An Analysis of Fish Attracting Effect of "Komashi" or Fish Attracting Bait

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INTRODUCTION

Fishing baits can be classified, according to the use of them, into three, i.e. (1) the bait attached to the hook, (2) the bait prepared in the trap or snare to allure fish into confinement, and (3) the bait to be scattered at the fishing spot to attract the fishes from far to come close to the spot. "Komashi" (some times called "komase," "kabushi" or "kabuse") is a common name to call the bait of the third category in Japan.

As it is thought to be so effective in the fishing, since olden time various sort of baits had been used for this purpose in the various kinds of fishing of both commercial and sports in this country. For example, a modern intensive industrial mackerel fishing in Korean Straights is done by the method called "hanezuri," a sort of rod and line fishing alluring the mackerel school to the boat by "komashi" made of chopped meal of salted cheap fish such as sardine, herring, saury and often mackerel itself. Hard-tail "azi," *Trachurus japonicus*, is one of the most important food fishes, having a large landing amount, and also this is caught by using "komashi" either by hook and line or by lift net. "Isaki," *Parapristipoma trilineatum*, is also caught by similar method in commercial quantity. For the both fish species, usually the salted minute Crustacea, mostly *Mysis* spp., is used as "komashi." In various kinds of sports fishings in this country, the same principles are applied in many cases. "Isozuri," a big game fishing at rocky shore for sea wrasse, "ishidai," and others needs grinded shell-fishes such as top-shell, having scattered around the fishing spot to allure fish near by. In the fishing of "kurodai," *Sparus swinhonis*, at the sandy beach, powdered dried silk-worm cocoon, boiled sweet potato, boiled noodles made of corn flour and others are used as "komashi." Beside these, so many game fishings are going on by the aid of "komashi" in this country.

As so various sort of substance, some are marine products, but some are land products, are found among "komashi" as effective to allure the fishes, the authors had been interested to see what kind of chemical ingredient in them might have the alluring effect, as well as to analyse the alluring effect caused by the existence of the figure which is recognized by this sense of vision of fish. And, if these factors could be

clear out, about "komashi," that would be some key to find out the same about the bait in hook and bait in trap also.

On the other hand, during the food shortage period in and after the World-War II in this country, as most of "komashi" are the substance to be available as human or live-stock food. And it needs so big amount to be used in fishing, accordingly it became too costly and fisherman required an effective substitute for this.

During a stay at Misaki Marine Biological Station of University of Tokyo, HIYAMA found an interesting material, a school of fish reared in the aquarium attached to this station, to do this sort of experiment, and a series of the experiments were done by himself. However, as he wanted to go further after that, in the next summer, YOSHIZAKI and NAKAI, students of Fisheries Course of University of Tokyo at that time, continued the experiments, as a graduation thesis work under Professor I. AMEMIYA.

The present paper, compiled by HIYAMA, is based on all of these works altogether. Here, the authors wish to express their thanks to Dr. AMEMIYA, Prof. Emeritus, for his kind guidance and generosity to publish this.

1. MATERIALS

At the entrance hall of the aquarium, a round and shallow (80 cm deep) tank surfaced by white tiles, 3.8 m diameter, is settled for the exhibition to see it from above, which usually keeping fish school of sardine, mackerel and hard-tail.

During the summer time of 1942, about one and half hundred individuals of hard-tail, *Trachurus japonicus*, with several individuals of *Parapristipoma trilineatum* mixed in, of the size about 10 to 20 cm long, had been kept in this tank, having been fed by salted *Mysis* (exactly speaking, this is a mixture of the several species belong to Mysidacea) since several weeks before the experiments. As these fishes almost died during winter after the first experiment, the fishes used for the second experiment at summer time of 1943 were almost entirely another fish school of about 200 individuals of hard-tail, with several *Parapristipoma trilineatum* mixed in, of size of 10 to 15 cm in length, and about 10 individuals of mackerel, *Scomber japonicus*, of 20 to 30 cm long. All of these had been fed by the same materials during several weeks prior to the experiments.

In every case of feeding, a conspicuous aggregation of fish was seen to the spot where the food (salted *Mysis*) was thrown in by any feeders. This aggregation occurred at any spot where the foods are thrown in without regard to any particular location in the circular tank.

This aggregation is manifestly a sort of a response behavior conditioned by feeding, and the presence of food is the main factor to cause the locomotion of fish.

However, during the preparatory experiments the author noticed that this also occurs by some factors other than the presence of the food. These are as follows.

(1) Response to human figure. The school of fish is apparently conditioned to response to the appearance of any human figure approaching to the certain distance

from the ridge of the tank. So, the aggregation of some degree was seen frequently before the man throw the food into the tank. And, this significantly happened from a certain long distance from the tank, if the feeder makes the sound of foot steps by the nailed sole shoes with concrete floor. This shows the fish is conditioned to response to the sound of foot steps. However, even though the feeder wears the rubber sole shoes and steps carefully so as to make no noise, when he reaches to a certain distance from the tank, enough to close to be able to be recognized by vision of fish, the aggregation towards to that spot happened usually. This is considered to be that the fish is conditioned to response to the human figure shown up close to the tank by the both visual and hearing sense of the fish. So to eliminate this factor, during the entire series of experiments, the investigator had to wear the rubber sole shoes, and had to walk silently. And also, a rubber tube is settled on the ridge of the tank to pour the feeding matter into the tank conveyed from the distance from where the fish can not see the investigator.

(2) Response to stir in water. The fish school had been conditioned to response to move toward to any substance which could be recognized by the sense of vision, such as a piece of paper or even a foam of water. Moreover, as the foods had been thrown into the water in every time of feeding, the fish school showed the significant response of aggregation even when 1 cc of pure sea water was poured into the tank by shooting it by a pipette. And also it was the same when a man stir the surface of water by a long stick. So it was recognized that the fish was conditioned to response to any stirring wave at the surface.

To avoid this effect, every test samples in the following experiments were poured into the water carefully and gently under the surface of the water by the aid of the tube.

Besides these above mentioned conditions of fish, the following conditions were considered to carry out these experiments.

Water current The tank is usually supplied by sea water from a certain spot and an exhaust pipe is furnished at the almost opposit side to the supply. So, usually a slow water current exists always in the tank, and the fish school has a slight tendency to aggregate to the point under the water supply. To eliminate this tendency, the sea water supply was stopped during these experiments, and the point where the food matter is supplied in the experiments was selected from the points far from usual water supply.

Light During the daytime illumination on the tank was rather homogeneous, but at some time in the afternoon the sun light directly came to some particular part of the tank through the windows located at west side of it. However, after frequent observation the author is convinced that this heterogeneity of the illumination does not effect the fish behaviour as much as to bother the exact observation of these experiments.

Time of a day The response behaviour of the fish was inactive when the fish was fed well, and was rather active in morning and late afternoon than in the time

around noon. The experiments were done only while the fish response is active, testing it prior to the experiment by feeding them by a small amount of salted *Mysis*, the food they were accustomed.

Usually, when no food is exist in the tank, the fish school is rather homogeneously scattered around entire area of the tank. But, when a certain matter which has some effect to allure the fish was given, the fish school aggregate toward the point where this matter was supplied into the water. Some times this was quite significant, so almost entire fish school comes together to the spot, but some times merely a part of it was allured by it and others were remaining to the previous location as if they did not noitce the presence of the matter. So, in order to express these various degree of the intensity of the response, the author classified this continuous variation roughly into the following four grades for the convenience of the expression in this paper, though the observations were recorded in detail originally.

(1) *None.* No difference was seen from the usual behaviour since the test substance was in, as if the fish does not notice the existence of any attractive matter.

(2) *Slightly.* Under about 10 % of the total number of the fish was recognized to be allured to the spot where the test matter is poured in, and the remaining fishes was not.

(3) *Partly.* Over about 10 % and under 3/4 of the total number of the fishes were recognized to be allured to the spot where the test matter was poured in, and others were remaining in the same location. About these cases, some times the rough fraction figure of the number of fish allured is attached.

(4) *Entirely.* Almost entire fish school in the tank was recognized to gather toward the spot where the test matter was put in.

(5) *Negative.* When the test matter was poured in fishes behaved to move from the spot toward to opposit spot as if the fishes did not like it. The degree of negative response was also expressed as *slightly negative*, *partly negative* or *entirely negative* as the same meaning as mentioned above, if it is neccessary.

In order to recognize these phenomena of response, some times it requires a considerable time to bring the situation, probably because the diffusion of the matter in the water in the tank was slow and gradual. So, the observer had to wait until at least five minutes to decide the degree of response.

2. CHEMICAL EFFECT OF NATURAL SUBSTANCE

About 27 kinds of natural substance, prepared various ways were tested to see the chemical attracting effect, so as to see any common ingredient among them, and at the same time to find out any substitute for "komashi."

These materials were either minched or crashed and mixed with water, and either boiled or not. And then the extract juice was filtered by filter paper, and decolored to avoid the any effect caused by the sense of vision of the fish. As it is shown in Table 1, in which the total results obtained are included, the concentration of this sort

Table 1.

	Test Substance	Date of Exp.	Amount of Sample		
			1 cc	10 cc	Other Amount
0	Sea water	Sept. 20, 1942	None	None	100 cc None
〃	〃	Nov. 20, 1943	〃	〃	〃
00	Distiled water	Sept. 20, 1942	〃	〃	〃
〃	〃	Nov. 20, 1943	〃	〃	〃
1	Onion (row)	〃	Slightly	Slightly	20 cc None
〃	〃	Nov. 21, 1943	None	None	〃
1′	Onion (boiled)	Nov. 19, 1943	〃	〃	〃
2	Sweet potato (row)	〃	〃	〃	〃
〃	〃	Nov. 21, 1943	—	—	〃
2′	〃 (boiled)	Nov. 20, 1943	None	None	20 cc Partly (2/3)
2″	〃	Sept. 21, 1942	—	Partly (1/2)	—
〃	〃	〃	—	Partly (1/3)	—
〃	〃	Sept. 22, 1942	—	Partly (2/3)	—
〃	〃	〃	—	Partly (1/2)	—
3	Potato	Nov. 20, 1943	Slightly	Slightly	20 cc Partly (1/5)
〃	〃	Nov. 21, 1943	—	None	20 cc Slightly
4	"Satoimo" potato	Nov. 19, 1943	Slightly	Slightly	20 cc Partly (1/4)
〃	〃	Nov. 20, 1943	—	—	20 cc Slightly
5	Skin of orange	Nov. 23, 1943	—	Slightly	20 cc None
〃	〃	Nov. 24, 1943	—	〃	20 cc Slightly
6	Leaf of pine	Nov. 23. 1943	—	None	20 cc None
〃	〃	Nov. 24, 1943	—	〃	20 cc Slightly
〃	〃	〃	—	—	〃
7	Leaf of "kuzu"	Sept. 21, 1942	—	Partly (1/3)	—
〃	〃	〃	—	None	—
〃	〃	Sept. 22, 1942	—	〃	—
〃	〃	〃	—	Partly (1/4)	—
8	Leaf of "tsuta"	〃	—	None	—
〃	〃	〃	—	〃	—
〃	〃	Sept. 23, 1942	—	Slightly	—
9	Leaf of "mizohagi"	〃	—	〃	—
〃	〃	〃	—	〃	—
〃	〃	Sept. 24, 1942	—	〃	—
10	Rice straw	〃	—	None	—
〃	〃	〃	—	Slightly	—
〃	〃	Sept. 25, 1942	—	None	—
11	Sea weed "kajime"	Sept. 20, 1942	—	Partly (1/3)	—
〃	〃	〃	—	Partly (1/2)	—
〃	〃	Sept. 21, 1942	—	Entirely	—
〃	〃	〃	—	Partly (1/3)	—
〃	〃	Nov. 23, 1943	—	—	20 cc Entirely
〃	〃	〃	—	Partly	〃
〃	〃	Nov. 24, 1943	—	Partly (1/5)	20 cc Slightly

	Test Substance	Date of Exp.	Amount of Sample		
			1 cc	10 cc	Other Amount
12	Sea weed "arame" (row)	Nov. 27, 1943	—	None	30 cc None
	〃	Nov. 28, 1943	—	〃	20 cc None
12′	〃 (boiled)	Nov. 27, 1943	Slightly	Partly (2/3)	30 cc Partly (2/3)
〃	〃	Nov. 28, 1943	—	None	20 cc Partly (1/2)
〃	〃	〃	—	—	30 cc Partly (1/2)
〃	〃	〃	—	—	50 cc Partly (1/4)
13	Sea weed, Sargasum	〃	—	—	20 cc Partly (1/5)
〃	〃	〃	—	—	20 cc Slightly
〃	〃	〃	—	—	20 cc Partly (1/5)
14	"Miso"	Nov. 19, 1943	None	—	20 cc None
14′	〃 (boiled)	〃	Slightly	Partly (1/3)	20 cc Partly (1/4)
15	"Nuka" rice bran	Nov. 23, 1943	—	None	20 cc Slightly
〃	〃	Nov. 24, 1943	—	〃	20 cc None
〃	〃	〃	—	〃	〃
15′	〃 (boiled)	Nov. 23, 1943	—	Slightly	20 cc Slightly
〃	〃	Nov. 24, 1943	—	None	20 cc Partly (1/3)
16	"Togishiru" of rice	Sept. 20, 1942	—	〃	20 cc Slightly
〃	〃	〃	—	Slightly	20 cc Partly (1/5)
〃	〃	Sept. 21, 1942	—	〃	50 cc Partly (2/3)
17	Plankton decoction	Sept. 25, 1942	Slightly	〃	20 cc Partly (1/5)
〃	〃	Sept. 26, 1942	〃	Partly (1/5)	20 cc Partly (1/3)
17′	〃	〃	〃	Partly (1/3)	〃
〃	〃	〃	—	Partly (1/5)	20 cc Partly (1/5)
17″	〃	Nov. 27, 1943	None	Slightly	40 cc Slightly
〃	〃	〃	—	〃	20 cc None
18	Salted *Mysis*	Sept. 20, 1942	Partly (1/4)	Entirely	—
〃	〃	〃	Partly (1/2)	〃	—
〃	〃	Sept. 21, 1942	Partly (2/3)	〃	—
〃	〃	〃	Partly (1/3)	〃	—
18′	〃	Sept. 25, 1942	Partly (1/5)	〃	—
〃	〃	〃	Partly (1/3)	〃	—
〃	〃	〃	Partly (1/4)	〃	—
18″	〃	Dec. 14, 1943	〃	〃	0.5 cc Slightly
〃	〃	〃	〃	Almost entirely	〃
18‴	〃	〃	Partly (1/3)	Slightly	100 cc Partly (1/5)
19	Silkworm cocoon	Nov. 23, 1943	None	None	20 cc Slightly
〃	〃	Nov. 24, 1943	〃	Partly (1/4)	20 cc Partly
〃	〃	〃	—	Slightly	20 cc Partly (1/4)
20	Fish viscera	Nov. 19, 1943	None	〃	20 cc Partly (1/2)
〃	〃	〃	〃	Partly (1/3)	20 cc Partly (3/4)
〃	〃	Nov. 21, 1043	—	None	20 cc Slightly
21	Salmon egg (row)	Nov. 19, 1943	None	Partly (1/4)	〃
〃	〃	Nov. 21, 1943	—	Partly	20 cc Partly
21′	〃 (boiled)	Nov. 20, 1943	Slightly	Partly (1/4)	20 cc Partly (1/4)
22	Salted sardine	Sept. 25, 1942	Partly (1/3)	Entirely	—

	Test Substance	Date of Ext.	Amount of Sample		
			1 cc	10 cc	Other Amount
22	Salted sardine	Sept. 25, 1942	Partly (1/5)	Entirely	—
23	White bait	Nov. 23, 1943	—	〃	20 cc Entirely
〃	〃	Nov. 24, 1943	Almost entirely	〃	〃
〃	〃	〃	Partly (1/3)	〃	—
〃	〃	〃	Partly (2/3)	〃	—
24	Ascidia	Nov. 23, 1943	〃	Slightly	20 cc Partly (1/3)
〃	〃	〃	〃	Partly (1/3)	〃
〃	〃	〃	〃	Entirely	20 cc Partly (1/4)
25	Crab meat (leg)	Nov. 24, 1943	〃	Slightly	20 cc Slightly
〃	〃	〃	〃	Partly (1/5)	20 cc Entirely
25′	〃 (body)	Nov. 27, 1943	Slightly	Partly (2/3)	30 cc Entirely
〃	〃	〃	Slightly	Entirely	〃
25″	〃 (boiled)	〃	None	Slightly	〃
〃	〃	〃	—	〃	20 cc Partly (1/2)
25‴	Crab viscera	Nov. 23, 1943	—	〃	〃
〃	〃	〃	—	Partly (2/3)	〃
26	Mytilus	Nov. 27, 1943	Slightly	Almost entirely	
〃	〃	〃	〃	—	40 cc Partly (1/2)
〃	〃	〃	—	Slightly	20 cc Partly (1/2)
〃	〃	Nov. 23, 1943	None	Partly (1/4)	20 cc Partly (1/3)
〃	〃	〃	Slightly	〃	50 cc Almost entirely
27	Land mud	Sept. 25, 1942	None	Slightly (?)	30 cc Slightly (?)
〃	〃	〃	—	None	30 cc None
〃	〃	〃	—	〃	50 cc Slightly
28	Pure salt	Sept. 20, 1942	None	〃	100 cc Slightly (?)
〃	〃	〃	〃	〃	100 cc None

of extract varies the result so much, as well as the amount of the test matter. In Table 1, the same material but the different treating or concentration was numbered with dash. The concentration and the method of preparation of the test matter should be added to the table, but the space of the paper did not allow to do it. Even in the case when just a slight response was shown, there is the possibility that the response would be more significant if the concentration would be higher. So the amount of the test matter was changed according its effect in a series of the same experiment to see the variation of the degree of response.

The behaviour of the fish allured to the test matter was various, and hard to express it in a simple sign. In most of cases of the effective matter, fishes were behaving as if they are eating the invisible matter and stayed for a while at the spot, but some time even though in the case the entire fish school quickly came together to the spot, then immediately they backed to the normal behaviour as if they could not find anything to eat.

From No. 1 to No. 16 of the test materials are of vegetable origin, and from No. 18 to No. 26 are of animal origin, the both being either marine or land product. In

general, the more number of the test matter in the part of animal origin is proved to have attracting effect than that of vegetables as far as these series of the test matters concerned.

Seeing Table 1, the test matters proved to have significant effect are No. 11, 12, 12′, 14′, 17, 18, 22, 23, 24, 25 and 26, (class A), while these have no or very slight effect were No. 0, 00, 1, 2, 6, 8, 9, 10, 14, 15, 27 and 28, (class C), and the remainings proved to have medium effect (class B). In the most effective case, No. 18 (salted *Mysis*) and No. 23 (white bait), the existence of water extract from merely 0.01 g substance in the tank of 10,000 liter volume could cause the alluring effect.

As these fishes were conditioned to the salted *Mysis*, which had been supplied to them as a daily food before and during the experiment, the test matters in class A, and some degree in class B, would be considered to have some sort of similarity or some common ingredient with the salted *Mysis*. Seeing the substances of class A, the common ingredient among these substances could be supposed as some sort of amino acid or its allied matters.

On the other hand, the results of these experiments tell some possibility to find out the effective substitute for salted *Mysis* as "komashi" among the substances in class A, seeing its cost and abundance.

3. PURE CHEMICALS

The same type of experiments were made by the authors as the extension of the above experiments about the same fish schools in the same tank using various sorts of pure chemicals as listed below, to find out a certain effective fish attract among them.

By the foregoing experiments on the natural substances, the author thought that some sort of amino acid may do some thing, so most of the effort was concentrated to use various kinds of amino acid as the test chemicals. All of these were used as water solution of certain concentrations as noted in the branket.

No. 29 alcohol (93 %)
No. 30 cane sugar (30 %)
No. 31 glucose (5 %)
No. 32 mannite (10 %)
No. 33 formaldehyde (40 %)
No. 34 NH_4OH (conc.)
No. 35 urea (1 %, 10 %)
No. 36 agar-agar (1 %)
No. 37 gelatin (13 %)
No. 38 albumin
No. 39 succinic acid (1, 10 %)
No. 40 glycocoll (1, 10 %)
No. 41 alanine (1, 10 %)
No. 42* valine (1, 10 %)
No. 43* leucine (1, 10%)
No. 44 aspartic acid (1, 10 %)
No. 45 aspartic acid-HCl (10 %)
No. 46× glutamic acid (1, 10 %)
No. 47× glutamine-HCl (10 %)
No. 48 alginine chloride (1, 10 %)
No. 49* cystine (1, 10 %)
No. 50× l-cysteine-Cl (10 %)
No. 51 phenylalanine (1, 10 %)
No. 52 phenylalanine-HCl (1 %)
No. 53 tyrosine (1, 10 %)
No. 54× l-histidine-HCl (10 %)
No. 55 tauline (1, 10 %)
No. 56* inosinic acid (1, 10 %)
No. 57 betaine chloride

The results of these experiments were recorded and tabulated just like as Table 1, but to save the printing space this huge sized table is omitted here. All of these test matters were poured into the tank, where the fish school was kept, in various amount, such as 1 cc, 10 cc and some time 0.1 cc, 20 cc or 30 cc, if neccessary, by the same method as mentioned in the previous chapter, during (in Sept. 20—25, 1942) and just after (Dec. 5—25, 1943) the previous experiments.

The intensity of the response in these experiments using 28 kinds of chemicals were, contrary to the author's expectation, mostly either *none* or *slightly*, and only a few case were *partly*, and no *entirely* case was shown up. And, the some were found to have *negative* response. The chemicals which attracting effect would correspond to class A of the former experiments was not found among these. And the most effective chemicals, No. 46, 47, 50 and 54 marked as × in the list, can be considered to be in some part of class B. The chemicals recongnized to have some slight positive effect, but should be classified into class C if these are compared with the test matters of foregoing chapter, are No. 42, 43, 49 and 56 (marked as * in the list). And, No. 29 and 33 were proved to have *negative* effect, as when the matter was put in the tank fish moves toward to the opposite direction. And all others were proved to have no or very slight effect.

It should be noted here that even in the cases of class B to cause the *slight* response it requires 10 cc of 10 % solution, in other words, existence of 1 g of the substance is required to attract the fish in this tank. It is very curious compared with the fact that 0.01 g of No. 18 (salted *Mysis*) and No. 23 (white bait) is enough to do that by previous experiment. If these chemicals of class B, all of these are amino acid, would be the fish attracting ingredient in the effective natural substances, its weight enough to cause the response should be much smaller than that of the natural substances. Then the authors have to think that they may miss the right chemicals of higher effect to use in these tests. However, if these test matters of us included all the possible chemicals, and if the results we obtained in the experiments in the next chapter would be added, there would be a way to understand these curious results which will be mentioned in the chapter of conclusion.

4. FRACTION OF SALTED MYSIS

To find out the effective ingredient contained in salted *Mysis*, the junior authors made a chemical analysis of the substance to test the effect of each fraction of it. This analysis was done in Fisheries Chemistry Laboratory of Faculty of Agriculture, Tokyo Imperial University (at that time), under guidance of Professor Takajiro MORI, to whom the authors want to express their tanks here.

At the first step, with a thought that the effective matter may be found in basic substance, the alcohol extract (to exclude the salt in the material) of 200 g of salted *Mysis*, was analyzed into two, basic substance and non-basic substance, by phosphor-wolfram acid method. And, 36 % water solution of the non-basic substance and 60 % water

solution of the basic substance were served for the test. These substances were tested by the same method as mentioned in the previous chapters. The results tell, as shown in Table 2, contrary to the authors' expectation, that the both have attracting effect of similar degree though the basic substance has slightly more intensity than the another (but the concentration of this is about twice — 60 to 36 — of that).

Table 2.

No.	Substance	Date of Exp.	Amount of Sample			
			1 cc	10 cc	100 cc	Others
58	Non-basic substance	Dec. 11, 1943	Slightly	Partly (1/5)	Slightly	30 cc Slightly
〃	〃	〃	〃	Slightly	Partly (2/3)	50 cc Partly (1/3)
〃	〃	Dec. 14, 1943	None	〃	Partly (1/5)	50 cc Partly (1/5)
〃	〃	〃	〃	〃	Slightly	—
59	Basic substance	Dec. 11, 1943	Slightly	Partly (1/2)	Entirely	30 cc Slightly
〃	〃	〃	〃	—	Partly (1/3)	80 cc Partly (1/3)

To compare the intensity of attracting effect, it can be figured up from Table 2 that 0.6 g of the basic substance is needed to cause the response behaviour of fish and 0.3 (if 1 cc) to 3 g (if 10 cc) of the non-basic substance would do the same. These figures of the amount of substance is something close to that of some pure chemicals mentioned in chapter 3, but about a hundred times larger that of salted *Mysis* itself as well as that of class A. It means that the effect was weakened in the fraction very much.

This fact embarassed the authors who thought there may be some ingredient similarly effective as the row material, and were trying to find out it. And then the author had to give up to make chemical analysis further into more detailed fractions.

However, considering the all the evidence we got by our experiments including the ones described in the foregoing chapter, there may be some way to understand these fact at the present stage knowledge we could obtained, as will be mentioned in the chapter of conclusion.

5 FACTORS RELATED WITH SENSE OF VISION

During the preparatory experiments, the author noticed that the fish is attracted also by his sense of vision to any visual matter even to a foam at water surface or the coloured solution. And the effect was intense if the figure is near to *Mysis*, such as a small piece of paper or of rice straw.

A. Size of Samples

At the first step, to see what size of the white paper the fish school would be attracted, a thin type-writing paper of the four sizes were tested, by the same way as mentioned in the foregoing chapters. The test materials were put into the boiled water for a while to take out any soluble chemical matters, and poured into the test tank where the fishes were in, with a proper amount (10 to 100 cc) of sea water.

The sizes of the papers are (A) 0.5×5 mm, (B) 1×10 mm, (C) 2×20 mm and (D)

Table 3.

Size \ Number of paper	1	5	10	50	100	1000
A	—	—	—	—	Slightly	Slightly
A	—	—	None	—	Slightly	Slightly
B	—	—	Slightly	—	Slightly	—
B	None	—	Slightly	—	Slightly	—
C	—	—	Slightly	Partly (1/5)	—	—
C	—	—	Slightly	Slightly	—	—
D	Slightly	Partly (1/5)	Partly (2/3)	—	—	—
D	Slightly	Slightly	Partly (1/3)	—	—	—

3×30 mm. (Natural *Mysis* is about the size of B.)

The results of the test are shown in Table 3.

As it is shown in Table 3, the result of the experiments tells that the larger the size of the white paper the less number of paper enough to attract the fish. So, the authors were trying to enlarge the size of the samples bigger than size D, however, by a few preparatory experiments, we found that even a single piece of the paper of large size, such as a sheat of type writing paper could significantly attract the fish, so it may involve the other factors than the problem now we are going to see, i.e. what size of the bait fish would prefer. And, in the case that the more than two size of the paper were mixed, the fish has the tendency to be attracted by the larger sized paper than the smaller ones.

These results simply tells that the larger the size of the samples it is more conspicuous to be recognized by the sense of vision of fishes, though they are attracted by any kind of matter which can be recognized by their vision.

B. Colour of Sample

At the second step, the following experiments were done to see what colour of the sample would have most attracting effect.

The same sort of paper of the size B (1×10 mm) stained by dyes of (1) black, (2) brown, (3) blue, (4) purple, (5) red, (6) green, (7) yellow, (8) non-stained white and (9) transparent cellophane were the sample for these experiments.

These were washed by the boiled water before the experiments to remove any water soluble matter from these. And, the same sort of experiment as mentioned in the foregoing chapters were done, with ten pieces of the above mentioned samples of each colour, putting one by one into the water in a random order so as to avoid the fish may accustom to the order of colour.

The results of the eight series of the experiments, each of these was carried on during a half day in December of 1943, were shown in Table 4, expressed in the same way as in Table 1.

By these eight series of the experiment it can be said that "white" hat most effective attract and "black" is worst of all.

Table 4.

Date	Dec. 15, 1943	〃	Dec. 18	〃
Experiment / Colour	I	II	III	IV
1 Black	Partly (1/2)	Slightly	None	None
2 Brown	Partly (2/3)	〃	Slightly	Slightly
3 Blue	Partly (1/2)	Partly (1/3)	〃	〃
4 Purple	Partly (1/3)	Slightly	〃	None
5 Red	Slightly	Partly (2/3)	None	〃
6 Green	Partly (1/3)	Partly (1/3)	Slightly	Slightly
7 Yellow	None	None	〃	〃
8 White	Partly (1/4)	Entirely	〃	Partly (1/2)
9 Transparent	Entirely	None	〃	Slightly

And the second is "green." The next to these are "blue" and "brown." "Red," "purple" and "yellow" are somewhat worse than these. And, "transparent" cellophane piece had usually no or slight effect as it was expected by us, but in a few cases when a few fish individuals could came close to it, the most of all others remained behaved to run with them to the matter.

By the way, we have to mention that the coloration of "salted *Mysis*" to which this fish school was conditioned to response is faint pinkish or almost white.

6. CONCLUSION

By the results of this series of experiments of various angles, consisted from several hundreds of single experiment, the followings are the considerations of ours about the effect of "komashi."

(1) "Komashi" has the effect to attract the fish by the two factors. The one is the presense of the water soluble substance in the water where the fish is in, which spread out in the water by difusion and the current, and recognized by the fish with their sense of smell or chemical sense. The another is the presence of the figure of the substance itself, which is recognized by the fish with their sense of vision.

(2) Though the fish school here we used in the experiments were conditioned to response to "salted *Mysis*," but they also responsed to the water extract of the other substance of natural product of various kinds.

(3) When the water extract of "salted *Mysis*" was analyzed into two fractions, basic and non-basic, the attracting effect of each of these fractions was reduced considerably compared with the one of non-analyzed extract.

(4) Among the pure chemicals we tested, some of the amino acid had a slight attracting effect. But, their intensity is far weak if it is compared with that of the natural substances.

(5) By the above mentioned evidence the authors have to consider that the fish is recognizing the attracting extract as a whole substance, and not analyzing their

Dec. 19	〃	Dec. 24	〃	
V	VI	VII	VIII	Judgement
None	None	None	None	Worst
〃	Slightly	Slightly	Slightly	Medium
Slightly	None	None	〃	〃
〃	〃	〃	None	Bad
〃	〃	〃	Slightly	〃
Partly (1/4)	Slightly	Slightly	〃	Good
None	〃	None	None	Bad
Partly (1/3)	Partly (1/3)	〃	Slightly	Best
Slightly	None	〃	〃	Bad

chemical fraction or ingredient by their sense of smell or chemical sense.

So, the water extract of the natural products having the complex and various chemical ingredients included has more effect than any of the more simple or pure chemical property, as far as we tested.

(6) Regarding to the figure of the substance, being recognized by the sense of vision of fish concerned, the larger the size of the substance, and having the colour of white (green is the next, and the blue and brown are the third) has more effect to attract the fish. And, this can be simply considered that these are more conspicuous to be recognized by the sense of vision of the fish.

As the matter to be cleared out in some days later on, the authors recognized the variation of the fish behavior supposed to be caused by the following two factors during the observations of these experiments.

The one is that when a few individuals of fish in the fish school come close to the substance and behaved as if they are biting the food snapping their mouths, then the other remaining fishes suddenly rashed to the spot to get together. This phenomenon suggests the authors that a certain sort of under-water sound caused by the biting fish may allure the remaining fishes.[1] The authors put a hydrophone of sensitive charactor in the aquarium and amplified it electrically to catch the biting sound, but failed to hear them. It might be the sound of "non-audible" charactor by human ears. But, as the sense of hearing of the fish differs from the human being, and it might be more sensitive than we know already, and the author have experience to succeed to attract the fish of Monacanthidae by reproducing the "feeding sound" to the water, so there may be some possibility to be heard by the other members in a fish school.

The another point is that when we were testing the sense of vision with the sample made of paper and cellophane, and also when we are using the artificial "komashi" as it would be described in the following lines, we noticed that the fish might have some choice of the substance to be the bait by the touch when they bite it with jaws or some inner part of the mouth. Because we noticed that when the substance

is soft or elastic, such as piece of cellophane, sea-weed or fish muscle, they will bite these for a while, and then the other remaining fish would come up to the spot to join them. But, on the contrary if the substance is too hard, such as a piece of paper or cut wood wool, though the fish come close and bite these, but soon they went away, and no other fish comes up to the spot. This phenomenon tells to the author that the sense of the touch of the fish must be the matter to be considered in this sort of problem, and also in the case of selection of bait either in the case of "komashi" or bait on the hook, in the actual fishing.

Knowing the above mentioned fact about "komashi" the authors were ambitious to try an actual fishing using artificial "komashi" or the substitute of it. And, the several kinds of them were used by themselves in the occasion of hard-tail (*Trachurus japonicus*) fishing near Misaki at the following summer. Among them, a sample of cut sea weeds (of various kinds) boiled with water and added with mashed littoral crabs (of various kinds of small size) was not worse than real "salted *Mysis*" and could get actual game of some amount.

By the way, if any of conspicous matter, such as white paper, was added to this as it can increase the alluring effect, the size of which should be smaller than that of the bait on hook, unless the fish would not take the hook as they are more attracted by the "komashi" than the bait on the hook.

As this series of the experiments were aiming rather practical analysis to contribute the improvement of fishing method, so the method we used is the direct observation, not of zoopsycological method which can go more exactly like WALKER and HASLER (1949),[2] but this result might bring some to the problem of the chemical sense of fish.

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