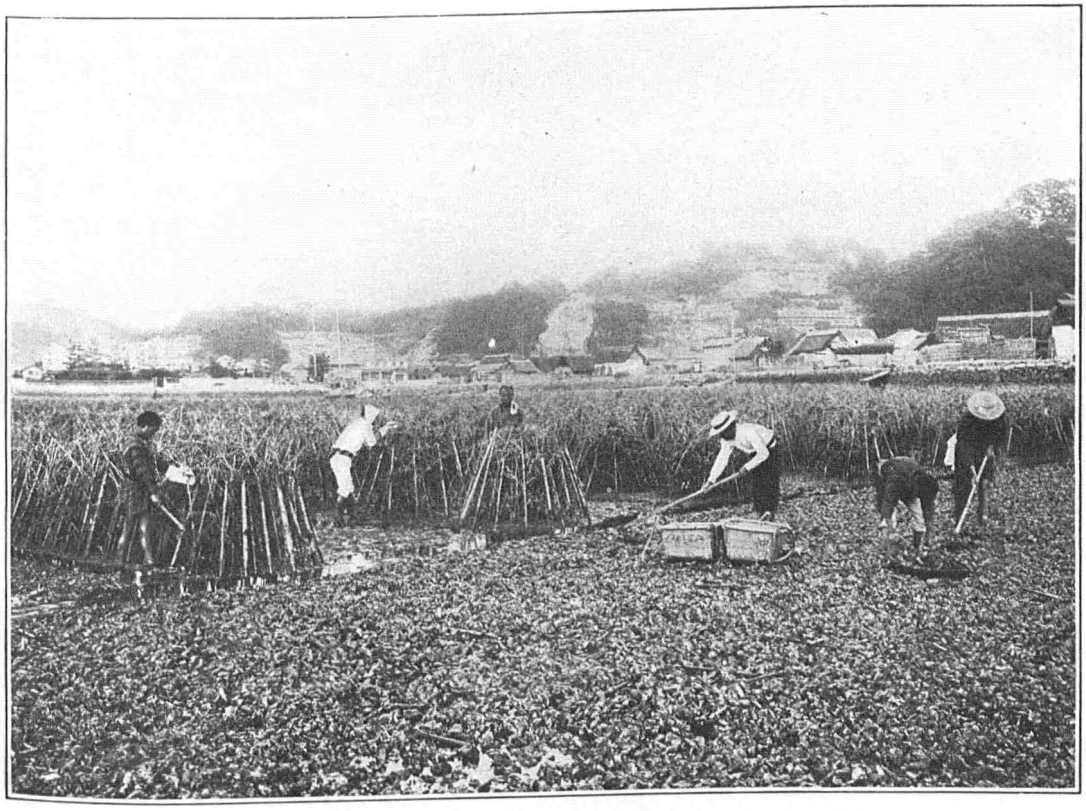


CUT 7.—Bamboo collectors arranged after the fashion common in Kusatsu. They stand about 3 feet above the bottom and their tips diverge; the clumps are set 4 or 5 feet apart.

mouth of a river, which naturally brings down a great deal of fresh water. As I think, for this very reason the spat collecting is done just outside the inlet. Here, in April, when the breeding season begins, bamboo collectors, four or five in a bundle, are planted in close clusters along the channel to receive the spat. Figure 1, plate IX, shows two of these clusters. At the end of the breeding season—that is, in the latter part of August—the collectors are uprooted and conveyed inside the inlet, care being taken not to injure the spat upon them. There they are built into peculiar structures called "toya," which are round pyramidal in shape, and measure about 3 to 4 feet high and 5 to 6 feet across at the bottom (see fig. 2, pl. IX, left side). A "toya" is constructed (cut 8) as follows: In the center are small bamboo collectors of last year on which some young oysters are still adherent. Outside of these the new bamboo collectors which have just been brought in from the spat-collecting ground with tiny oysters adherent on them are placed in two circles, one outside



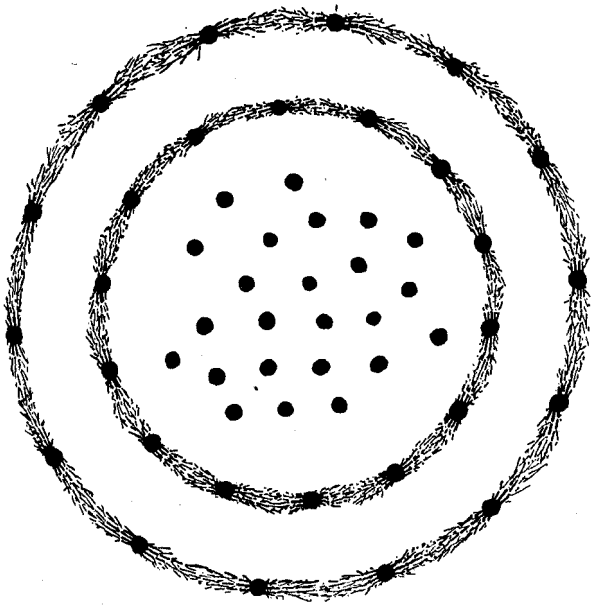
1. SPAT COLLECTORS OUTSIDE NIHOJIMA INLET.



2. NIHOJIMA OYSTER GROUNDS, SHOWING "TOYA" GROUND AND LIVING GROUND.

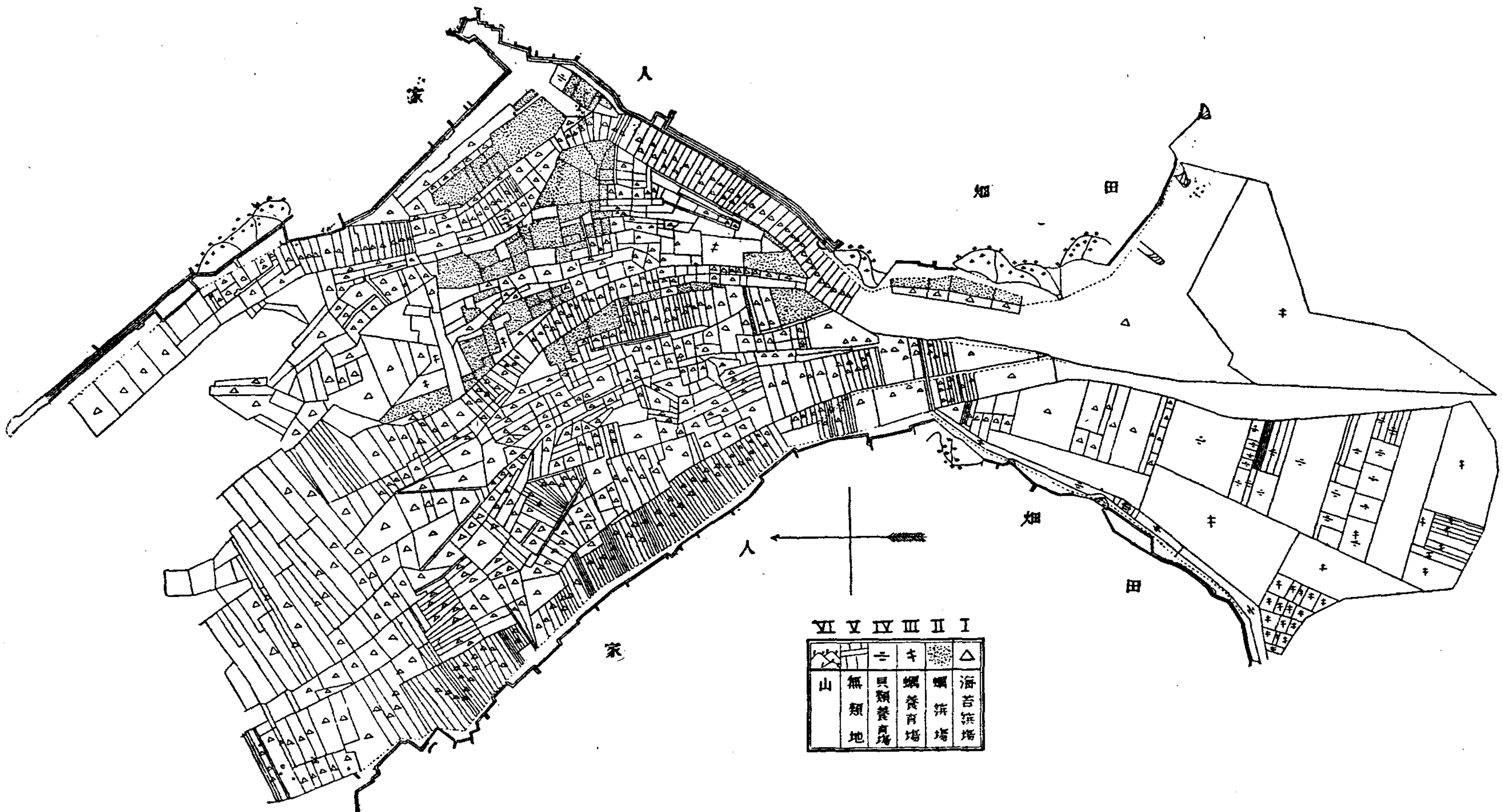
the other, the bamboo branches being made to interlock. The "toyas" are left in this condition exactly one year, when they must give place to the next new set.

The oysters that are now in their second year and are of a fair size are struck off the bamboo collectors, which are rotten by this time, and are then placed in the living ground (fig. 2, pl. IX, right side), where they lie directly on the hard and gravelly bottom. They are left here until the next year, although they are given thorough raking every fortnight or so. By autumn of the third year they are ready for the market. How completely the sea bottom in the inlet of Nihojima has been utilized may be gathered from the accompanying photograph and map. The photograph (fig. 1, pl. X) was taken at low tide, when the oyster living grounds and "toya" grounds are fully exposed. The map (cut 9) gives an idea as to how this sea bottom has been cut up into lots and leased to different persons. Put this together with the fact which you can gather from some of these photographs (fig. 1, pl. IX and fig. 1, pl. X), that hills around here are cultivated to the very top—it would be difficult to go beyond this in the utilization of land and water. Hiroshima has perhaps gone ahead of most places in Japan in this respect.

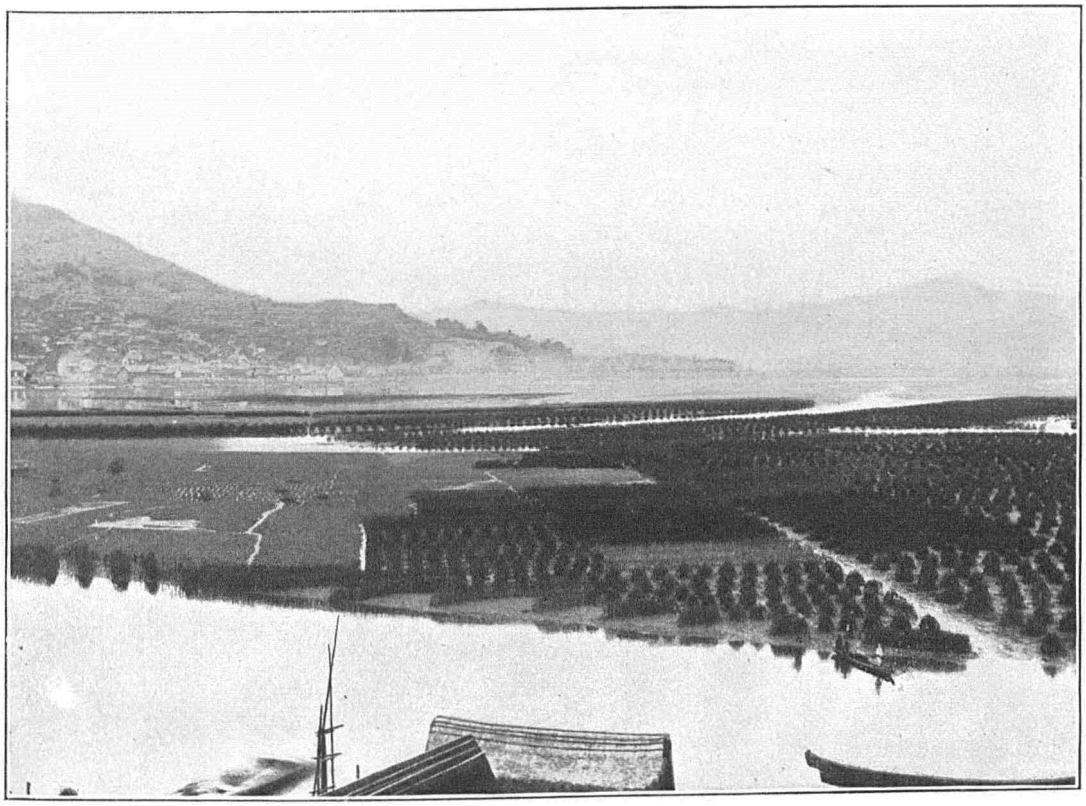


CUT 8.—Ground plan of a "toya." Collectors bearing well-grown oysters are indicated by the black spots within the two circles of branching collectors.

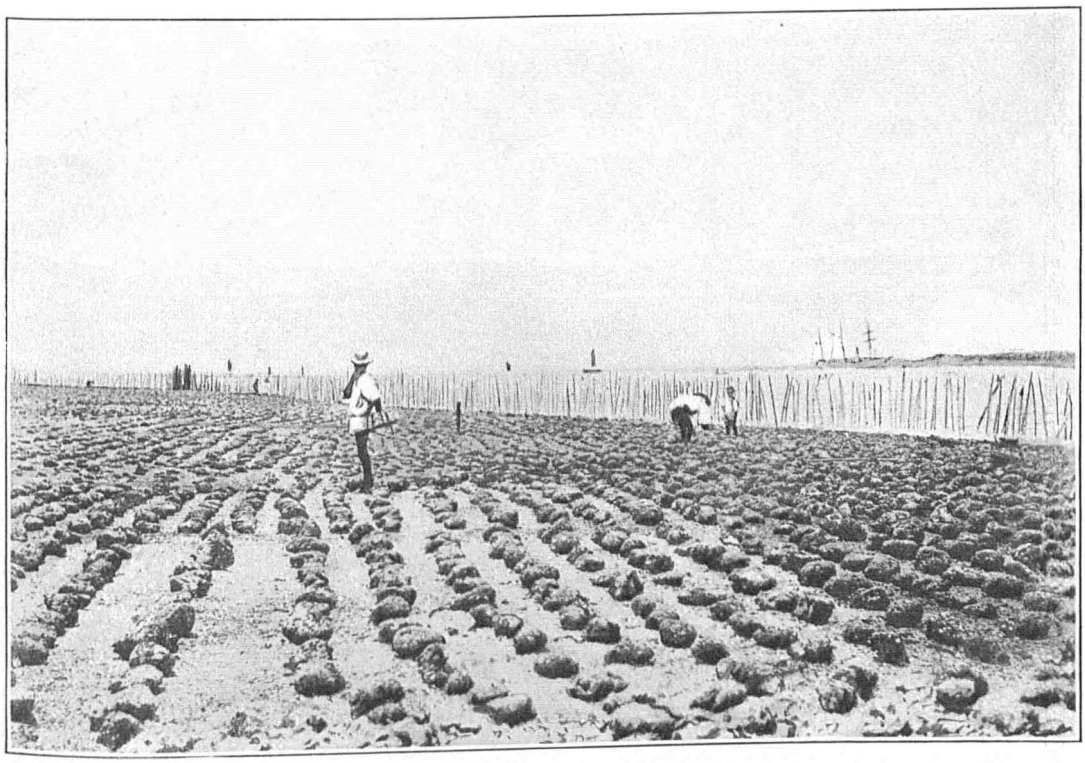
A rather interesting and simple system of oyster culture has been developed within the last twenty years at the mouth of the Suminouye River, in Ariake Bay, in the prefecture of Saga, Kiushiu. It seems that people here were in the habit of collecting all the natural oysters they could and of preserving larger ones among them for a little while on the bottom of the Suminouye River to be sent later to Nagasaki for sale. For some reason, in 1884 those thus preserved were left over winter and it was discovered that by next year they had grown to a large size. This fact was not lost on the sagacious people thereabouts, of whom Mr. Murata, an enthusiastic culturist, seems to have been the head and soul. From this beginning the industry was developed so that 18,330 bushels of oysters, valued at 21,181 yen, were produced in 1897, and the output has no doubt increased since. The method is as follows: Young oysters about an inch or more in length are collected constantly from July till March of the next year from stone walls, old shells, etc. All these are placed on oyster beds in the river mouth, and as these small ones may be choked by being covered up with the silt, they are heaped close together in masses, and are moreover washed and cleaned two or three times in a month, at low tide. In April these oysters are stuck into the mud almost vertically with the hinge-end below



CUT 9.—Map of the oyster and seaweed concessions in one of the estuaries of Nihojima, to show how completely the cultural area is developed: I, collectors bearing purple seaweed; II, collectors bearing oysters; III, grounds for rearing oysters; IV, cultural area for other mollusks, Tapes, Arca, etc.



1. GENERAL VIEW OF NIHOJIMA INLET WHEN THE TIDE IS OUT, SHOWING "TOYA" GROUNDS AND LIVING GROUNDS.



2. OYSTER GROUNDS NEAR TAMSUI, FORMOSA.

and with the ventral margin above. As the mud is firm, they seem not only to keep this position, but also to grow finely. They are often cleaned, and as they grow they are often thinned out and given more space. In August and September they grow most rapidly. By October they are 6 by 5 inches in size and ready for the market. I think the rapid growth, the round shape, and the large size must distinguish this from the ordinary Japanese species of oyster. This system seems very profitable, as 1 tsubo (6 feet square) is said to give a return of 3 yen. In Formosa there is also a system of oyster culture practiced by the Chinese. Figure 2, plate x, gives a view of an oyster farm near Tamsui, on that island. Large blocks of stone are arranged 1 foot apart in regular rows, and on these the spat is collected and the oysters are left to grow.

There are various other methods and variations of methods carried on with more or less success in different parts of Japan, and they are increasing every year.

THE PEARL OYSTER.

Avicula martensii Dunker.

Various kinds of pearl oysters are found in the southern semitropical islands of Japan, but the only one which is at all common in Japan proper is the species named above. This pearl oyster is found more or less along the whole of the coast of Japan, but there are some localities famous for producing it in quantities. Such are Shima, Omura (province Hizen in Kiushiu), Noto, Tosa, etc., and some fine pearls have been obtained from these places. As in so many other matters in Japan, there was a time after the restoration of 1868 when the fishery for these precious shells was thrown into a chaotic state, and, as is usual in such a case, carried to an excess, so that the yield of pearls dwindled to almost nothing.

In 1890 I suggested to a Mr. Mikimoto, a native of Shima, who had grown up and lived in the midst of the pearl-producing district, the desirability of cultivating the pearl oyster. He took up the subject eagerly and began making experiments on it. Soon after I pointed out to him also the possibility of making the pearl oyster produce pearls by giving artificial stimuli. He at once proceeded to experiment on it. The results have been beyond expectations, and to-day the Mikimoto pearl-oyster farm, put on a commercial basis, has millions of pearl oysters living on its culture grounds, and is able to place annually a large crop of pearls on the market.

The Mikimoto pearl oyster farm is in the Bay of Ago, on the Pacific side of central Japan, a few miles south of the famous Temple of Ise. The bay, like all in which the pearl oyster grows in abundance, is a very quiet piece of water with a most irregular, highly broken-up coast line full of deep-running inlets, coves, etc., with a depth of 3 to 7 fathoms, and affording most favorable shelter. Somewhat out of the center of the bay to the north there is a little island called Tadoko, where the land part of the enterprise, necessary buildings, etc., are placed, and where altogether about 100 persons connected in some way with pearl-oyster culture are now living. Around and in the neighborhood of this island a large area of sea bottom, which with several large recent additions now amounts to 1,000 acres, has been leased by Mr. Mikimoto.

The farm is divided into two portions: (1) Those parts where the spat is collected and the young are kept to their third year, and (2) the parts where the shells older than 3 years are kept. The breeding season of the pearl oyster is July to August, and before this comes round—namely, in May to June—stones 6 to 8 pounds in weight are placed over the bottom of the spat-collecting grounds, which are generally in shallower parts, penetrating deep into land. By August tiny shells not more than 3 to 4 millimeters long are first discovered, attached to these stones by their byssus, and the number increases steadily with the season. An immense number of shells is collected every year. They are allowed to lie as they are until November, and then those that are too near the shore are removed with the stones on which they are anchored into depths greater than 5 or 6 feet. This is necessary to protect them from cold, from the effects of which they are apt to die in the course of winter if left in the original places. The young shells are then left quietly and allowed to grow for three years, or, better, some may be removed to deeper waters and where they are given more space and get more food, and grow better. At the end of three years, when they are about 5 to 6 cm. across, they are taken out of the water and the operations necessary for inducing them to produce pearls—that is, of putting in nuclei for pearls—are performed on them. At present the number thus operated on in a year is only 250,000 to 300,000. They are then put back in the sea and spread out at the rate of about 30 to every tsubo (6 feet square), and are left alone for four years more. At the end of that time, or seven years and a half from the beginning, they are taken out of the water and opened. Natural pearls, as well as "culture pearls," as I have named those produced from the introduced nuclei, are thus harvested and put on the market.

As in all culture enterprises, there are many enemies of the pearl oyster, as well as unexpected difficulties in the way of its culture. *Octopus*, *Codium*, *Clione* (sponges), all sometimes play a sad havoc among the mollusks, but the most dreaded enemy of all is the "red current" or "red tide." This is an immense accumulation of a Dinoflagellata, *Gonyaulax*, causing discoloration of the sea water, and, in some way not well accounted for, causing in its wake an immense destruction of marine organisms, large and small.

The "culture pearls" (fig. 1, pl. XI) are, I regret to say, either half pearls or only a little more than half pearls, but as regards luster, shape, and size, they are beautiful beyond expectations, and meet the requirements completely in cases where only half pearls are needed.

Pearl-oyster culture is still in its infancy, but its promises are bright. If, in addition to half pearls, full or "free" pearls can be produced at will, as there are some hopes, it will be a great triumph for applied zoology.

THE ARK-SHELL, "HAIGAI."

Arca granosa Lischke.

One of the most interesting cultural enterprises in Japan is that with the ark-shell (*Arca granosa*), or "haigai" as we call it. This was originally and is at the present day most extensively carried on at Kojima Bay, near Okayama. This bay opens

into the Inland Sea by a narrow mouth, hardly a mile across, and is about 8 miles in length by 6 miles of breadth. The differences between high and low tide marks are comparatively great here as in all parts of the Inland Sea, being 5 to 7 feet, and at low tide the whole of the bottom of the bay is exposed, leaving only four river channels which run through the bay to its mouth. This flat is the area utilized for the cultivation of *Arca granosa*. It seems that this idea was present in the minds of some of the people as far back as the sixties in the last century, and was actually put in practice by 1869. At the beginning different individuals undertook the cultivation by themselves, and the conflict of interests soon became the source of endless disputes. People soon getting tired of this, it was agreed in 1886 to form an association in which all the conflicting interests were amalgamated, and as this worked very smoothly, it was organized in 1890 into a stock company. At present a little over 830 acres of the bottom is utilized, the cultivated areas being scattered mostly along the southern and western sides of the bay. The annual sale amounts to 75,000 to 100,000 bushels, valued at more than 30,000 yen, and yielding a return of 40 to 60 per cent on the capital invested.

The method of culture is as follows: By September or October of every year, the larvæ of the mollusk, quitting their swimming stage, have become tiny shells not more than 2 or 3 millimeters long, buried directly below the surface of the bottom mud. These are collected from various parts of the bay by an ingenious instrument which may be described as a huge comb more than 6 feet long, being a series of short pieces of wire with their points slightly bent, and planted with the other end on a piece of board. This, being applied on another piece of plank, is forcibly pushed along the mud bottom with the tooth part down, and all the tiny shells in the mud are caught between the teeth of the comb and accumulated on the bent ends of the wire. These are collected once in a while and put into a tub, after which another raking is gone through. The distance between the wires regulates the size of the shells to be caught. If the interval is large the shells caught are naturally large, and vice versa.

These tiny shells collected from various parts of the bay are placed in the culture grounds. It has been found that the best size for starting culture is quite small—that is, one which will go in to the number of 30,000 to 70,000 per "sho" (1.58 quarts or 1.8 liters). In order to distribute them over the ground allotted to them, the little shells which have been collected are heaped up in a boat. One man rows the boat along slowly and two others measure out the shells and throw them overboard with wooden scoops. The quantity of shells that can be most profitably put into a unit area differs of course with the size and age of the shells, and has been very carefully studied out.

The tiny shells that in September are only 2 to 3 millimeters across and run 30,000 to 70,000 to a "sho," grow by the autumn of the next—that is, the second—year to nearly 20 millimeters in length and run only 1,000 to a "sho." In the autumn of the third year their average length is already 32 millimeters and they run only 200 to a "sho," and by the autumn of the fourth year they become 42 millimeters long or only 120 to a "sho."

As the shells grow their number per unit area must be diminished to the proper number determined by previous experience, and all the superfluous ones must be removed to near lots. These culture grounds show therefore a large number of

partitioned or marked areas, each of which contains a special lot as regards size and age, and give one an idea of the most methodical procedure.

It has been found that the crop of tiny shells which can be collected each season differs greatly in amount with different years. For instance, in 1893 the crop was very large, amounting to 14,145 bushels, but in the following year there were only 15 bushels, and in the two years after that matters were still worse, there being practically none at all. In order, therefore, to have the market supply constant and not fluctuating as these "seed" shells, it has been found possible to retard the growth of the shells. That is, after they reach a size of 2,000 to a "sho" they are removed to a somewhat deeper place, where the current is slow and where they are no doubt also kept more crowded than usual. This has been found enough to make their growth slower, and the seed shells collected in one year can thus be depended on to supply the market for five years.

The 3-year old shells are exported in the fresh condition to China, where they are very much valued, while the 4-year old and the older are consumed in Japan.

Another species of *Arca* (*A. suberenata* Lischke) is cultivated more or less in the same Kojima Bay, but this shell flourishes best in deeper waters which are not exposed at low tide and where seaweeds are growing. Such a condition is found in Nakano-Umi near Matsui, province Isumo, on the Japan Sea side, where the ark-shell has now been cultivated for over a hundred years. The system of culture is that of rotary crops, giving fine results. The area under cultivation is at the present day about 2,631 acres.

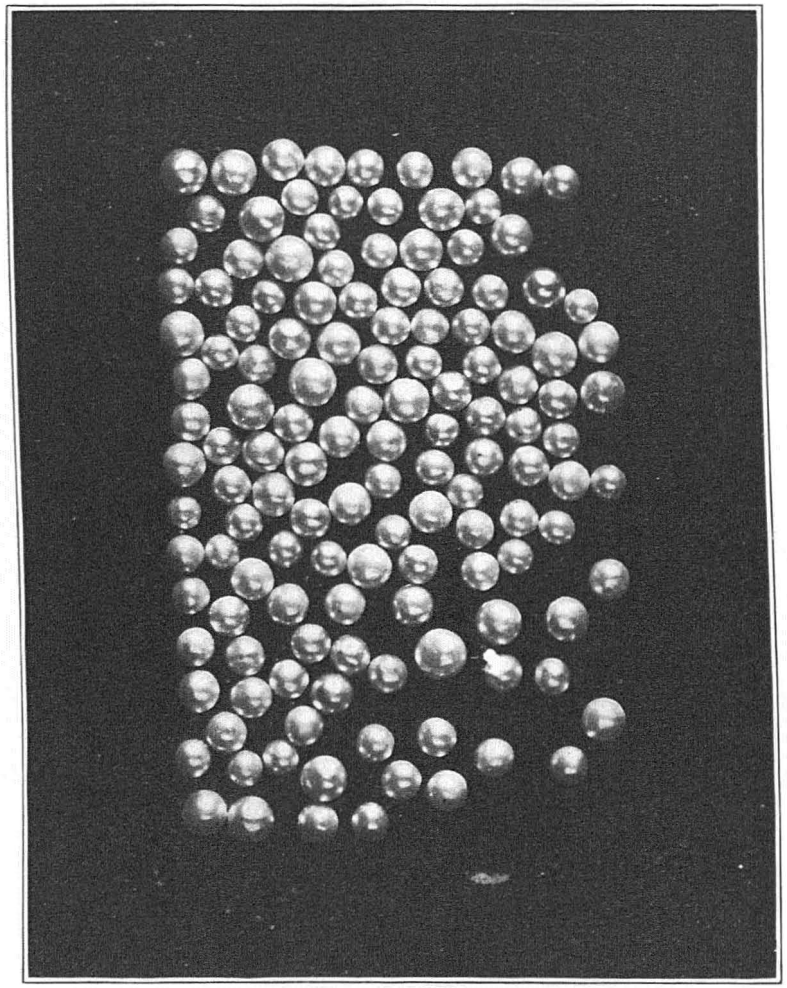
THE RAZOR CLAM, "AGEMAKI."

Solecurtus constricta Lamarck.

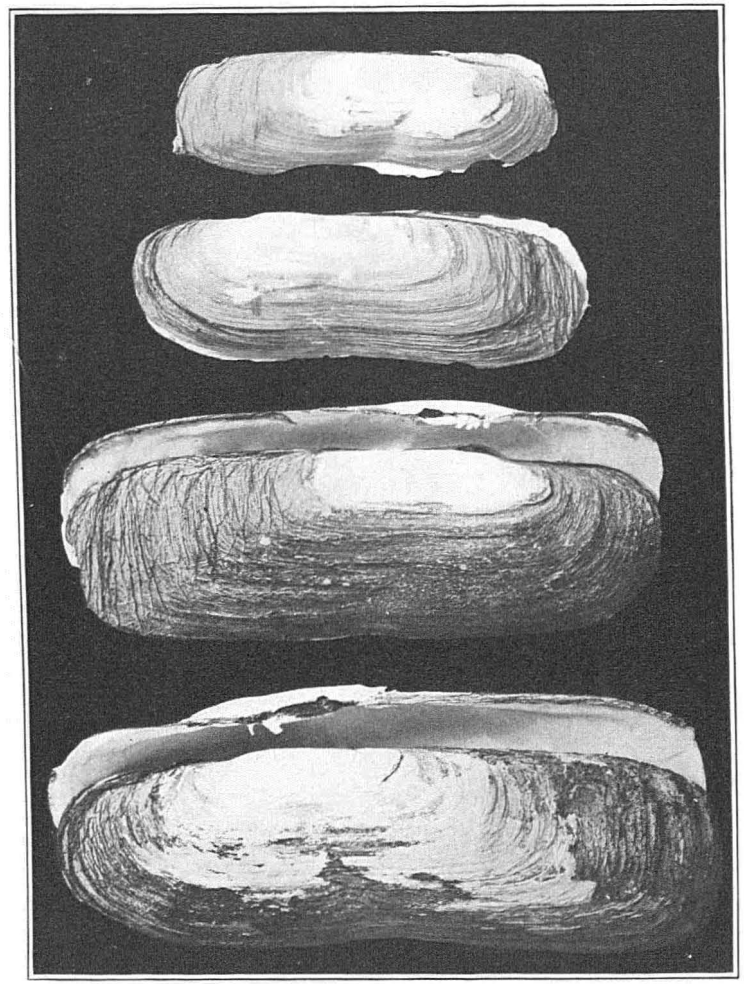
Reference has been made to a peculiar system of oyster culture begun lately in the mouth of the Suminouye River in Ariake Bay. The shores of the same bay have extensive mud flats exposed more or less at low tide and here the cultivation of two other animals has gradually been developed, "agemaki" (*Solecurtus constricta*), a shell somewhat resembling razor shells, and barnacles (*Balanus* sp.).

The first of these ("agemaki," fig. 2, pl. XI) is dried and exported to China. The trade began in 1875, and increased so rapidly that by 1882–83 the supply was not equal to the demand, and owing to the consequent overfishing the shells caught were becoming smaller and smaller. To remedy this state of things, the Department of Agriculture and Commerce established there an experiment station for the cultivation of the shell, and one Mr. Negishi, belonging to the district, one year put in, for trial, about 135 bushels of the shell in the tide flats, and found that these had increased by the following year to 820 bushels, thus thoroughly demonstrating the practicability of the culture. From this beginning the industry increased so rapidly that by 1896 in this part of the bay alone over 700 acres[a] were under cultivation and about 50,000 bushels of seed shells were collected, and 112,845 bushels sold, fetching 79,329 yen. The cultivation has since extended to other parts of Ariake Bay, and promises to become more and more important.

[a] The calculation of areas on the sea bottom in Japan is very rough and only approximate. As a general thing it falls far short of the actualities.



1. CULTURE PEARLS, NATURAL SIZE.



2. "AGEMAKI" SHELLS.

The method of culture is very simple. The young are collected all over Ariake Bay in July and August of each year. They are then between 4 and 5 centimeters in length, and are dug out by spades and hands and then transplanted to culture grounds, care being taken to protect them from the sun's rays during the passage. Arrived at the culture grounds they are scattered about and soon find their way into the mud of the bottom, which must therefore be well adapted for the life of this mollusk.

These shells are left for about three years. According to the specimens given me by Mr. Fujita for examination, at the end of the first year after transplanting they are 5.6 centimeters long; at the end of the second year, 6.6 centimeters; at the end of the third year, 9 centimeters; and at the end of the fourth year, 10 centimeters. In some parts growth is no doubt more rapid.

BARNACLES, "JIMEGI."

Balanus sp.

Further out in the same tide flats where the agemaki is cultivated as described in the previous section, there are planted bunches of bamboo collectors that look like the collectors for oyster spat. Here, however, they are to collect a species that is generally considered injurious to cultural enterprises—namely, the barnacle. The collectors are put up twice in a year—that is, in the spring and in late August. The spring collectors begin to be taken down after sixty days and it is thirty days more before they are all disposed of. The autumn collectors are left standing one hundred days, after which they are gradually taken away before the next March. The barnacles that are attached to the collectors are beaten off and used as manure. The annual yield is 400,000 bushels, fetching 30,000 yen. This cultivation has been going on ever since 1830 or thereabouts.

MISCELLANEOUS.

"Tairagai" (*Pinna japonica* Reeve). The cultivation of *Pinna* is confined to a small village on the Inland Sea, but it is interesting as a specimen of what can be done in the way of mollusk cultivation. A little west of Onomichi, a large town on the north side of the Inland Sea, there is a small village called Hosojima. It has only twenty-five households, but each of these twenty-five possesses a small *Pinna* culture ground of its own, not more than 50 by 30 feet.

Every October young *Pinna*, between 7 and 8 centimeters long, are collected at a shoal near the village and put rather thickly into the culture grounds. The triangular shell, upright, with the acute apex below, is buried in the mud to the edge of the shell and placed in such a way that the hinge line is toward the land and the open gaping side toward the sea, thus preventing the muddy water that runs down from entering the mantle cavity of the mollusk. By October of the next year the shells have increased about two and one-half times in size, although they are said to decrease in number 40 per cent, and will not grow much more even if left longer. They are then taken out, and new, young shells are put in their place.

Egg cases of Gastropoda. The peculiar leathery egg cases of various gastropods have a commercial value in Japan. You see them sold in the streets, dyed red, each

costing about half a cent. They are bought by young girls. The cases are turned about in the mouth, and when filled with air and then squeezed between the tongue and the roof of the mouth emit a peculiar sound. The same use is made of the fruit of a plant (hozuki), and the mollusk egg cases serving the purpose are called "umi-hozuki" (sea hozuki). These toy things are in such a demand that the supply can not be left simply to the accidental finding of them, and so various methods of cultivating them have been devised in different parts of Japan. In Chiba boxes are constructed 6 by 3 feet and 2 feet high, with wooden sides and covered with bamboo basket work on the top and the bottom, and in these large whelks (*Rapana bezoar*) are placed and the whole left floating in the sea. The mollusks soon deposit their egg cases on the wooden sides. In Noto pine sticks 2 to 3 feet long are anchored by a line and a weight and are left floating in the sea for the mollusks (*Fusus inconstans*) to come and deposit their egg cases on them. In Okayama inverted bamboo baskets are kept anchored in the same way and serve as the repository of the eggs. There are, no doubt, other methods in other places. These egg cases, although mere toys, must altogether be worth several tens of thousands of yen. Chiba alone produces them to the value of 30,000 yen and Noto 10,000 yen.

"Bakagai" (*Mactra sulcatoria* Deshayes); "asari" (*Tapes philippinarum* Adam and Reeve); "shijimi" (*Corbicula atrata* Prime, and other species). These mollusks, especially the last two, are very common and are consumed in enormous quantities, which facts have naturally led to a greater or less amount of cultivation in some places. They may be collected when young and allowed to grow in culture grounds, or they may be allowed to grow by systems of rotary crops. Methods would seem to differ in different places.

The trepang, "namako" (*Stichopus japonicus* Selenka). In a recent paper of mine (Notes on the Habits and Life History of *Stichopus japonicus* Selenka, Annotations, Zoological Japonicæ, Vol. V., pt. 1), I offered suggestions on the method of propagation of this holothurian, after a study of its life history. My ideas have not yet been given a fair trial, but in Mikawa Bay, where a part of them have been enforced, the complaint of the decrease of the supply, at least, seems to have ceased. I may perhaps be allowed to quote the last paragraph of the paper. "After I had thought out these measures of protection for *Stichopus japonicus* from its habits and life history, my friend, Doctor Kishinouye, was traveling in the somewhat out-of-the-way island of Oki and found that people there had been a hundred years or more in the habit of putting up loose stone piles in the shallow sea in order to obtain a supply of the holothurians. A village headman had thought it out from practical experiences. Verily there is nothing new under the sun."

"Amanori" (*Porphyra tenera* Kjellman); "Funori" (*Gloiopeltis furcata* Post and Ruprecht). Although the present discussion is on the cultivation of animals, I can not help alluding at the end to the cultivation of some seaweeds, as one of them at least is very important indeed. The "amanori" or "asakusanori" is most extensively cultivated in various parts of Japan. Of all places, however, the system has reached greatest perfection at Shinagawa and Omori, at the mouth of the Sumida River, which passes through Tokyo. In the late autumn or in the winter you can see here miles upon miles of culture areas in which tree branches are set up as collectors. During the cold season the alga keeps growing on them, and any fair

day you can see hundreds of little skiffs, mostly with women and young girls, going out to collect it. Being brought home, the plant is thoroughly cleansed and then made and dried in the shape of thin rectangular sheets about 25 by 18 cm., looking very much like sheets of dark paper. In this state it can be kept for a long time and is sold in shops. When slightly roasted the sheets have a peculiar taste and are used much to give flavor to various articles of diet. The production about Tokyo alone is over 1,000,000 yen, and for the whole country it must of course be much more.

"Funori" (*Gloiopeltis*) is used as the starch-yielding source in the manufacture of various kinds of silk and cotton goods and in washing, and is one of the most important articles produced by the sea. Its cultivation is not as extensive as that of the amanori, but, according to Mr. Endo, it is undertaken to some extent in the village of Shimofuro, in the district of Shimokita, prefecture of Aomori, on the south side of the strait between Hokkaido and Honshu. At that place there is a large ledge of rock that is exposed at low tide. Here people place 700 to 800 large blocks of stone, and the alga, which grows between tide marks, soon becomes attached to these. After five or six years, when the blocks become too old and the alga no longer grows on them, they are pushed into deeper parts and new blocks are placed in their stead.

I think I have now given—how imperfectly, I am but too well aware—a brief survey of the marine and fresh water animals cultivated in Japan. The subject has always been an attractive one to me, as it might in many respects be called applied embryology. Aside from its immediate economical results, there are many things in it which might be utilized to solve problems in heredity, growth, ecology, etc.

In conclusion, I wish to express my thanks to all who helped me in the preparation of this paper. Especially I would mention Doctor Kishinouye, Messrs. Fujita, Mikimoto, Nishikawa, Wada, Fujimura, and Hattori. To Mr. Uchiyama, my assistant, I am indebted for much painstaking photographic work.