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Observations and Experiments on the Behavior of Fishes Toward Floating Objects in Aquarium (Preliminary Report)¹⁾

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(With 1 Plate)

In a previous paper the author recorded about 60 species of marine fishes obtained together with the floating sea weeds which appeared in the eastern part of Sagami Bay during the last four years.

In other localities of Japanese waters 20 more fishes were reported from the same habitat by several authors such as Uchida and Shojima (1958) or Kimura, Hotta, Fukushima, Odate, Fukuhara and Naito (1958).

The role of drifting masses of weeds in relation to marine fishes was naturally suggested as to offer them places for resting, feeding and sheltering.

This interpretation, however, has been based only on the mere collection data, and no close observation or experiment has yet been attempted. The present paper deals with the results of observations in the aquarium and preliminary experiments to analyse the role of the floating objects in relation to young fishes.

The author is deeply indebted to Professor T. Uchida, Hokkaido University, and Dr. S. Mawatari for their kind directions and invaluable help.

Materials and methods

Fishes : In the course of the ecological research ranging over four years numerous fishes were collected together with floating sargassums. Before the preparation of specimens a number of them were kept alive a day or two in the aquarium to observe their behavior. Three common fishes *Oplegnathus fasciatus*, *Abudefduf vaigiensis* and *Stephanolepis cirrhifer* were especially selected for further experiments. In each experiment use was made of ten young individuals of these three species, total length measured 32-56 mm., 18-37 mm. and 16-43 mm. respectively. They were kept and habituated to the experimental tank over two days before experiments and fed once a day on ordinary fish meat.

Floating objects : A small drifting cluster of a common sea weed *Sargassum ringgoldianum* was collected fresh from the sea and placed in the aquarium

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for observations or put into a tank for experiments.

To reproduce a similar habitat in the analytical experiments the author manufactured a kind of "imitation sea weeds" for trial. It consisted of a number of bundles made of fifteen soft, thin and undulating vinyl resin strips, each of which measured 35 cm. in length and 2 cm. in width. When such a bundle was put into the water the lower half of the strips spread out just like the sargassum leaves in the sea, and thus it was expected to give a comfortable sheltering place to fishes. Furthermore, to clarify their shading effect on the behavior of fishes two kinds of "imitation sea weeds" were prepared, one composed of black and opaque strips and the other of grey and semi-transparent ones.

For further understanding of the light intensity effecting the gathering habit of young fishes, two film-like plates of vinyl resin 30×35 cm. in area and 0.1 mm. thick were also prepared. One of them was opaque and black coloured and the other semi-transparent and grey coloured just like the above mentioned "imitation sea weeds."

Methods: For ecological observations a fresh mass of sargassum and collected live fishes were placed together in an ordinary aquarium tank $100 \times 100 \times 150$ cm³. in size. The behavior of the fishes was continuously recorded day and night.

The experiment was carried out in a small aquarium tank $70 \times 100 \times 50$ cm³. in size. Oxygen contents, hydrogen ion concentrations, water temperatures and current streams were properly controlled by a "air-lift system" designed by the author. Light intensities were measured by an electric photometer.

The designated kind of floating objects was gently put into the tank containing 10 young fishes so as to drift along slowly at the rate of 1 or 2 cm. a second on the circulating current. Two minutes after the setting of the floating objects the distribution of 10 fishes was recorded by photographs. The experiments were repeated five times respectively.

Observations

As a result of the author's frequent observations the following three types of responses were distinguishable in the behavior of fishes which gather under the drifting sea weeds in wild life:

- Type 1, staying among the leaves of weeds
- Type 2, swimming under the weed masses, and
- Type 3, freely swimming without any relation to weeds.

Type 1: Youngs of *Sebastes joyneri* usually rest among a cluster of sargassum weeds holding on to the leaves by their pectoral fins, and even when the cluster is gently moved horizontally or vertically they always follow the drift of weeds.

Adults and youngs of *Pterophryne histrio* and some of the adults of *Antennarius tridens* also hold their bodies close on to the stems and leaves of sea weeds by their pectoral, ventral and caudal fins and move along with the weeds. The

latter fish generally stay quietly on the bottom of the aquarium, but when it has fed fully enough it comes up and drifts about two or three days near the surface, and if there is a cluster of weed it approaches slowly with spouting the water out of its gill, and at last takes up residence among the leaves of weeds.

Canthidermis maculatus usually rests against a side wall of the tank.

Almost all individuals of *Paramonacanthus oblongus*, *Stephanolepis cirrhifer*, *S. japonicus*, *Rudarius ercodes*, *Amanses pardalis*, *A. howensis* and *Aluterus monoceros* of the family Aluteridae rest at night on the floating objects as well as on the walls or pipes of the aquarium holding their body still by means of their snouts.

This curious way of holding can also be seen even in the day time in the larval stage of *Stephanolepis cirrhifer* and *Rudarius ercodes*. On the other hand *Stephanolepis cirrhifer*, *Rudarius ercodes*, *Aluterus monoceros* and *A. scriptus* are frequently observed to peck the leaves of drifting sargassums or other organic substances. A kind of thigmotropic response is thus recognized in the above mentioned fishes.

Type 2: Larvae and juveniles of *Seriola quinqueradiata*, *Oplegnathus fasciatus*, *O. punctatus*, *Girella punctata* and *Stephanolepis cirrhifer* generally crowd just below the floating sea weeds in the aquarium and move about with the drifting movements of the weeds by current. The fact agrees well with the author's frequent findings while making investigations of wild fishes in the eastern part of Sagami Bay and with Dr. Kojima's observation in the western part of the Japan Sea. The latter author reported the young of *Girella punctata* and others migrating in company with drifting bamboo rafts.

Type 3: Contrary to the author's expectation a number of fishes which had been collected from the sea together with the drifting sea weeds and transferred immediately to the aquarium did not show any tendency to gather under the floating objects.

Independently of their age, *Ocyrius japonicus*, *Upeneus* sp., *Abudefduf vaigiensis* and others always swam about freely and actively in the aquarium without relation to the floating objects. The greater part of the collected individuals of *Seriola quinqueradiata*, *Oplegnathus fasciatus*, *O. punctatus* and others also moved about freely in the tank and only a small proportion of them gathered under the floating sargassum weeds.

As mentioned above in *Type 1* some of *Sebastes joyneri*, *Pterophryne histrio* and *Antennarius tridens* rest among a cluster of sargassums holding their bodies with their fins, but a number of them stay still on the bottom of the aquarium.

The fact seems to indicate a weak response to the shading effect of the floating objects and that their appearance with drifting sea-weeds is rather accidental.

Results of experiments

To study further the response to the shading effects of the drifting sea weeds the author selected *Abudefduf vaigiensis* from Type 3 and *Oplegnathus fasciatus* and *Stephanolepis cirrhifer* from Type 2 and carried on the following experiments described.

Experiment 1: A cluster of a natural sea weed *Sargassum ringgoldianum* and two sorts of the "artificial sea weeds" were placed simultaneously in the aquarium containing 10 youngs of the above named three fishes. Results of observations are shown in Table 1.

Table 1. Responses of fishes to the natural floating sea weeds and "imitation sea weeds"

Species	Position relative to	Experiment No.					Total number	%
		1	2	3	4	5		
<i>O. fasciatus</i>	under natural sea weed	2	0	0	2	0	4	8
	under black "i.s.w."	4	10	4	2	2	22	44
	under grey "i.s.w."	0	0	0	0	0	0	0
	freely swimming	4	0	6	6	8	24	48
<i>A. vaigiensis</i>	under natural sea weed	0	0	0	0	0	0	0
	under black "i.s.w."	0	0	0	0	0	0	0
	under grey "i.s.w."	0	0	0	0	0	0	0
	freely swimming	10	10	10	10	10	50	100
<i>S. cirrhifer</i>	under natural sea weed	2	0	6	4	0	12	24
	under black "i.s.w."	2	4	2	6	6	20	40
	under grey "i.s.w."	0	0	0	0	0	0	0
	freely swimming	6	6	2	0	4	18	36

A. vaigiensis took no interest in the presence of any objects as expected, but a majority of *O. fasciatus* (52%) and *S. cirrhifer* (64%) showed a clear response to the floating objects.

None of the latter two gathered under the semi-transparent "imitation sea weeds," while they were attracted more strongly (44% and 40% respectively) to the black, opaque "imitation sea weeds" than to the natural sea weeds (8% and 24%).

Such facts seem to indicate that the gathering behavior of these two species is raised by the shading effect of the floating objects more strongly than by any substantial difference of those objects.

Experiment 2: Similar experiment was carried out without natural sea weeds, with the results shown in Table 2.

Similar to the behavior described in the previous experiment, *A. vaigiensis* showed no response to the floating objects, but most of *O. fasciatus* and *S. cirrhifer* (90% and 96%) gathered under the "imitation sea weeds," with only 4% of *S. cirrhifer* staying under the semitransparent ones.

Table 2. Responses of fishes to the black and grey "imitation sea weeds"

Species	Position relative to	Experiment No.					Total number	%
		1	2	3	4	5		
<i>O. fasciatus</i>	under black "i.s.w."	10	7	9	10	9	45	90
	under grey "i.s.w."	0	0	0	0	0	0	0
	freely swimming	0	3	1	0	1	5	10
<i>A. vaigiensis</i>	under black "i.s.w."	0	0	0	0	0	0	0
	under grey "i.s.w."	0	0	0	0	0	0	0
	freely swimming	10	10	10	10	10	50	100
<i>S. cirrhifer</i>	under black "i.s.w."	10	10	8	10	8	46	92
	under grey "i.s.w."	0	0	2	0	0	2	4
	freely swimming	0	0	0	0	2	2	4

Experiment 3: To study the effect of a single strip of "imitation sea weeds" the third experiment was carried out, with the results indicated in Table 3. When black "imitation sea weeds" are put into the aquarium tank almost all of *S. cirrhifer* swim into the shade, but when a bundle of semi-transparent or grey-coloured "imitation sea weeds" is settled only 16% of fishes gather under it. The fact shows the conspicuous effect of shade caused by the floating objects.

Experiment 4: The fourth experiment employing filmy plates instead of the "imitation sea weeds" was carried out to ascertain the shading effect. As

Table 3. Responses to a single "imitation sea weed"

Species	Position relative to	Experiment No.					Total number	%
		1	2	3	4	5		
<i>S. cirrhifer</i>	under black "i.s.w."	10	10	10	9	10	49	98
	freely swimming	0	0	0	1	0	1	2
	under grey "i.s.w."	2	4	2	0	0	8	16
	freely swimming	8	6	8	10	10	42	84

Table 4. Responses of fishes to the black and grey filmy plates

Species	Floating objects	Experiment No.					Total number	%
		1	2	3	4	5		
<i>O. fasciatus</i>	under black filmy plate	9	8	10	10	10	47	94
	under grey filmy plate	0	0	0	0	0	0	0
	freely swimming	1	2	0	0	0	3	6
<i>A. vaigiensis</i>	under black filmy plate	0	0	0	0	0	0	0
	under grey filmy plate	0	0	0	0	0	0	0
	freely swimming	10	10	10	10	10	50	100
<i>S. cirrhifer</i>	under black filmy plate	0	3	4	8	8	23	46
	under grey filmy plate	7	5	3	2	0	17	34
	freely swimming	3	2	3	0	2	10	20

shown in Table 4 *A. vaigiensis* showed no response but *O. fasciatus* and *S. cirrhifer* indicated strong interest in it; 94% of the former and 80% of the latter stayed within the shade of the filmy plates.

Discussion

As the results of the above described observations and preliminary experiments one or two points seem to be clarified.

Fishes collected together with drifting sea weeds from near Enoshima are physiologically divided into three groups. The first includes several fishes with weak locomotive activity which migrate with drifting sargassum holding on to the stems and leaves of the weeds. The second includes some species which show clear response to the shade of floating objects and probably crowd under the sea weed masses actively making use of their swimming ability.

The third group consists of a large number of fishes showing no special response to light intensity in the sea; The cause by which they gather under the weed masses is still unknown.

Comparing the quite different results of experiments shown by *Abudefduf vaigiensis* (Group 3) and *Oplegnathus fasciatus* (Group 2) difference in physiological character such as response to light intensity seems to be determined more or less specifically and hereditarily.

At least in some species such as *Oplegnathus fasciatus* or *Stephanolepis cirrhifer* the behavior of gathering under the shade of floating objects is clearly affected by the reduction of light intensities.

Summary

1) Near Enoshima a number of fishes which were collected during the past four years together with floating sea weeds were kept in an aquarium tank to observe the behavior of the fishes.

2) The fishes are divided into three groups on the basis of their reaction to the natural sea weeds.

3) To clarify their response to the sea weeds four series of experiments were carried out; for the analytical study the author used film-like plates and "imitation sea weeds."

4) Several of the fishes seem to gather under the floating objects in response to the reduction of light intensities.

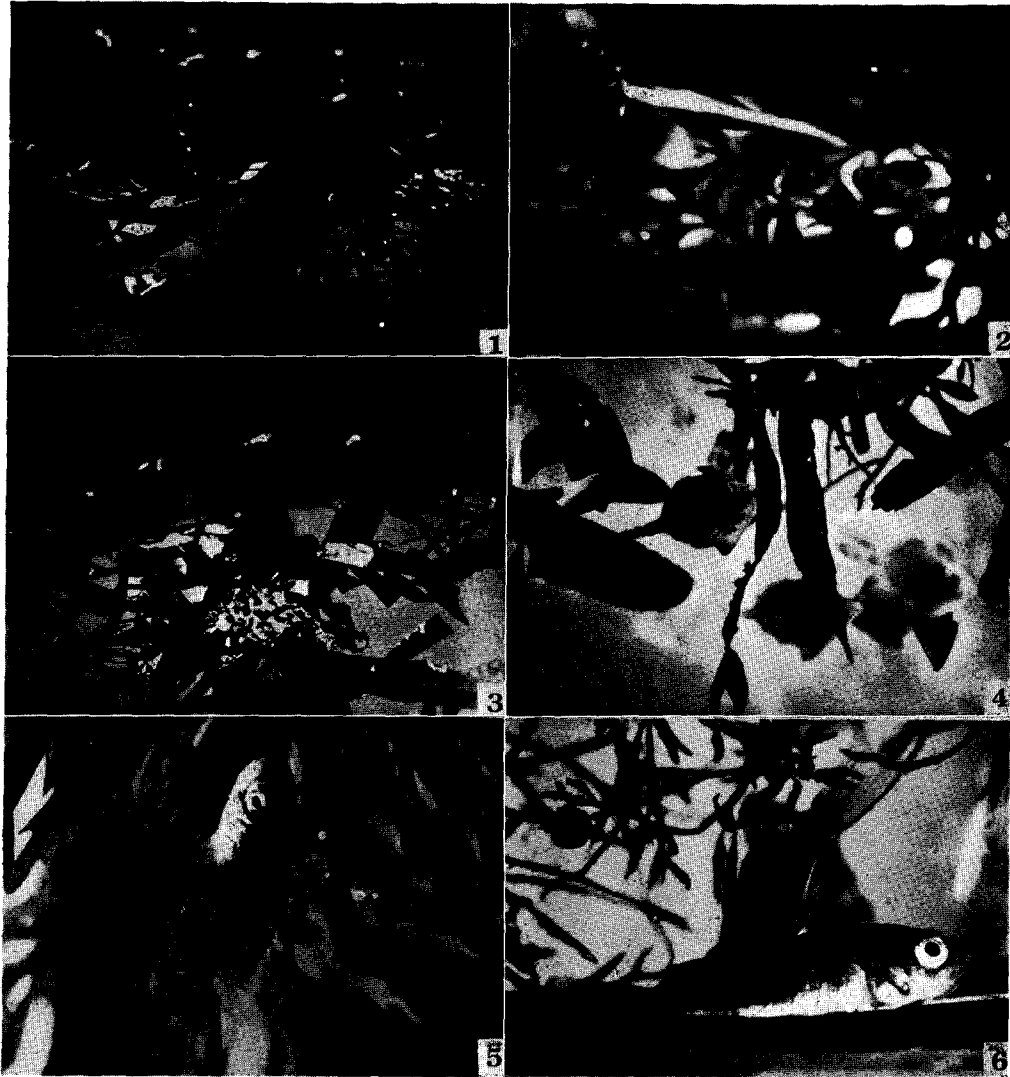
5) The response to the shading effect of floating objects is determined more or less specifically.

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Explanation of Plate VI

- Fig. 1. *Sargassum ringgoldianum* (right below), black "imitation sea weeds" (left) and grey "imitation sea weeds" (upper).
Fig. 2. *Oplegnathus fasciatus* staying among leaves of *Sargassum ringgoldianum*.
Fig. 3. *Pterophryne histrio* holding on to stems and leaves of black "imitation sea weeds".
Fig. 4. *Rudarius ercodes* holding the body by its snout.
Fig. 5. *Sebastes joyneri* holding on to *Sargassum* leaves by its pectoral fin.
Fig. 6. The same staying on the bottom of the aquarium.



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