DISTRIBUTION OF YOUNGS OF TWO REEF FISHES, *GIRELLA PUNCTATA* GRAY AND *G. MELANICHTHYS* (RICHARDSON), IN TANABE BAY AND THE RELATIONSHIP FOUND BETWEEN THEIR SCHOOLING BEHAVIORS[1,2]

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With Plates XVI–XVII, 6 Text-figures and 1 Table

Three papers have been published by the present author and two others concerning the mode of life, distribution and general behavior of rocky reef fishes in Tanabe Bay (OKUNO, 1956 a, b and OKUNO, FUSE and HARADA, 1958). But, in these papers, they did not realize the presence of the species of the genus *Girella*, *G. punctata* GRAY (Japanese name: *mezina*) and *G. melanichthys* (RICHARDSON) (Japanese name: *kuro-mezina*) separately; they were treated only in those papers under one species, *G. punctata*.

On July 11 and 12, 1962, when I had a chance to repeat the observations on the distribution and behavior on young fishes of the genus *Girella* in Tanabe Bay, it was found that both young and adult populations of *Girella* comprise each two species mentioned above and that young fishes of these two species not only gathered at the same reef but also formed the same school.

In the present paper, I am going to record the details of the distribution of youngs of the two species of *Girella* with special references to the interrelation between them in the natural environment.

Before going further, I wish to express my hearty thanks to Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory, for his kindness in giving so many helpful advices and reading the manuscript. To Prof. Huzio UTINOMI of the Seto Marine Biological Laboratory, Prof. Denzaburo MIYADI and Dr. Eiji HARADA of the Kyoto University, and Mr. Kiheiji INOUE, Director of the Suma Aquarium, I am indebted as well for their valuable advices and criticisms. I also want to record here my cordial thanks to Mr. Sôhachi IWAKI, a skillful fisherman in the vicinity of Shirahama, for his many precise informations on

1) Contributions from the Seto Marine Biological Laboratory, No. 393.
2) Contributions from the Suma Aquarium of Kobe City, No. 34.

behaviors of reef fishes in Tanabe Bay and his kindness in helping me to carry out field surveys.

Material and Method

There are reported three species of the genus *Girella* in the Japanese waters. *G. punctata* GRAY has the widest distribution among the three, extending northerly to Hokkaido and southerly to Formosa. On the other hand, the distribution of *G. melanichthys* (RICHARDSON) and *G. mezina* JORDAN et STARKS (Japanese name: *okina-mezina*) is limited to the warm water region stretching from the middle part of Honshū to Formosa (MATSUBARA, 1955 and MITO, 1957). *G. mezina* is very scarce, while the other two are seen abundantly along the southern coasts of Japan.

In this survey, merely young fishes of *G. punctata* and *G. melanichthys* having 3–8 cm total length in summer, namely 0-year fishes hatched in winter and spring of this year, were studied, besides a few data was obtained on the 1-year fish with 15–20 cm total length. Of adult fishes over 2 or 3 years old and 25–50 cm in total length, data were obtained only from the informations given by a fisherman.

G. punctata and *G. melanichthys* are very closely related with each other. Differences in larval stages have not yet been clarified between these two species (UCHIDA et al., 1958). But, the specimens with 3–8 cm total length can be distinguished easily from each other as mentioned below (Plate XVII), although it is somewhat difficult to discriminate these species exactly in underwater observations, while these youngs are swimming around actively.

Main differences in external features between these two species are shown below:

	G. punctata	*G. melanichthys*
Shape	Comparatively short and fatty	Rather slender and thin
Caudal fin	Straight	Slightly concave
	Upper and lower angles are slightly rounded	Angles are pointed
Scale	Large; lateral line scales 52–53	Small; lateral line scales 62–66
Opercular flap	Pale	Black

These characteristics can be recognized on the fishes of about 5 cm long at the distance of 1 m in the sea.

Observations were made at stations as shown in Fig. 1. The oceanographic conditions and topographical features of reefs in Tanabe Bay are mentioned in detail in the papers collaborated by FUSE, YAMAZI and HARADA (1958) and OKUNO, FUSE and HARADA (1958). Stations A and B are located in the innermost part

of the studied area in the bay that is characterized by low transparency, thick mud-covering and relative evenness of the reef surface. On the other hand, Sts. H and I are situated as the place evidently with the oceanic features, such as high transparency and rough appearance of the reef which is quite free from muddy deposit. Sts. C, D, E, F and G show an intermediate state between the two groups of stations.

All the data presented in this paper were gained from the direct observations by skin diving, as SCUBA was not available effectively in very shallow places where young fishes of *Girella* were living, they are scarcely met with at the places deeper than 3 meters. Usually it took approximately an hour to complete the observation. Individual numbers of each species, their estimated total length, general behaviors and positions in the reef were recorded on schools of these two species in the water. When schools of these fishes comprise less than 30 individuals, I tried to count the actual number of individuals as possible. When the school was too large, only rough estimation was made on the individual number. The same was done to find out the proportion of respective species in the school when the school was not monotonous.

Distributions of Two Species in the Bay

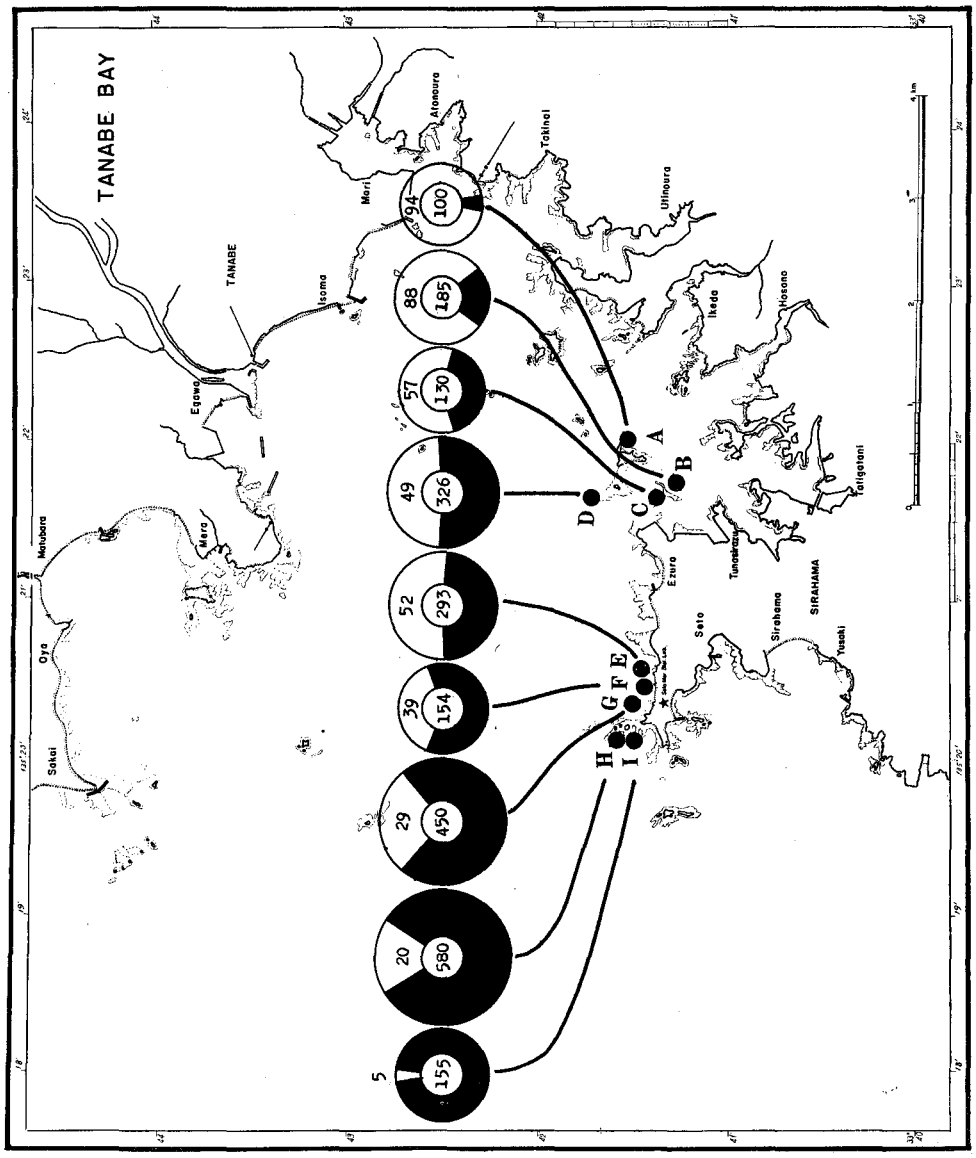
Results of the observation at each station are shown in Fig. 1. The size of circle represents the abundance observed at each station and proportions of *G. punctata* and *G. melanichthys* are indicated by the wideness of white (*punctata*) and black (*melanichthys*) areas. It is needless to mention here that it is quite insignificant to be compare one another.

At only St. E, observations were made twice, the former was at 4 p. m. on July 11 and the results of this observation is given in Figs. 1 and 3, while the latter at noon of the next day. In all 293 fishes were observed in the former and 359 in the latter, and the ratio of *melanichthys/punctata* (hereafter the ratio will be indicated by *m/p*) was respectively 1.07 (52% : 48%) and 0.75 (43% : 57%). The differences found between the results of two surveys are considered to be attributable to an observational error: They are not so remarkable as to both the total individual number and the ratio between two species. This is probably due to the fact that the population of young *Girella* at this reef is settled there, without going out to other places and resultantly the total number of fishes inhabiting at this reef constant as in the case already reported in my previous paper (Okuno, 1956 b).

The following facts may be deduced from the results shown in Fig. 1.

1) The ratio *m/p* gradually increases from the inner part of the bay toward the outer part along the direction from St. A to St. H.

2) Values of ratio *m/p* can be sorted into three groups; one comprising the values less than 0.5 (A: 0.06, B: 0.28) at Sts. A and B, next one including the

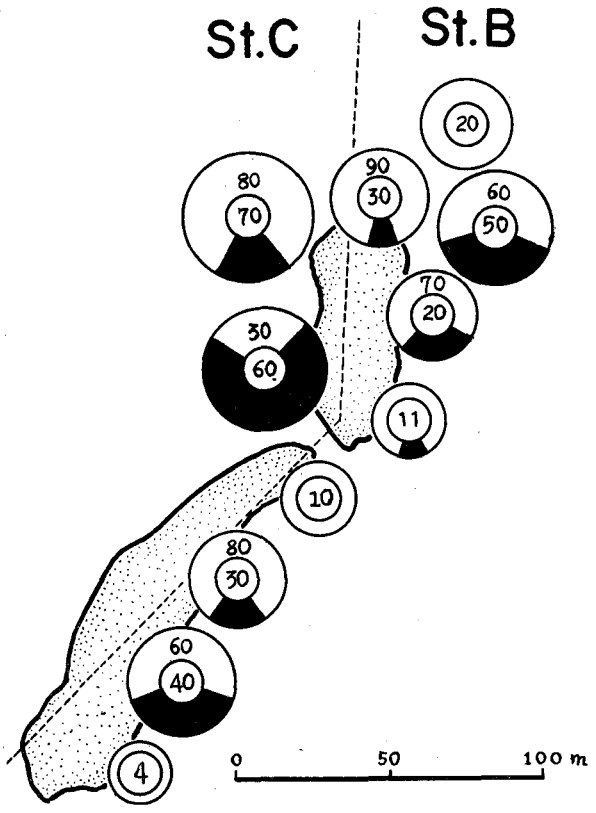


Text-fig. 1. Distribution of *Girella punctata* and *G. melanichthys* at 9 stations in Tanabe Bay.
Size of circles shows the abundance of both fishes.
Total individual numbers are given at the center.
White and brack areas show the proportions of *G. puntata* (white) and *G. melanichthys* (black).
Number in white area represents the percentage of *G. punctata* to the total.

values in the range between 0.5 and 2.0 (C: 0.76, D: 1.1, E: 0.93, F: 1.6) at Sts. C, D, E and F and the rest consisting of values more than 2.0 (G: 2.4, H: 2.9, I: 18.4) at Sts. G, H and I.

3) Although Sts. B and C are located respectively on the inner and outer sides of the same reef, the ratio *m/p* differs significantly between two stations.

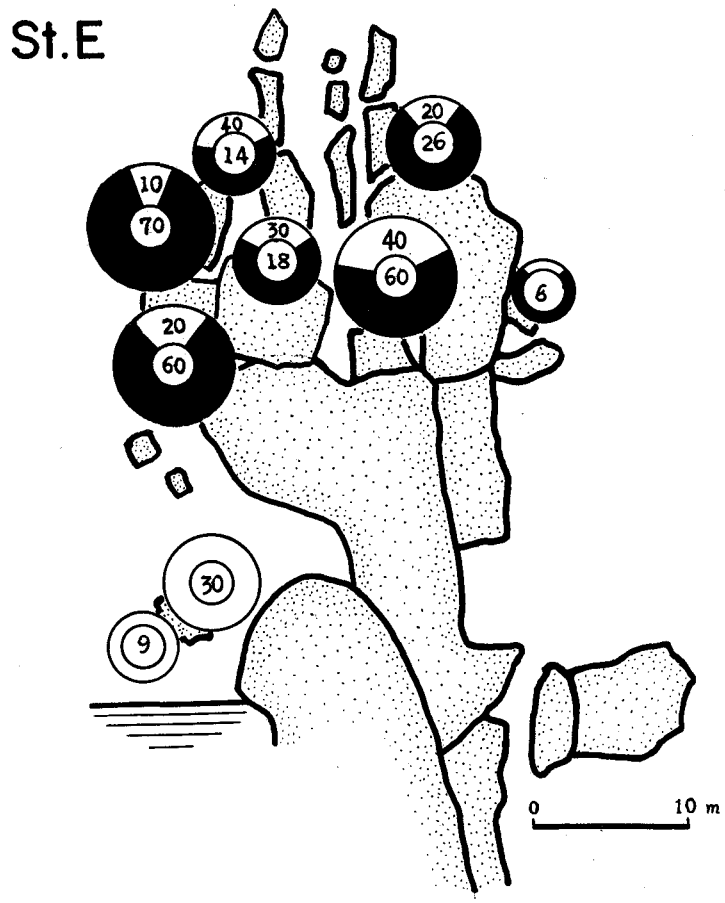
In addition to the above-mentioned observations, another survey was made on July 4, when I observed near St. A, tremendous numbers of young *G. punctata*



Text-fig. 2. Distribution of schools at Sts. B and C, prepared in the same way as in Fig. 1.

were schooling settled at live net cages holding yellow tail, *Seriola quinqueradiata* TEMMINCK et SCHLEGEL and other carangids for commercial purpose. For example, the three large groups of *G. punctata* settled to one of the live net cages, 5 meter square in extend. Of these groups, two had 300 individuals and the rest had 500. The two groups of 300 individuals were consisting solely of *G. punctata*, while in the group of 500, two individuals of *G. melanichthys* were recognized among *G. punctata*.

During the collecting trips to the vicinity of Shirahama made by the Suma Aquarium in the years 1958–1962, many young *Girella* were caught in tide pools on the rocky reef, Shisôzima, just outside the bay by making the pool empty. Most of these fishes were *G. melanichthys*, while only a few *G. punctata* were found. Another case showing the offshore distribution of *G. melanichthys* is given by members of the Shirahama Aquarium who got ten young *Girella* on July 12,



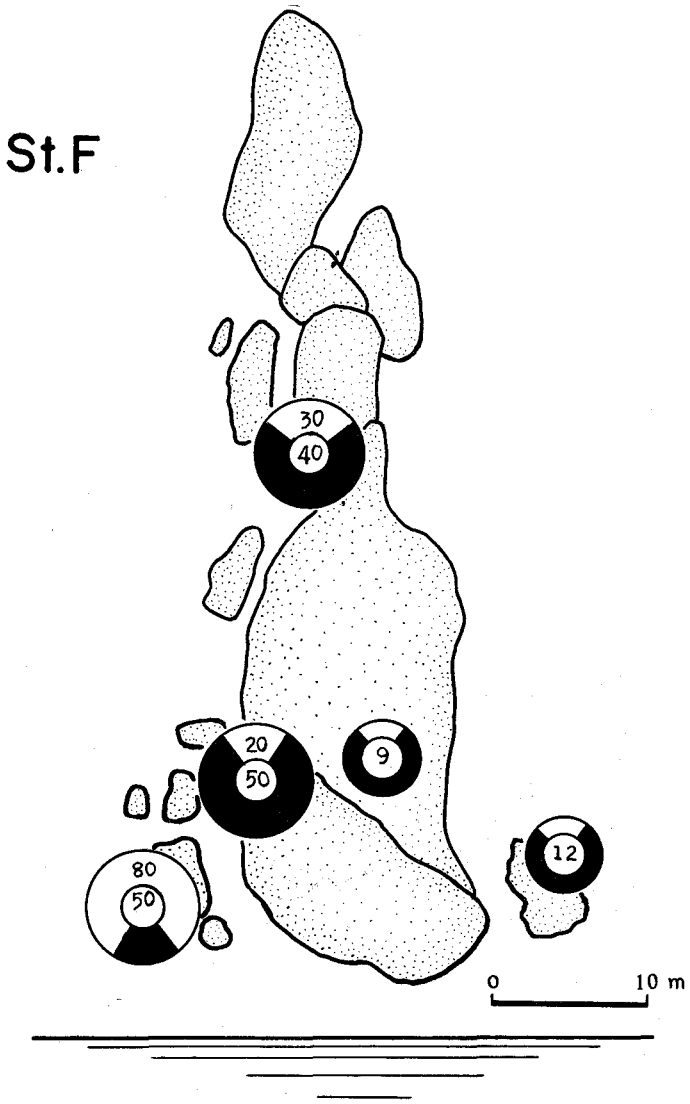
Text-fig. 3. Distribution of schools at St. E.

1962, near St. H; none of *G. punctata* was caught at that time.

From the facts shown above, it is very probable that young *Girella punctata* distributes mainly in the inner part of the bay and young *Girella melanichthys* is more abundant in the outer part. The middle part of the bay is, then, an area where the two species are inhabiting together.

Distribution of Schools at Each Station

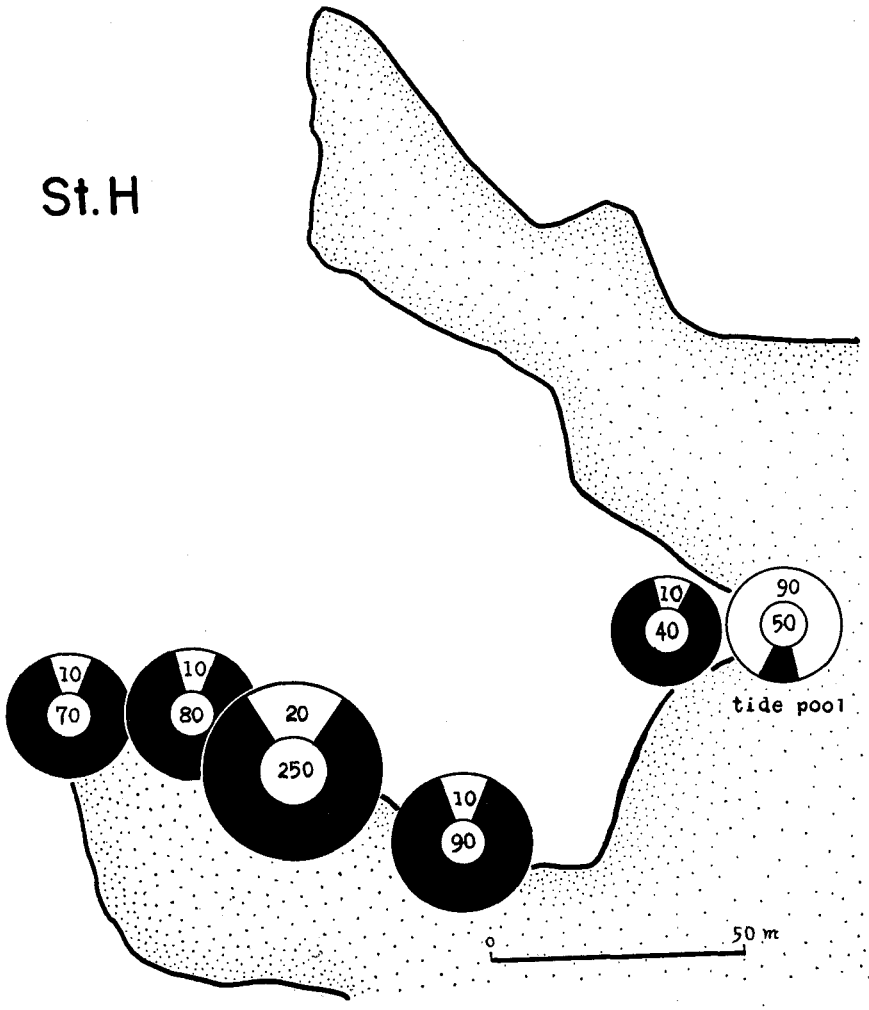
Some examples are given to show the distribution of schools of young *Girella* in each station (Figs. 2–5).



Text-fig. 4. Distribution of schools at St. F.

The reef at St. E (Fig. 3) situated in the middle part of the bay, is surrounded by sandy beach, it is 60 meters long, 30 meters wide and the top is about

5 meters under the surface at high tide. Even at such a small reef, the trend was seen that *G. punctata* stayed on the inshore side and *G. melanichthys* on the offshore side. Also at St. F located near St. E, the same tendency was observed (Fig. 4). The same tendency was also found at Sts. B and C (Fig. 2). A tide



Text-fig. 5. Distribution of schools at St. H.

pool, 3 m long, 2 m wide and 1 m deep, at the innermost part of the cove at St. H, harbored many *G. punctata* (Fig. 5). On the basis of these evidences, it may be said safely that young *G. punctata* is bound more intimately to the reef or to the shore than in *G. melanichthys*.

Schooling Behaviors in Two Species of *Girella*

As seen clearly in the above-mentioned data (Figs. 2-5), the youngs *G. punctata* and *G. melanichthys* form common schools in which they are living peacefully without any fighting. General behaviors reported in my previous paper (OKUNO, 1956 b) on *G. punctata*, might very possibly be the behaviors comprising those of the two species.

Of 62 schools observed, 19 schools were consisted of a single species (pure schools of *G. punctata* 16 against those of *G. melanichthys* 3), while 43 schools were compound ones (Table 1). Most of simple schools were distributed in the

Table 1. Distribution of simple and compound schools and variations found in school size.

Station	A	B	C	D	E	F	G	H	I	
Simple school										
number of school	10	3	0	0	2	0	2	0	2	19 (total)
average individual number per school	8.3	11	—	—	20	—	7	—	40	13 (mean)
Compound school										
number of school	3	6	2	5	7	5	7	6	2	43 (total)
average individual number per school	5.7	25	65	65	36	51	62	97	38	50 (mean)

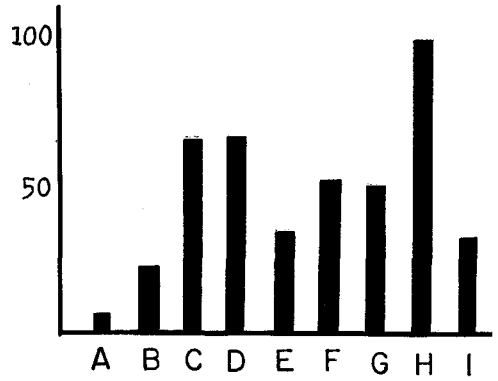
innermost part (10 schools at St. A and 3 at St. B) or in the outer part (2 schools at each of Sts. G and I) of the bay, but only two occurred in the middle part. On the other hand, compound schools were distributed rather uniformly throughout the whole stations in the bay. Therefore, the compound school is considered to be the general form in the middle part of the bay.

The average individual number in a school at respective stations shows a trend towards the gradual increase to the outer part of the bay with a few exceptions as shown in Fig. 6. The increase is parallel to that of the area of respective reefs (OKUNO, FUSE and HARADA, 1958). This is quite resonable as the size of school of young *Girella* is affected by the size of the unit feeding area (OKUNO, 1956 b) which means the surface of the rock covered by small algae (OKUNO, 1956 a). The appearance of large groups around live net cages of yellow tails at St. A can be understood easily at that they are fed sufficiently by bait remnants for yellow tails.

Average indidual numbers in a simple school seems to be formed there only under some unusual conditions such as an area very close to the shore or as small groups accidentally strayed out of the compound school.

There were observed some cases in which other kinds of fishes had strayed into *Girella* schools. Three schools were found containing one to three individuals of *Siganus fuscescens* (HOUTTUYN) with 5 cm total length, two contained five or

six *Kyphosus lembus* (CUVIER et VALENCIENNES) of about 10 cm in total length, and two other schools included both of these species. For example, in an instance of the last case, three individuals of *S. fuscescens* and five of *K. lembus* were seen mingled in a school of about 200 individuals of *Girella* at St. G. There, three individuals of *S. fuscescens* were aggregating as if they were forming a small group of the *Girella* school independently. Five individuals of *K. lembus* were also found not only gathering together, but also sometimes going away from the *Girella* school in a small group. However, *G. pnnctata* and *G. melanichthys* were never observed to form any simple subgroups within the compound school. Thus, it is apparent that *G. punctata* and *G. melanichthys* form the compact common school together. Although it is allowed that other fishes may stay within such a compound school, it cannot be said that such a school is regarded as a perfectly formed compound school. In other words, young *G. punctata* and *G. melanichthys*



Text-fig. 6. Average individual number per school at each station.

recognize each other as the same fish, whereas *S. fuscescens* and *K. lembus* are not recognized by *Girella* as the same fish and *vice versa**.

As to the schooling behavior of 1-year fishes only a few data were obtained during the present researches, which seem to show that 1-year fishes of *G. punctata* and *G. melanichthys*, with 15–20 cm total length, form compound schools as stable as in 0-year fishes.

No differences are seen between the general behavior of young *G. punctata* and that of young *G. melanichthys* as far as the results of underwater observations, excepting that *G. punctata* is bound to the reef or shore more intimately

* The capacity of recognizing other kinds of fishes was affirmed in a small tank while I was watching their chasing behavior, namely, *G. pnuctata* and *G. melanichthys* chase each other but never do against other kinds of fishes, the details of the observation will be reported in a future paper.

than in *G. melanichthys*. Therefore, the descriptions of schooling behavior given for *G. punctata* in my paper of 1956 b, may be available to the compound schools of *G. punctata* and *G. melanichthys*.

Note on Behavior of Adult Fishes

Here are introduced some of the informations on the behavior of adult fishes given by Mr. S. IWAKI, a fisherman at Tsunashirazu, the eastern district of Shirahama.

The breeding season of *G. punctata* is supposed to extend from December to May (MITO, 1957) on the coast of Kyûshû Island. This is true in Tanabe Bay too, probably with the peak in March and April. Reproductive groups of *G. punctata*, containing both mature male and female, are caught with the seine on the sandy beach near St. F in early April every year. These schools consist of 300–500 individuals with an average total length of about 35 cm and a mean weight of 1 kg. And they are always simple schools of *G. punctata* and no exception is recorded. On the other hand, no reproductive group or mature individual of *G. melanichthys* have ever been found in Tanabe Bay.

It is said that several hundreds of adult *Girella* are occasionally found in or out of the bay, swarming at the surface and floating without any active movements. The cause of this strange phenomenon is not yet explained. Most of these groups are of *G. punctata*, but a few of them are said to be constituted of rather small and pale fishes which may possibly be *G. melanichthys*; the group of *G. punctata* looks more darkly because of the blackish coloration of individual fish.

Judging from these informations, it is supposed that schools of adult *G. punctata* and *G. melanichthys* do not mix together, but each of them forms its own school. Especially, reproductive groups of *G. punctata* are strictly monotonous.

Mr. IWAKI also insists that adult *G. punctata* is bound to the reef more intimately than adult *G. melanichthys* is. This agrees well with my findings about young *Girella* as mentioned already.

Some Discussions on Distribution of Two Species

In his paper on social behavior and competition of immature eastern brook trout, *Salvelinus fontinalis* (MITCHILL) and coastal rainbow trout, *Salmo gairdneri* RICHARDSON, NEWMAN (1956) mentions: "In Sagehen Creek the two species overlap in range for about a mile. Perhaps a single species would have a more extended range in the absence of the other." Very similar pattern of distribution have been shown in Japanese rivers on two species of trouts, 'iwana', *Salvelinus pluvius* (HILGENDORF) and 'yamane', *Oncorhynchus rhodurus* (GÜNTHER) or *O. masou* (JORDAN et MCGREGOR) (IMANISHI, 1951).

It was pointed out by NEWMAN that two species of trout fight in the aquarium and in rivers regardless of species and that their aggressive behavior is a representation of competition between them. On the other hand, it was assumed by IMANISHI on Japanese trouts that the habitat segregation of two species are not caused on direct struggles between them, but on the distributional difference of their food insects.

Many students insist that the competition is seen between such animals that are related one another very closely having similar demands of life and occupying the same habitat.

However, in the case of young *G. punctata* and *G. melanichthys*, they form perfectly mixed schools without any struggles between them in spite of the fact that their distributions clearly overlap each other. Competitions cannot be considered between these two species as far as the results of underwater observations show.

Summary

1) Distributions and behaviors of young *Girella punctata* GRAY and *Girella melanichthys* (RICHARDSON) were studied by skin diving observations made on July 11 and 12, 1962, in Tanabe Bay on the western coast of Kii Peninsula.

2) Distributions of these two species in Tanabe Bay are shown in Figs. 1-5.

3) *G. punctata* is distributed in the innermost and middle parts of the bay, while *G. melanichthys* in the middle and outer parts of the bay.

4) These are parfectly mixed schools of two species in the middle part of the bay, where they are living without any struggles.

5) Sometimes *Siganus fuscescens* or *Kyphosus lembus* may join the *Girella* schools, but in such cases, the compound schools thus formed cannot be considered to be as stable as those formed of two species of *Girella*.

6) Informations given by fisherman tell that adult *Girella* seems not to form any compound school, this is especially pronounced about reproductive groups.

7) Young fishes of two species of *Girella* have overlapping distributions, but no competitive behaviors are observed between them.

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EXPLANATION OF PLATES XVI–XVII

PLATE XVI

Fig. 1. Living specimen of *Girella melanichthys* (RICHARDSON) in aquarium. Body length: 133 mm. Total length: 167 mm.

Fig. 2. Living specimen of *Girella punctata* GRAY in aquarium. Body length: 118 mm. Total length 146 mm.
Both specimens were gained in Tanabe Bay in August, 1961, and photographed in the Suma Aquarium in September, 1962.

PLATE XVII

Fig. 3. Specimens of *G. melanichthys* (above) and *G. punctata* (below). The same with those shown in Figs. 1 and 2.

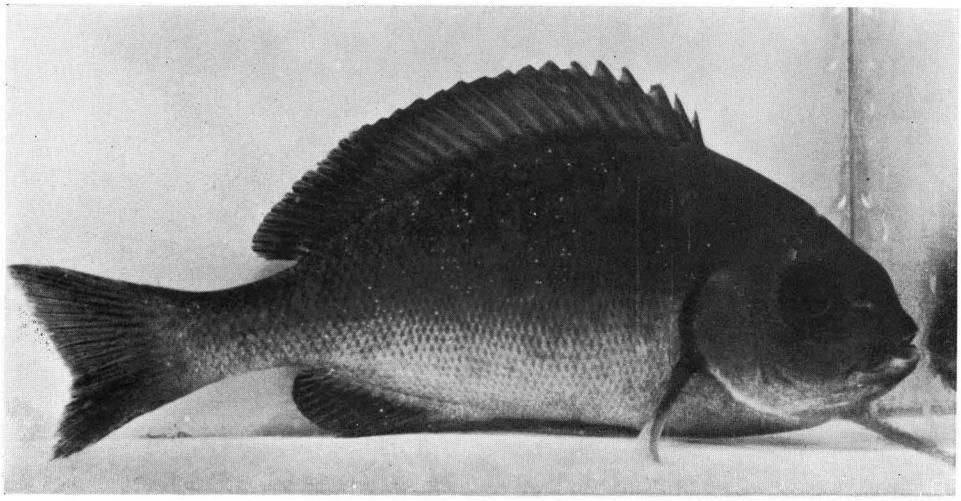

Fig. 1.

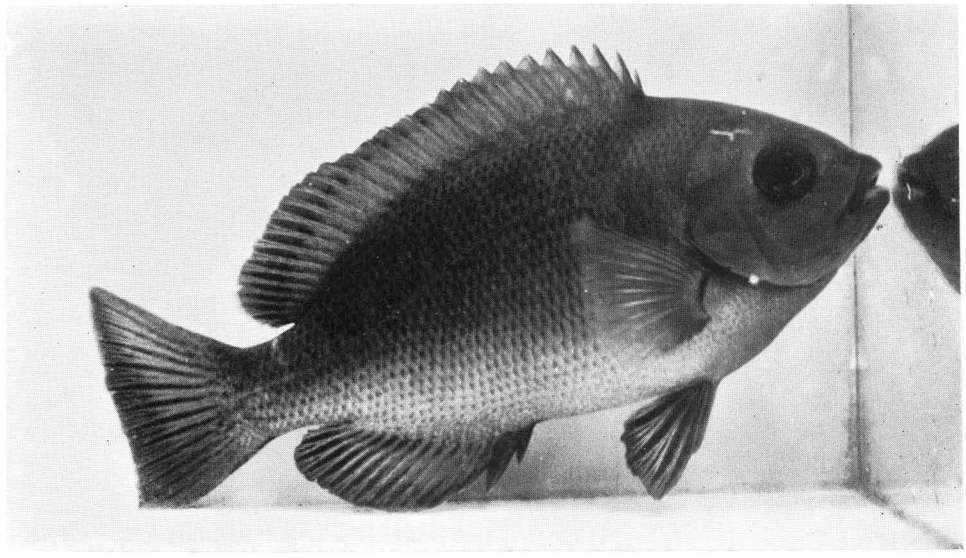

Fig. 2.

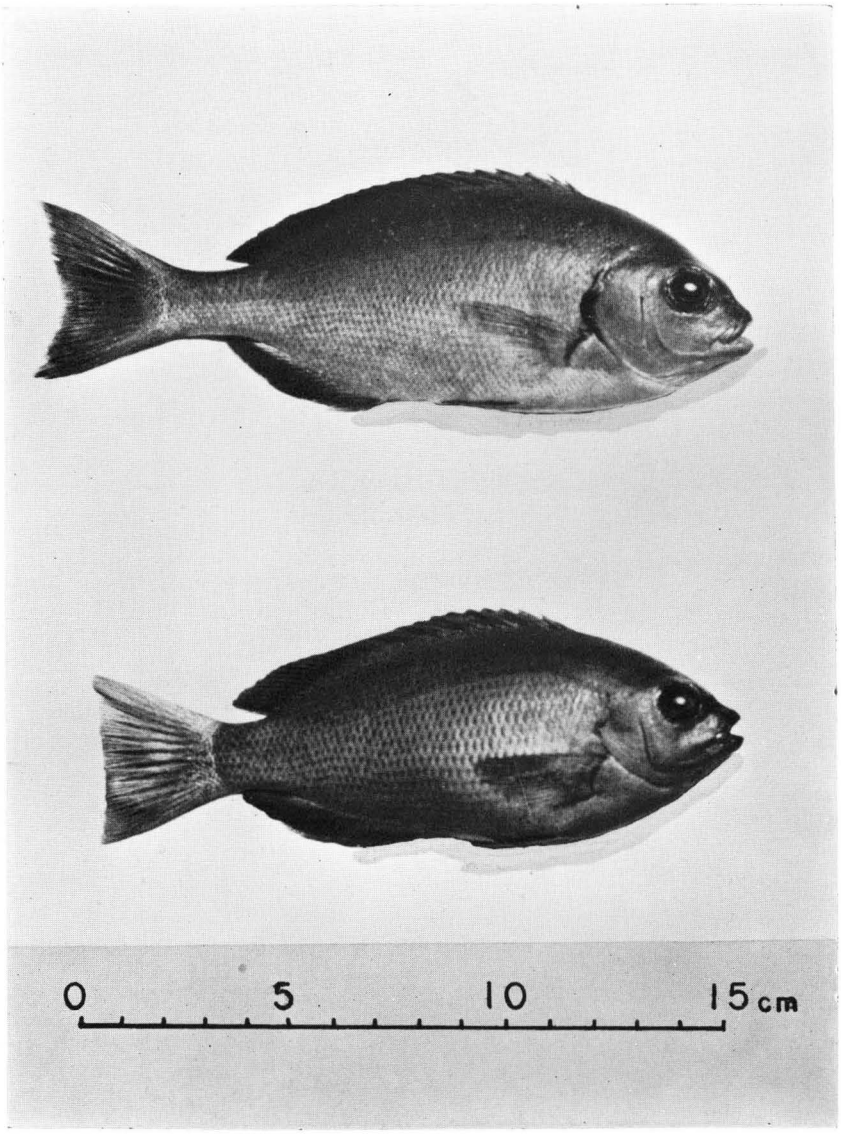

Fig. 3.